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**Coupling System Design Optimization - A Survey and  
Assessment of Automatic Coupling Concepts for  
Rail Freight Cars. Volume II: Text and Appendices**

**A. T. Kearney, Inc, Chicago, Ill.**

**Prepared for**

**Transportation Systems Center, Cambridge, Mass.**

**May 78**

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**COUPLING SYSTEM DESIGN OPTIMIZATION  
A Survey and Assessment of Automatic Coupling  
Concepts for Rail Freight Cars  
Volume II: Text and Appendices**

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MAY 1978

FINAL REPORT

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Technical Report Documentation Page

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| 16. Abstract<br><p>The purpose of this study is to provide an independent identification, classification, and analysis of significant freight car coupling system concepts offering potential for improved safety and operating costs over the present system.</p> <p>The basic method of approach was to make a comprehensive search as a prerequisite to establishing significant coupler concepts which would be used to formulate candidate coupling systems. The search program consisted of a literature search, a patent search, and railroad industry interviews.</p> <p>Coupling development efforts have been decreasing due to changing usage and profitability of the American railroads. The functional concepts of existing development efforts range in sophistication from increasing the gathering range of the present coupler system to providing automatic train air connection and a complete redesign of the mechanical coupler.</p> <p>A sufficient number of new coupler concepts were identified to derive coupling systems which represent a significant improvement over the present system. This is the second of two volumes. Volume I, 48 pages, is an executive summary.</p> |                                                                                                                                                                     |                                                                                 |
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## PREFACE

The work described in this report was carried out under the direction of the Transportation Systems Center of the U.S. Department of Transportation in the context of an overall project of the Federal Railroad Administration (FRA) to provide a technical basis for the improvement of rail transportation service, efficiency and productivity. The work was sponsored by the FRA Office of Research and Development, Office of Freight Systems.

The work reported here has been coordinated with the Association of American Railroads (AAR) Advanced Coupling Concepts Steering Committee. It is an element of a larger program initiated by the FRA and AAR Joint Study Group on Advanced Coupler Concepts which contains both economic and technical elements.

This final report is organized into two volumes. The Executive Summary (Volume I) is an easily readable summary of the project to survey and assess coupler systems for rail freight cars. The Report (Volume II) includes the full documentation and details of the project activity.

Kearney gratefully acknowledges the cooperation of the many railroads, rapid transit companies, manufacturers, research and development organizations, U.S. Patent Office, AAR Technical Center, AAR Advanced Concepts Steering Committee, and other interested parties who provided the information required to conduct a professional, objective study. We would also like to thank DOT personnel in the Transportation Systems Center and the Federal Railroad Administration for their cooperation and assistance throughout the course of the study.

Finally, the authors are grateful to L.K. Kloss for his help in preparing this report.

# METRIC CONVERSION FACTORS

| Approximate Conversions to Metric Measures |                        |             |                        |
|--------------------------------------------|------------------------|-------------|------------------------|
| Symbol                                     | When You Know          | Multiply by | To Find                |
| <b>LENGTH</b>                              |                        |             |                        |
| m                                          | meters                 | 1           | meters                 |
| cm                                         | centimeters            | 100         | centimeters            |
| mm                                         | millimeters            | 1,000       | millimeters            |
| km                                         | kilometers             | 1,000       | kilometers             |
| <b>AREA</b>                                |                        |             |                        |
| m <sup>2</sup>                             | square meters          | 1           | square meters          |
| cm <sup>2</sup>                            | square centimeters     | 10,000      | square centimeters     |
| mm <sup>2</sup>                            | square millimeters     | 1,000,000   | square millimeters     |
| km <sup>2</sup>                            | square kilometers      | 1,000,000   | square kilometers      |
| <b>MASS (weight)</b>                       |                        |             |                        |
| g                                          | grams                  | 1           | grams                  |
| kg                                         | kilograms              | 1,000       | kilograms              |
| mg                                         | milligrams             | 1,000       | milligrams             |
| ton                                        | metric tons            | 1,000       | metric tons            |
| <b>VOLUME</b>                              |                        |             |                        |
| m <sup>3</sup>                             | cubic meters           | 1           | cubic meters           |
| l                                          | liters                 | 1           | liters                 |
| ml                                         | milliliters            | 1,000       | milliliters            |
| gal                                        | gallons                | 3.785       | gallons                |
| qt                                         | quarts                 | 0.946       | quarts                 |
| pint                                       | pints                  | 0.473       | pints                  |
| cup                                        | cups                   | 0.237       | cups                   |
| oz                                         | ounces                 | 0.029       | ounces                 |
| lb                                         | pounds                 | 0.454       | pounds                 |
| ton                                        | metric tons            | 1,000       | metric tons            |
| <b>TEMPERATURE (Celsius)</b>               |                        |             |                        |
| °C                                         | Celsius temperature    | 1           | Celsius temperature    |
| °F                                         | Fahrenheit temperature | 1.8         | Fahrenheit temperature |



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### ABBREVIATIONS

|           |                                                           |
|-----------|-----------------------------------------------------------|
| AAR       | - Association of American Railroads                       |
| COMPENDEX | - Engineering Index                                       |
| DOT       | - U. S. Department of Transportation                      |
| EPA       | - U. S. Environmental Protection Agency                   |
| FRA       | - Federal Railroad Administration                         |
| ISMEC     | - Science and Mechanical Engineering Abstracts            |
| NASA      | - National Aeronautics and Space Administration           |
| NTIS      | - National Technical Information Service                  |
| ORE       | - Office for Research and Experiments                     |
| OSHA      | - Occupational Safety and Health Administration           |
| RPI       | - Railway Progress Institute                              |
| RRIS      | - Railroad Research Information Service                   |
| R-TRIS    | - Regional Transportation Research Information<br>Service |
| TRIS      | - Transportation Research Information System              |
| TSC       | - Transportation Systems Center                           |
| UIC       | - International Union of Railways                         |

## 1. INTRODUCTION

### 1.1 OBJECTIVE AND SCOPE

The purpose of this study is to provide identification, classification, and analysis of significant freight car coupling systems concepts offering potential for improved performance and operating costs over the present system. This study is being carried out in coordination with the Association of American Railroads (AAR) and the Railway Progress Institute (RPI) advanced coupling concepts program.

Research and development projects have been conducted by industry suppliers and others over recent years to design various coupler systems or coupler system components. The primary thrust of the R&D effort has been for U.S. rapid transit application or for European rail service. The functional concepts of these advanced systems range in sophistication from increasing the gathering range of the present coupler system to providing automatic train line air connection and a complete redesign of the mechanical coupler. Some of these systems are in the conceptual stage; others have advanced beyond physical prototypes to actual installation. To evaluate the potential of advanced coupling systems for enhancing operating efficiency and for providing greater safety in coupling operations, an organized review of the proposed and existing advanced coupling concepts was required. The review identifies those systems offering potential for major improvements in the current freight coupling operations.

#### 1.1.1 Study Objectives

- 2) To assemble and synthesize information related to

advanced coupler systems in terms of their respective functional concepts.

2) To identify, characterize, and select the most promising concepts of these systems and group them into logical combinations for candidate coupling systems which warrant further study.

3) To conduct an objective feasibility study and preliminary engineering and cost analysis of the concepts in the candidate coupling system; specifically excluded is an estimate of the benefits of implementation.

#### 1.1.2 Study Scope

The scope of the study includes advanced coupler concepts that have been proposed either domestically or abroad, patented or nonpatented, regardless of their respective stage of development or degree of sophistication.

The results of this project will be coordinated with the economic study of advanced coupler systems under AAR sponsorship. For this reason, particular emphasis was placed upon evaluation of advanced coupling systems from the functional standpoint as they might impact railroad operational procedures, safety and efficiency of operations.

The scope of the study does not include original research, design of hardware, or development. The thrust of the study is to review and characterize work performed by others and to identify and evaluate concepts that could most readily effect improvements in the rail freight industry.

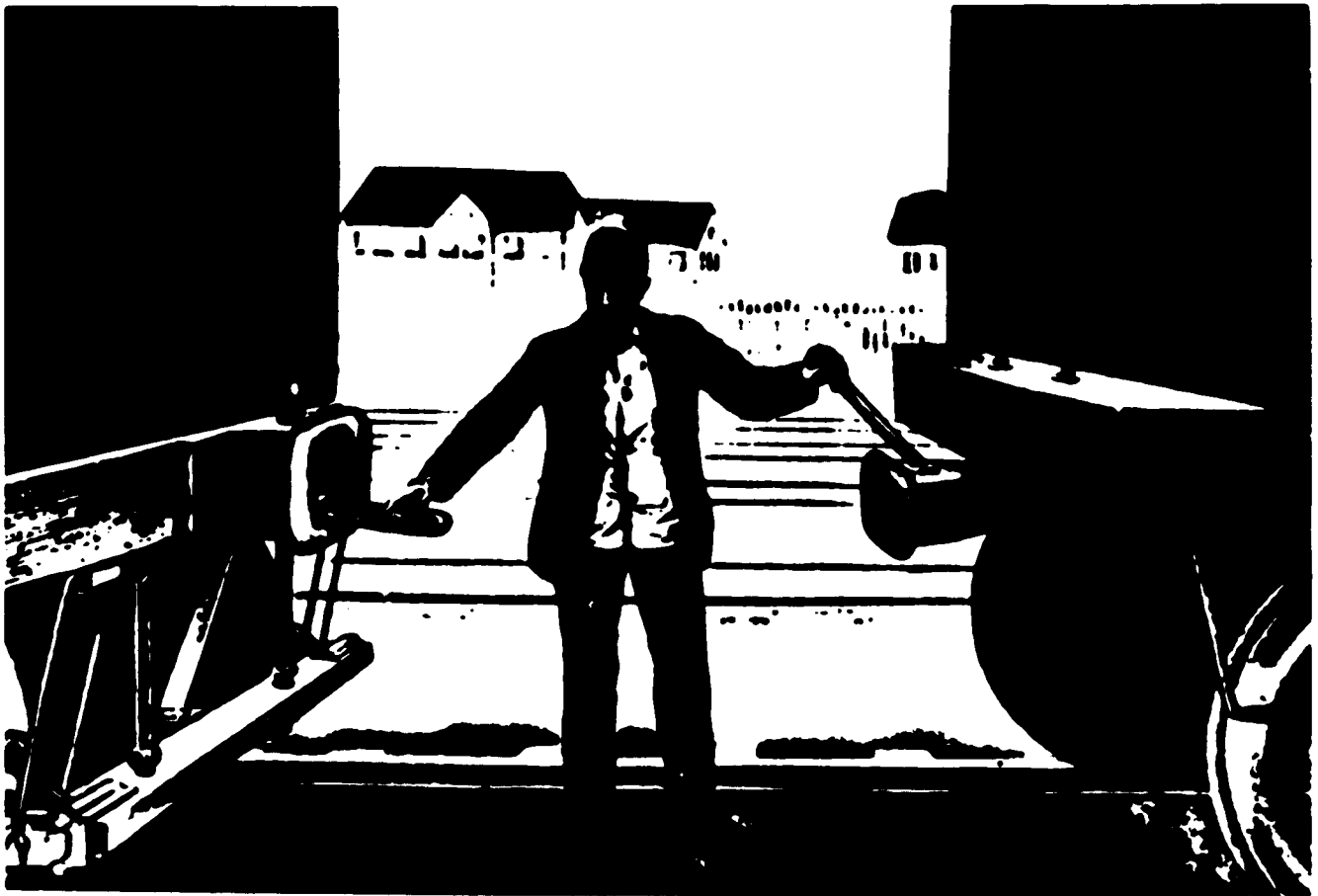
#### 1.2 BACKGROUND

In the early days of American railroading, freight, and

passenger cars were coupled together with links of chains. This coupler system had many drawbacks, and was replaced by a link and pin type coupler. The link and pin coupler was reasonably effective in holding cars together. However, to make up a train, it was necessary for the brakeman to stand between cars during coupling, guide the link into the socket, and then drop the pin that would hold the cars together. As a result, it was responsible for more deaths and injuries to railroad employees than any other single cause. (See Figure 1-1).

The need for an improved coupler system was apparent. In 1848, the filing of numerous coupler patents was begun by A. G. Heckrotte, although his device was not accepted. Twelve years later, D. A. Hopkins of Elmira, New York, patented a device that was tried for a short time by the Erie Railroad, but later abandoned as unsatisfactory. In 1863, Ezra Miller designed and built a coupler system called the "Miller Hook." This was hailed as the solution. Many roads experimented with it, but it, too, was rejected.

In 1868, a former Confederate officer, Major Eli Hamilton Janney, patented an automatic coupler. (See Figure 1-2). The Janney coupler is recognized as the direct ancestor of the present-day coupler. Coupling was accomplished by a movable knuckle which closed automatically upon car engagement. Uncoupling was accomplished by using a manually operated side lever. Coupler problems still prevailed, since repair and replacement of the Janney coupler was difficult, and miscoupling occurred frequently because of a limited gathering range. Gathering range is the amount of horizontal or vertical distance from the coupler center line within which the coupler will operate properly when coupling.



**FIGURE 1-1. LINK AND PIN COUPLER**

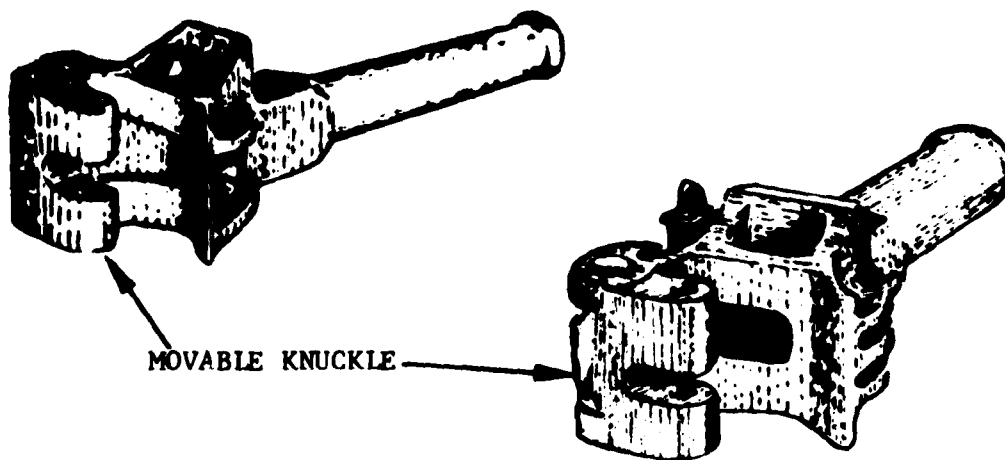


FIGURE 1-2. THE JANNEY COUPLER

Coupler problems such as free slack were determined to be related to application time and rate of buildup of the braking force in the train. Accordingly, automatic coupler development appears to parallel the development of the Westinghouse air brake (first applied for passenger service in a demonstration run in 1869) and the first patented automatic air brake in 1872.

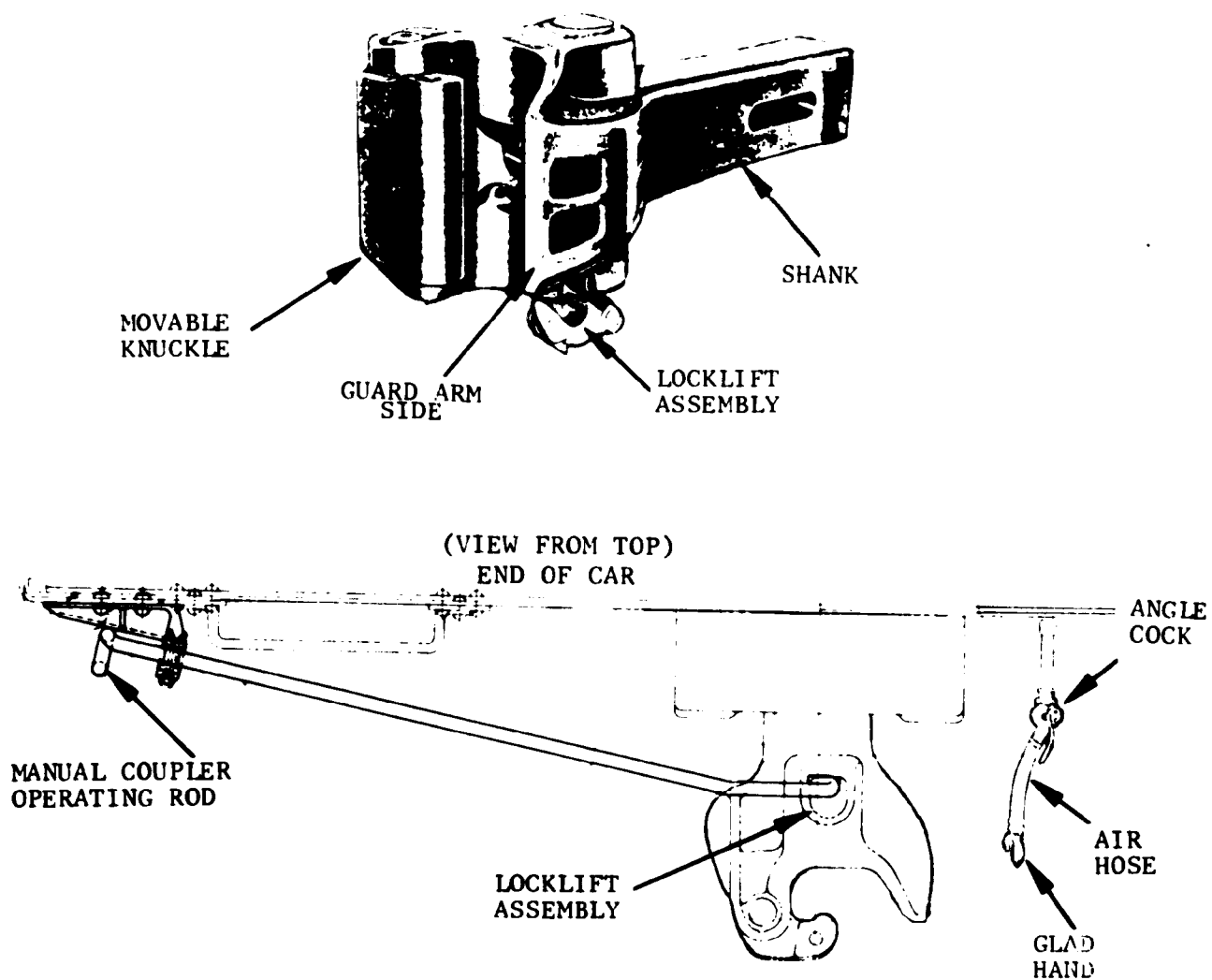
In 1877, the Pennsylvania Railroad tested the Janney coupler and adopted it as standard equipment. This same year marks the first recorded sale of automatic air brakes for freight service. After further exhaustive tests, the Master Car Builders Association, the predecessor to the AAR, adopted the automatic coupler in 1882.

Improvements in automatic coupler design have continued up to the present day. In 1916, an improved version of the Janney coupler known as Type "D" was adopted as the standard. The Type "D" coupler featured interchangeable parts which were produced by numerous manufacturers.

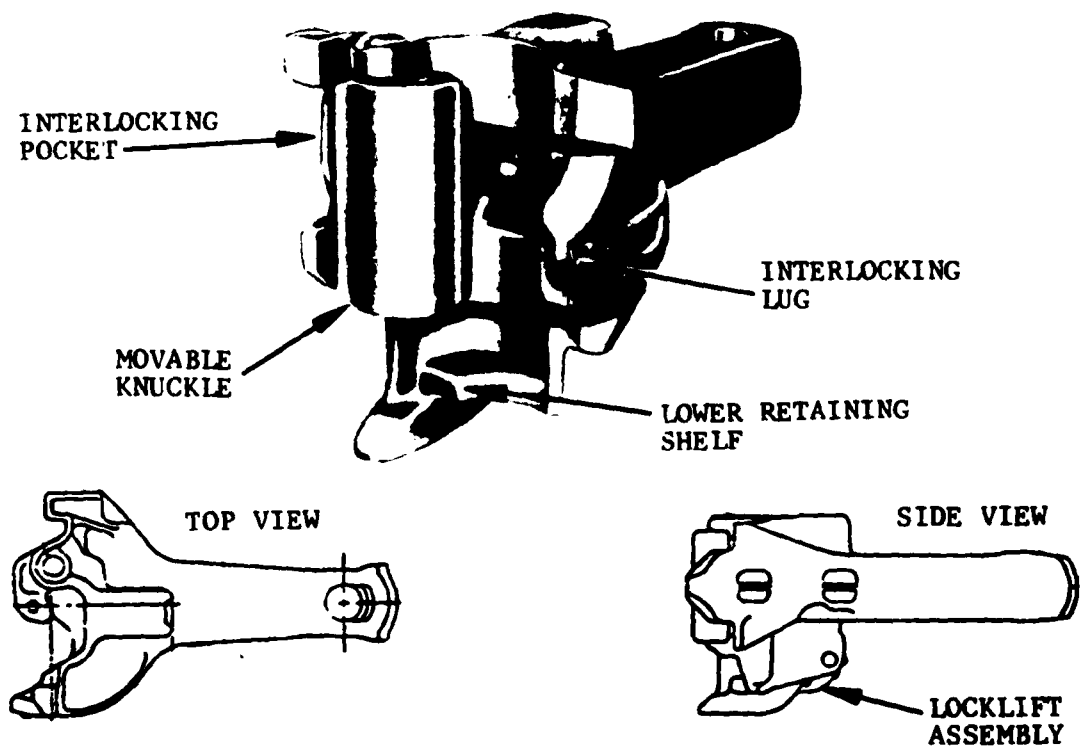
Today, probably the most common freight car coupler in use on U.S. and Canadian Railroads is the AAR Type "E" rigid shank coupler. (See Figure 1-3.) The Type "E" design, which evolved from the Type "D" standard, was adopted in 1931. It offered greater strength and was easier to operate than the Type "D." In 1968 the Type "D" was restricted from use on interchange cars.

The AAR Standard Type "E" coupler has interchangeable and standardized parts and offers greater strength than the Type "D" coupler. Still, there is excess free slack between mated couplers with approximately 25/32 inches for newly installed units. The lateral gathering range is approximately 4 inches total with both knuckles open, 2 inches with one knuckle open.

During the 1940's, at the request of the AAR Committee on Couplers and Draft Gears, a joint working committee was formed to develop a general purpose freight coupler to include several design advantages of the Standard Type "E" design. The new design, identified as the Alternate Standard "F" Interlocking Coupler, was adopted in 1954 (see Figure 1-4) and can be readily



**FIGURE 1-3. THE AAR STANDARD TYPE "E" COUPLER**



**FIGURE 1-4. THE AAR STANDARD TYPE "F" COUPLER**

distinguished from the Type "E" design by the cast wing pockets and interlocking lugs on the side and bottom of the coupler head. The advantages of the Type "F" coupler over the Standard "E" design include the following:

- 1) A 52 Percent Reduction of Free Slack Between Mating Couplers. The reduction of slack greatly improves train handling and reduces the probability of damage and run-in and run-out of slack in long trains.
- 2) Elimination of Vertical Slipovers. The interlocking lugs of the "F" coupler prevent relative vertical movement between the two mated couplers, thus keeping cars in alignment and preventing climbing or telescoping in the event of a derailment.
- 3) Wear Reduction. The virtual elimination of vertical movement between couplers, and the reduction of free slack between couplers, combine to reduce significantly the wear on mating surfaces of the coupler.
- 4) Protection in Case of Coupler Pull-Out. The interlocking feature of the coupler keeps a broken mating coupler from falling to the track and causing a derailment.
- 5) Better Distribution of Buff Loads. The alignment shoulders assist in keeping couplers centered and cars aligned under buff compressive forces.

The primary disadvantage of the "F" coupler is excessive shank failures occurring at the shank pin hole area. Compounding the problem is failure detection due to the need for complete dismantling from the suspension system prior to inspection. The "F" coupler unit cost is approximately 40 percent greater than that for the "E" primarily due to economies of scale. The lateral gathering range for the "F" is greater than for the "E", but it is still limited to approximately 5 inches with both couplers open.

Today, the type "F" coupler is used primarily on tank, extra long, and hazardous cargo freight cars - approximately 5 percent of all freight cars.

The present day mechanical coupler is often termed "automatic," meaning that the coupler automatically locks in the closed position when two cars being coupled are pushed together. However, for the coupling to be made at least one of the mating couplers must be in the open position, and the mating couplers must be laterally aligned with respect to each other so that the gathering range is not exceeded (normally 2 inches).

Problems encountered in present day coupling operations are primarily centered around the frequent situations in which the couplers do not "make," or couple, because their misalignment exceeds their effective gathering range. This occurs, for example, in gravity yard operations in which individual cars coast from the hump at relatively high rates of speed through one or more turnouts and impact with cars already humped and standing on the classification tracks. Because of vibration and lateral acceleration of the cars through the turnouts, couplers sometimes "slew" to one side and fail to have sufficient alignment upon impact with the standing cars. This situation is especially aggravated in poorly maintained classification yards in which the cars rock excessively from side to side as they approach impact, resulting in coupler bypasses.

The problems of coupling necessitate the expenditure of superfluous transportation labor costs. Strings of cars in classification yards must be physically "walked" and "made solid" before they can be pulled. After cars are coupled in industry and flat switching operations, they are normally "stretched" by the yard engine so that the crew is convinced that the couplings

are made on all cars, thereby avoiding "run-away" cars.

After cars are coupled for handling in linehaul trains, the air brake hoses must be connected manually. This requires a brakeman, switchman, or airman to go between cars, straddle one rail, and reach down below the mechanical couplers and connect the air brake hoses. This operation is both time-consuming and dangerous.

The mechanical uncoupling is achieved by a trainman who opens the closed or locked coupler by activating an "operating rod" which extends from the coupler across the face of the car to an outside corner of the car. Activation of the operating rod or uncoupling lever requires that the coupler be in compression in order for the coupler to unlock. Once the uncoupling lever is activated, it must be physically held in the uncoupling position by the trainman until the two cars physically separate. In hump yard operations a "pin puller" walks with the cars about to be uncoupled as they approach the crest of the hump (where they are in buff force), activates the uncoupling lever, and continues walking with the car holding the lever up until the lead car reaches the hump.

In a flat switching operation, the trainman must perform a similar sequence, only in this case the cars are "kicked" by the yard engine to speeds sufficient for the car to coast to the end of the classification tracks. It is not uncommon, therefore, to see a trainman activate the uncoupling lever when the switch engine accelerates the cut (coupler in buff), and run with the car until sufficient kick speed is attained. At this time the engineman applies the locomotive brakes, the slack runs out, and the uncoupled car separates from the cut. This process is repeated for each car classified, exposing the trainman to danger (especially when there is moisture on the ground), and the

freight cars and lading to damage due to the impact upon coupling.

Because the uncoupling levers are located on the right side of the car (as observed by standing in the center of the car and facing one end), and because the effective gathering range of couplers is increased if both mating couplers are in the open position, in flat switching yards the trainmen typically crosses over the track in front of the cut and operates the uncoupling lever with one hand and opens the knuckle with the other. When the coupler is positioned properly, he returns to the engineer's side to give hand signals to "kick" the car. While this procedure reduces the "make-solid" time, it is dangerous and time-consuming.

As the cars separate at uncoupling, the air brake hoses are placed in tension. The tension causes them to lift up, which in turn causes the "glad hand" (Figure 1-3) connections to angle sufficiently to separate. Thus, while the air hoses disconnect without manual activation, each uncoupling produces a tension strain on the air hoses and contributes to their eventual rupture. Ruptured air hoses on linehaul trains automatically cause an undesired emergency application of train brakes creating several slack action forces, and occasional derailments. Broken air hoses also create delays in road operations since the break must be located and repaired before the train can proceed.

Closely associated with the air brake hose is the air hose shut-off valve known as the "angle cock" (Figure 1-3). The angle cock is located at the top of the air hose alongside the mechanical coupler. Operating the angle cock requires the trainman to go between cars, straddle the rail, and reach over the

mechanical coupler to the angle cock. Again, this requirement is dangerous and time-consuming. The angle cock is activated during the coupling when the air valves are opened. The reverse applies during uncoupling.

In summary, the operation of the present-day coupler system is not, in reality, automatic. The mechanical coupling is "Automatic" if coupler alignment is within narrow limits, if at least one of the couplers is open, and if the cars impact at the proper speed and on tangent or only slightly curved track. Air brake hose and angle cock operations in coupling are completely manual.

Mechanical uncoupling is manual, as is the angle cock operation. While the air hose disconnection can be termed "automatic," it is accomplished in a manner which subjects the air hoses to high levels of tension and high probability of eventual failure. On any given uncoupling, the probability of hose damage is low.

Thus, the coupler engagement is automatic and the air hose connection is manual in the coupling operation. The present coupling system requires a combination of automatic and manual actions for proper operation:

- 1) Couplers must be aligned within a 2-inch gathering range.
- 2) At least one knuckle must be open.
- 3) Cars are moved together for mechanical coupling.
- 4) Cars are "stretched" to verify that coupling is made.
- 5) Air hoses are manually connected.
- 6) Air valves are opened as needed.

During uncoupling, coupler disengagement is manual and the air line disconnects automatically. Uncoupling requires that

several conditions be satisfied:

- 1) Cars are bunched (no slack).
- 2) Unlock coupler on at least one car.
- 3) Air valves are closed on each car.
- 4) Cars are moved apart to affect full uncoupling.
- 5) Air hoses are separated (automatic).

With slight modification to the coupler and air connection mechanisms, the basic freight car coupling operations have remained static since their inception - over one hundred years. It is not surprising that safety hazards, time loss, and damage are several problems still identified with present freight coupling systems.

### 1.3 SUMMARY

Safety problems remain a key issue - manual intervention is hazardous to the train crew during coupling, uncoupling, and switchyard operations. If couplers are misaligned by greater than the 2-inch gathering range, or if both knuckles are closed upon coupling, then the trainman must step between cars, risking injury. Similarly, air hose connection and valve adjustment always require that a trainman step between cars. In classification yards, the "pin pulling" operation involves a risk of falling near rolling freight cars.

Time losses occur in a multitude of ways. Manual connection of air hoses and operation of air valves slow the total coupling, uncoupling and switching operations. Hanging air hoses are vulnerable to damage and environmental conditions resulting in time loss during repair and replacement. Train inspection to verify couplings requires walking the length of

the train and reconnecting bypassed couplers. This imposes a further time constraint. In the event of damage due to coupler bypass, significant time is lost in car repair. Also cars can be damaged during coupling if the impact is too great or if the cars are not lined up at impact.

## **2. METHOD OF APPROACH**

### **2.1 GENERAL**

The study approach adopted to establish significant coupler concepts which would be used to formulate candidate coupling systems consisted of establishing basic assumptions, searching literature and patents, conducting railroad industry interviews, categorizing coupler concept data, and preparing abstracts and an indexed bibliography. Each of these tasks is explained below.

### **2.2 BASIC ASSUMPTIONS**

The definition of basis assumptions was fundamental to the advanced coupler concepts study:

- 1) Equipment will be limited to:
  - (a) Individual cars
  - (b) Mechanical and air connections
  - (c) Individual car air brakes as they affect coupling or uncoupling
- 2) Baseline coupling system for comparison purposes - AAR Type "E"
- 3) New concepts must consider possibility for:
  - (a) New car construction
  - (b) Retrofit on old cars
  - (c) Adaption of new components to fit basic system
  - (d) Trains with mixture of old and new couplers
- 4) New concepts should be restricted to those utilizing currently available technology. "Currently available technology" is understood to include recent coupler system designs regardless of availability, and these designs need not necessarily be dependent upon a breakthrough in basic technology.

## 2.3 LITERATURE SEARCH

The study team conducted an extensive search of published sources of advanced coupling concepts. This literature included railroad industry technical literature, trade publications, and journal articles extracted from 21 search topics needed to interrogate the information retrieval sources for information on railroad coupling. These search topics are given in Appendix D.1.1. In addition, specific product trade names such as Willison, Unicoupler, and Compatimatic were used for further interrogation cross-referencing.

A computer interrogation using these search topics was made from the six retrieval sources noted below:

- 1) RRIS - Railroad Research Information Service
- 2) NTIS - National Technical Information Service (Lockheed Aircraft)
- 3) ISMEC - Science abstracts, Mechanical Engineering and Engineering Management - Part of INSPEC (Lockheed Aircraft)
- 4) P-TRIS - Regional Transportation Research Information Service (Transportation Center Library of Northwestern University)
- 5) COMPENDEX - Engineering Index (Lockheed Aircraft)
- 6) TRIS - Transportation Research Information System (Battelle Automated Search Information System)

Citations were obtained for the indicated search topics from all of the six search sources noted above. These citations (or condensed abstracts) were reviewed to obtain specific references for potential coupling concepts. Complete reference documents were obtained for each of the references determined to be pertinent to the coupling study.

For some references it was necessary to obtain additional information through the DOT library or the Library of Congress. For a few references, a translation into English was required. These documents are located in Appendix E of this report.

Where sufficient technical information was not included in the reference document, it was necessary to initiate contacts with the author or his company to obtain full specification details necessary for the comparison of coupling concepts.

Literature obtained from North American and foreign industry suppliers and railroads consisted of sales literature, specification manuals, installation manuals, and blueprints.

#### 2.4 PATENT SEARCH

A patent search was conducted for the purpose of identifying major concepts which might have been patented but not yet developed into an actual coupling system. (Undeveloped but patented concepts would not necessarily be reviewed in the literature or discussed during visits to the manufacturers.)

The primary field of search was in the patent class 213 covering Railway Draft Appliances and subclasses within that class. Also, the most relevant secondary fields were searched, particularly class 105, covering Railway Rolling Stock, and within that subclasses 2, 3, and 4.

It was judged that a search of patents issued prior to 1960 would not be productive. Any significant concepts which had been developed prior to 1960 would have been improved upon since that time and thus would be covered with a search of patents

from 1964. This has proven true in two similar patent searches done recently.

It was also found in the patent search that the significant foreign concepts had all been patented in the United States, probably because it is a major railroad country. Thus, the search of the U.S. patents did, in fact, reveal patents secured by companies from foreign countries as well as patents of the U.S. companies.

A complete listing of all classes reviewed may be found in Appendix D.3.1 of this report.

## 2.5 COUPLER CONCEPTS

Significant coupling concepts were identified using all of these sources and were then categorized according to basic functional characteristics. See Appendix C.

## 2.6 ABSTRACTS

Literature sources and patents pertaining to significant concepts were abstracted. The abstracts are contained in Appendix B.

## 2.7 INDEXED BIBLIOGRAPHY

A detailed, indexed bibliography was compiled to record all literature reviewed in the study. This bibliography may be found in Appendix D.1.2.

## 2.8 RAILROAD INDUSTRY INTERVIEWS

The literature search provided the framework for defining the industry coupler-system suppliers and any other organizations, with research and development efforts directed toward significant advanced coupling concepts. Representatives of 17 manufacturers were contacted. Additionally, it was felt that coupler users - the railroads and transit system operators - could provide valuable insights relating to current products or products used during some phases of testing. Accordingly, interviews included discussions with eight rapid transit and railroad organizations.

Telephone contact was established with personnel in all organizations selected. The telephone contacts thus provided a mechanism for:

- 1) Clarification of information and addition of missing data not provided in the literature.
- 2) Identification of areas of potential improvement for present coupling systems.
- 3) Discussion of supplier developments not intended for general freight service which might have possible freight application.

### 3. SURVEY RESULTS

#### 3.1 CONCEPTS FOR COUPLER IMPROVEMENT

The potential list of possible improvements in the coupling interface between freight cars is virtually endless. A partial list of potential coupler improvements is included as follows:

- 1) Provide mechanical coupling of air lines automatically upon mechanical coupling of couplers.
- 2) Provide for the opening and closing of air passages as a result of mechanical coupling and uncoupling, while still maintaining the safety of emergency brake application when uncontrolled separation occurs.
- 3) Reduce or eliminate leakage of air at connections between cars.
- 4) Reduce air hose maintenance and wear rates.
- 5) Increase gathering range from the present 2 inches to reduce coupler bypasses.
- 6) Reduce and, if possible, eliminate free slack between couplers.
- 7) Provide means to keep knuckle open and ready for coupling, if knuckle type coupler is used.
- 8) Reduce contour angling to reduce jackknifing probability.
- 9) Provide a means of location control of couplers to reduce coupler bypasses.
- 10) Provide a means to prevent couplers from passing vertically.
- 11) Make certain that mechanical coupling will be completed regardless of minimum impact speed during coupling.
- 12) Provide for remote uncoupling whether on side of car, from remote position in-train, or from off-train.
- 13) Reduce wear and maintenance of coupler system

components.

14) Provide for an electrical train line for control or sensing to accomplish:

- (a) Continuous hot-box detection.
- (b) Derailment or wheel-off indication.
- (c) Provision for a second air line for retaining valve operation or for other use.
- (d) Automatic handbrake setting and release.
- (e) Remote uncoupling.
- (f) Electropneumatic braking.
- (g) Slave locomotive operation.
- (h) Direct communication to caboose.
- (i) Operation of unloading systems (remotely).
- (j) Draftgear lockout to reduce train action run-in and run-out.
- (k) Communication of wayside condition detector signals through train.

At the outset of the study, an attempt was made to eliminate those potential coupler improvements which were not considered germane to the scope of work of this contract. This was done in context with the task listings in the subject contract in conjunction with technical direction from DOT/TSC and members of the AAR Advanced Coupling Concepts Committee.

The survey was directed primarily at those concepts affecting the direct interface between adjacent cars. Concepts affecting an incidental interface (e.g., electric train lines within the car system) were specifically excluded. Consideration was given, however, to such items as control techniques to be used with electric train lines.

Many elements of freight car design are affected by the

coupler system. For advanced coupling systems as defined here, consideration was given only to those portions of the freight car system which are outward from the attachment point of the coupler shank to the yoke. Essentially, the advanced coupler system analysis did not include consideration for changes in yokes, draft gear and followers, center or side sills, cushion underframe devices, or portions of the braking system internal to the angle cock.

Similarly, detailed attention was not given to incidental items which are generally considered to be support items to the basic coupling system, or for internal incidental parts for improved performance of the coupler systems, which in and of themselves were not relevant to a basic change in coupler capability. These include such elements as support chain for the air hose, uncoupling levers, and changes in design or strength of internal parts within the coupler head such as knuckle pins.

### 3.2 CATEGORIZE CONCEPTS BY FUNCTIONAL CHARACTERISTICS

A review of the partial list of coupler improvements given above indicates a logical grouping of these concepts in terms of functional categories. These categories involve the impact of the concepts on improvements in the train air system, mechanical coupling and uncoupling, and general train control systems. Grouping of the salient concept ideas into these four functional categories is shown in Table 3-1.

It was then necessary to standardize the data to be obtained from each of the survey sources into a uniform format. A set of standard data sheets was established which included all of the information required to define the various concepts under each of the four mechanical operational categories and to include

TABLE 3-1. CATEGORIZATION OF FUNCTIONAL CHARACTERISTICS

| Mechanical Function                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Category                             | Improvement Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 1) Improve Train<br>Air Line System  | <ul style="list-style-type: none"> <li>(a) Automatic air line connection with coupling</li> <li>(b) Provide second air line system</li> <li>(c) Automatically open air valves upon coupling</li> <li>(d) Automatically close air valves upon intentional uncoupling</li> <li>(e) Automatically open air valves upon unintentional uncoupling</li> <li>(f) Improve integrity of air seal by lowering leak rates or gasket wear rates</li> <li>(g) Improve hose reliability regarding breakage, damage, or failure</li> <li>(h) Reduce hose and/or glad hand maintenance costs</li> </ul> |
| 2) Improve<br>Mechanical<br>Coupling | <ul style="list-style-type: none"> <li>(a) Improve lateral gathering range of mechanical coupling</li> <li>(b) Improve vertical gathering range of mechanical coupling</li> <li>(c) Provide positive locking of mated couplers</li> <li>(d) Increase speed range at which positive coupling can be made</li> <li>(e) Reduce free slack of mated couplers</li> <li>(f) Provide vertical interlock for mated couplers</li> </ul>                                                                                                                                                          |

TABLE 3-1. CATEGORIZATION OF FUNCTIONAL CHARACTERISTICS (CONT'D.)

| Mechanical Function<br>Category  | Improvement Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                  | <ul style="list-style-type: none"> <li>(g) Absolutely entrap broken coupler</li> <li>(h) Maintain position of coupler to center of car</li> <li>(i) Reduce contour angling capability of coupler</li> <li>(j) Maintain position of coupler to center of tracks</li> <li>(k) Reduce required coupler maintenance</li> </ul>                                                                                                                                                                                                                                                                            |
| 3) Improve Mechanical Uncoupling | <ul style="list-style-type: none"> <li>(a) Improve coupling capability through the use of an alternate side lever</li> <li>(b) Improve uncoupling capability through the use of a push button release on side of car</li> <li>(c) Provide means of automatically uncoupling from within train</li> <li>(d) Provide means of automatically uncoupling from point external to train</li> <li>(e) Provide means to uncouple in draft</li> <li>(f) Improve recoupling capability by automatically opening knuckle at uncoupling</li> <li>(g) Improve recoupling capability through other means</li> </ul> |
| 4) Improve General Systems       | <ul style="list-style-type: none"> <li>(a) Automatically control brake with time delay set provisions upon intentional uncoupling</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

TABLE 3-1. CATEGORIZATION OF FUNCTIONAL CHARACTERISTICS (CONT'D.)

Mechanical Function

| <u>Category</u> | <u>Improvement Concept</u>                                                              |
|-----------------|-----------------------------------------------------------------------------------------|
|                 | (b) Automatically control brake with emergency set upon unintentional uncoupling        |
|                 | (c) Provide electric train line system with automatic connection make and break         |
|                 | (d) Provide electric train line system with automatic sequencing of contractors         |
|                 | (e) Provide electric train line system with full environmental protection of contactors |
|                 | (f) Provide electric train line system having train sensing capabilities                |
|                 | (g) Provide electric train line system having train control capabilities                |
|                 | (h) Improve operational safety of coupler system                                        |

information on various related operational, safety and cost considerations. This set of data sheets was used to summarize the significant coupler concepts obtained from literature or patent searches and industry interviews. An example of the data sheet set is given in Appendix C.3. This example is completed with data obtained on one specific coupler concept and indicates the general level of detail which was available, also showing that detailed information was not available to answer some questions posed in the data sheets.

### 3.3 PRESENTATION OF DATA IN THE APPENDICES

Results of the survey are documented in the appendices of this report as follows:

- 1) Appendix A - Glossary of terms
- 2) Appendix B - Abstracts and patents
- 3) Appendix C - Significant coupler concepts
- 4) Appendix D - Bibliography
- 5) Appendix E - Translated documents
- 6) Appendix F - Report of inventions
- 7) Appendix G - Preliminary development specification for automatic train air line connector

Appendix A, glossary of terms, includes a standardized set of definitions for various coupling and railroad terms which appear frequently throughout the report. Most of these terms have the same general meaning throughout the railroad industry; however, some differ according to the geographic area in which the railroad operates. Thus, an attempt was made to standardize the meaning of the terms as indicated in this glossary.

Many different concepts were found during the various

elements of search and interview. Only those which were determined to have a potential for significant impact on the total coupling system were abstracted for highlighting in this report. Appendix B contains the abstracts of these significant concepts.

The survey data indicated a number of reports, patents, or interviews which related to the same basic coupling concept. In order to aid the reader of this report and, more particularly, to aid in later engineering program development, a complete cross-reference is given relating the primary bibliography number and the other bibliographies referencing the same basic concept. This cross-reference of bibliographies is given in Appendix C. Each concept is assigned the number of the primary bibliography reference. Whenever more than one concept is derived from a particular reference subsequent letters are added to the number (i.e., 6a, 6b, 6c).

In order to establish continuity among the several types of surveys, an assignment of primary bibliography numbers was given to each of the types of literature sources searched, each of the classes and subclasses of patents searched, and each of the railroad industry suppliers and users that were interviewed. This primary bibliography reference number assignment is given in Appendix D. The references are numbered as follows:

- 1) Literature - Appendix D.1 (1-465)
- 2) Interviews - Appendix D.2 (501-559)
- 3) Patents - Appendix D.3 (601 - 1221)

Appendix D.1.2, gives the individual bibliography reference information for all literature searches. The bibliography of railroad industry interviews, Appendix D.2, identifies the companies that provided interviews. Appendix D.3, gives reference information for each patent search.

From the literature search it was determined that several foreign language documents apparently had significant information concerning specific coupler concepts. Five such documents were set aside for separate translation after all recognized sources for previous translations had been exhausted. These five documents are listed in Appendix E.

### 3.4 SURVEY CONTENT

#### 3.4.1 Literature Search

A literature search or survey was performed to assess the state-of-the-art of coupling concepts together with the techniques for attachment of electric or pneumatic systems as part of the overall coupling system. Six of the search sources were associated with a computer memory and index system. These were: RRIS, NTIS, ISMEC, R-TRIS, Compendex, and TRIS. Of these, the RRIS search source was the most significant in terms of the depth of content and chronological time covered. The basic time frame covered by these railroad research and engineering index search sources was from 1958 through 1973. Salient bibliography references in some of these articles, however, covered reports and data from earlier periods.

Some of the reports and articles referenced the same basic concept but involved an analysis made under a different technical or time framework. A total of 52 significant coupling concepts were determined from the literature search. These have been abstracted and are included in Appendix B. Table 3-2 presents a quantitative summary of the literature search.

TABLE 3-2. SUMMARY OF LITERATURE SEARCH

| <u>Search Source</u>                        | <u>Citations<br/>Reviewed</u> | <u>Individual<br/>Reports or<br/>Articles<br/>Reviewed</u> | <u>Abstracted<br/>For a Signifi-<br/>cant Coupling<br/>Concept</u> |
|---------------------------------------------|-------------------------------|------------------------------------------------------------|--------------------------------------------------------------------|
| RRIS                                        | 155                           | 55                                                         | 19                                                                 |
| NTIS                                        | 12                            | 4                                                          | 1                                                                  |
| ISMEC                                       | 14                            | 5                                                          | 0                                                                  |
| R-TRIS                                      | 74                            | 23                                                         | 7                                                                  |
| COMPENDEX                                   | 17                            | 17                                                         | 1                                                                  |
| TRIS                                        | 7                             | 17                                                         | 1                                                                  |
| AAR Manual                                  | 3                             | 3                                                          | 0                                                                  |
| AAR Specification                           | 4                             | 4                                                          | 0                                                                  |
| AAR Yearbook                                | 1                             | 1                                                          | 0                                                                  |
| DOT Standard                                | 1                             | 1                                                          | 0                                                                  |
| Car Cyclopedia                              | 1                             | 1                                                          | 0                                                                  |
| UIC Specification                           | 1                             | 1                                                          | 0                                                                  |
| Bureau of Mines<br>Reports                  | 3                             | 3                                                          | 0                                                                  |
| Railroad Industry<br>Technical Publications | 8                             | 8                                                          | 3                                                                  |
| ORE Reports                                 | <u>6</u>                      | <u>6</u>                                                   | <u>0</u>                                                           |
| <b>Total</b>                                | <b>307</b>                    | <b>138</b>                                                 | <b>31</b>                                                          |

### 3.4.2 Patent Search

The primary patent class for couplers is class 213, defined as Railway Draft Appliances. Within this class, it is interesting to note that the patents granted since 1960 represent only an average of 12 patents per year and represent 3.5 percent of the total patents on couplers which have been granted. In addition, it is noted that of the limited number of patents granted since 1960, most of them cover only nominal changes to a portion of the coupling system (e.g., uncoupling linkage) which are not really significant in terms of new coupling concepts. Entire coupling systems per se are not patentable; only those individual concepts which make up the system can be patented.

Listed in Table 3-3 is a summary of patent searches which shows the class and subclasses which were reviewed, together with the number of patents which were reviewed and those within each subclass containing a significant coupling concept.

It should be noted that the majority of the patents referred to concepts also covered by bibliography references in the literature search or railroad industry interviews. These concepts, although significant in themselves, are not listed as a separate significant coupling concept but have been included under a separate primary bibliography and are shown in the cross-reference of bibliographies in Appendix B.

TABLE 3-3. SUMMARY OF PATENT SEARCH

| <u>Patent Reference</u> |                 | <u>Number of<br/>Patents Searched</u> | <u>Abstracted For<br/>a Significant<br/>Coupling Concept</u> |
|-------------------------|-----------------|---------------------------------------|--------------------------------------------------------------|
| <u>Class</u>            | <u>Subclass</u> |                                       |                                                              |
| 46                      | 241             | 1                                     |                                                              |
| 74                      | 527             | 1                                     |                                                              |
| 104                     | 26R             | 1                                     |                                                              |
| 104                     | 172             | 1                                     |                                                              |
| 105                     | 3               | 4                                     | 1                                                            |
| 105                     | 4               | 14                                    |                                                              |
| 213                     | 1.3             | 13                                    | 5                                                            |
| 213                     | 1.6             | 2                                     |                                                              |
| 213                     | 8               | 1                                     |                                                              |
| 213                     | 15              | 12                                    | 2                                                            |
| 213                     | 63              | 1                                     |                                                              |
| 213                     | 72              | 5                                     |                                                              |
| 213                     | 75              | 3                                     | 1                                                            |
| 213                     | 75D             | 1                                     | 1                                                            |
| 213                     | 75TC            | 1                                     | 1                                                            |
| 213                     | 76              | 17                                    | 9                                                            |
| 213                     | 100             | 24                                    | 3                                                            |
| 213                     | 103             | 1                                     | 1                                                            |
| 213                     | 104             | 1                                     |                                                              |
| 213                     | 110             | 4                                     | 1                                                            |
| 213                     | 111             | 1                                     |                                                              |
| 213                     | 112             | 6                                     |                                                              |
| 213                     | 127             | 1                                     |                                                              |
| 213                     | 133             | 1                                     |                                                              |
| 213                     | 142             | 1                                     |                                                              |
| 213                     | 144             | 1                                     |                                                              |
| 213                     | 145             | 1                                     |                                                              |

TABLE 3-3. SUMMARY OF PATENT SEARCH (CONT'D.)

| <u>Patent References</u> |                 | <u>Number of<br/>Patents Searched</u> | <u>Abstracted For<br/>a Significant<br/>Coupling Concept</u> |
|--------------------------|-----------------|---------------------------------------|--------------------------------------------------------------|
| <u>Class</u>             | <u>Subclass</u> |                                       |                                                              |
| 213                      | 147             | 2                                     |                                                              |
| 213                      | 148             | 1                                     |                                                              |
| 213                      | 151             | 6                                     | 4                                                            |
| 213                      | 152             | 3                                     | 2                                                            |
| 213                      | 153             | 4                                     | 3                                                            |
| 213                      | 154             | 1                                     |                                                              |
| 213                      | 158             | 2                                     |                                                              |
| 213                      | 159             | 5                                     | 2                                                            |
| 213                      | 162             | 5                                     |                                                              |
| 213                      | 166             | 22                                    | 1                                                            |
| 213                      | 167             | 2                                     |                                                              |
| 213                      | 168             | 2                                     |                                                              |
| 213                      | 211             | 9                                     | 1                                                            |
| 213                      | 212             | 7                                     | 5                                                            |
| 213                      | 217             | 1                                     |                                                              |
| 213                      | 219             | 5                                     | 2                                                            |
| 285                      | 12              | 2                                     |                                                              |
| 339                      | 15              | 1                                     |                                                              |
| 339                      | 48              | 1                                     | 1                                                            |
|                          |                 | —                                     | —                                                            |
| <b>Total</b>             |                 | <b><u>201</u></b>                     | <b><u>46</u></b>                                             |

### 3.4.3 Industry Interviews

During the initial search effort involving both literature and patents, it was determined that specific quantitative details were frequently not present in the supporting data included with the technical document. In general, the technical discussion concerning the coupling concept would describe only the qualitative merits of the concept without giving adequate technical information for a quantitative measure of the value of the concept. Moreover, in the case of some of the literature search documents, it was necessary to separate out the rhetoric of salesmanship, which in some cases described the capabilities of the concept in terms beyond that which seems technically feasible. From these earlier searches it was determined that first-hand interviews were required in order to obtain the necessary quantitative data needed to evaluate most of the concepts. Thus the industry interviews became a more important part of the overall survey than was originally anticipated.

In the case of concepts with a foreign origin (excluding Canadian), it was not deemed appropriate or necessary to schedule personal interviews. The reasons for this decision were:

- 1) There was a greater abundance of detailed technical literature of European concepts than on those in the United States.
- 2) European development efforts have been directed for the past 25 years at development of coupler systems which would meet the UIC synthesis design for a universally applicable coupler system. Thus the European design concepts centered on the attainment of a single coupling goal and therefore tended to overlap in technical approach.
- 3) The primary U.S. railroad suppliers are involved

through subsidiary or consortium contacts with the major design efforts in Europe.

The complete bibliography of railroad listing interviews is given in Appendix D.2. As was the case with the patent search activities, a great many of the coupling concepts uncovered during industry interviews, although significant, were included in other significant concepts listed under literature search primary bibliography numbers. The following is a list of industries interviewed.

- 1) American Steel Foundries
- 2) National Castings Division, Midland-Ross Corporation
- 3) Ohio Brass Corporation
- 4) General Foods Corporation
- 5) Canadian Steel Foundries
- 6) Hawker Siddeley Canada Ltd.
- 7) Stanray Corporation
- 8) Holland Company
- 9) McConway and Torley Corporation
- 10) Buckeye Steel Castings
- 11) Westinghouse Air Brake Division, WABCO
- 12) Evans Products Company
- 13) Dominion Foundries and Steel Limited
- 14) New York Air Brake Company
- 15) Freight Master
- 16) Walton Products
- 17) Dresser Transportation Equipment Division,  
Dresser Industries, Inc.
- 18) San Francisco Bay Area Rapid Transit System
- 19) Cleveland Transit System
- 20) Southern Railway
- 21) New York City Transit Authority
- 22) Chicago Transit Authority

- 23) Atchinson, Topeka and Santa Fe Railway Company
- 24) Washington Metropolitan Transit Authority
- 25) Canadian National Railways

### 3.5 SIGNIFICANT CONCEPTS

As a result of the literature and patent searches and the industry interviews, 108 separate significant coupler concepts were identified. A listing of the significant concepts and identification of the mechanical function category impacted by each concept is given in Table 3-4. A more detailed listing of concepts (categorized by impact on functional characteristics) is given in Appendix C.

### 3.6 CONCLUSIONS

Several specific conclusions can be drawn from a review of the technical data obtained in the survey:

- 1) In the United States, development efforts leading to patent application or published technical data on new concepts has been diminishing over the last 15 years as compared to previous times.
- 2) The decrease in U.S. development efforts has coincided with the decreasing usage and profitability of the American railroads.
- 3) In general, recent significant technical advancements have been patented. However, the necessary development work required for product marketing has been set aside, primarily as a result of an uncertain market for new concepts.

TABLE 3-4.--SUMMARY OF SIGNIFICANT COUPLER CONCEPTS

| CONCEPT NUMBER | CONCEPT IDENTIFICATION                                                 | MECHANICAL FUNCTION CATEGORY                |                                         |                                            |                                     |
|----------------|------------------------------------------------------------------------|---------------------------------------------|-----------------------------------------|--------------------------------------------|-------------------------------------|
|                |                                                                        | I<br>IMPROVE<br>TRAIN<br>AIR LINE<br>SYSTEM | II<br>IMPROVE<br>MECHANICAL<br>COUPLING | III<br>IMPROVE<br>MECHANICAL<br>UNCOUPLING | IV<br>IMPROVE<br>GENERAL<br>SYSTEMS |
| 6a             | Grimeshorpe ASF/V Coupler                                              |                                             |                                         |                                            |                                     |
| 6b             | Gresham and Craven Air Connector                                       | X                                           | X                                       | X                                          | X                                   |
| 8              | S-W Coupler Positioning Device (Mechanical Linkage, for Existing Cars) |                                             |                                         |                                            |                                     |
| 9              | S-W800 Coupler                                                         | X                                           | X                                       | X                                          | X                                   |
| 22             | Dresser Automatic/Pneumatic Coupling System                            |                                             |                                         |                                            |                                     |
| 25             | S-W "LC" Coupler                                                       | X                                           | X                                       | X                                          | X                                   |
| 26             | Controlled Swivel "G" Coupler                                          |                                             |                                         |                                            |                                     |
| 27             | Dresser Rapid Transit Coupler                                          | X                                           | X                                       | X                                          | X                                   |
| 31a            | S-W Positioning Device (Hydraulic Master-Slave, for Existing Cars)     |                                             |                                         |                                            |                                     |
| 31b            | S-W Positioning Device (Hydraulic Guided, for New Construction)        |                                             | X                                       |                                            | X                                   |
| 33             | Eurocoupler 68                                                         | X                                           | X                                       | X                                          | X                                   |
| 36             | British Wedglock Coupler                                               | X                                           | X                                       | X                                          | X                                   |
| 41a            | Holland Positioner Device                                              |                                             |                                         |                                            |                                     |
| 41b            | Evans Centering Device                                                 |                                             |                                         |                                            |                                     |
| 41c            | Evans Positioning Device                                               |                                             |                                         |                                            |                                     |
| 41d            | Stanray Centering Devices:                                             |                                             |                                         |                                            |                                     |
| 41e            | Coil Spring Type                                                       |                                             | X                                       |                                            |                                     |
| 41f            | Double Leaf Spring Type                                                |                                             | X                                       |                                            |                                     |
| 41g            | Double Coil Spring Type                                                |                                             | X                                       |                                            |                                     |
| 41h            | Swing Type                                                             |                                             | X                                       |                                            |                                     |
| 45a            | SWCP Double-Lip Seal Air Connector                                     | X                                           |                                         |                                            | X                                   |
| 45b            | SWCP Vacuum Brake Bleed System                                         |                                             |                                         |                                            | X                                   |
| 45c            | Khoeps Electric Connector                                              |                                             |                                         |                                            |                                     |
| 47a            | Simplified U.I.C. Coupler (French)                                     |                                             | X                                       | X                                          |                                     |
| 47b            | Pendulum Self-Centering System                                         |                                             | X                                       | X                                          |                                     |
| 52             | Type "G" Coupler with Top Shelf                                        |                                             | X                                       | X                                          |                                     |
| 54             | Type "G" Coupler with Top and Bottom Shelf                             |                                             | X                                       | X                                          |                                     |
| 254            | Walton "Electro-Pneumatic" Control System                              | X                                           |                                         |                                            |                                     |
| 301a           | Willison Type II (U.I.C.) Coupler                                      |                                             | X                                       | X                                          |                                     |
| 301b           | Scharfenberg Kupplung                                                  |                                             | X                                       | X                                          |                                     |
| 306            | Freightmaster Positioning Device                                       |                                             | X                                       | X                                          |                                     |
| 309            | Unicoupler (U.I.C.) Coupler                                            |                                             | X                                       | X                                          |                                     |
| 318            | ONE II Cross-Beam Centering Device                                     | X                                           | X                                       | X                                          |                                     |
| 387            | German U.I.C. Electrical Control                                       |                                             | X                                       | X                                          |                                     |
| 391            | Osaka Coupler System                                                   |                                             | X                                       | X                                          |                                     |
| 428a           | Standard AAR "H" Tightlock Coupler                                     | X                                           | X                                       | X                                          | X                                   |
| 428b           | Standard AAR "F" Interlocking Coupler                                  |                                             | X                                       | X                                          | X                                   |

TABLE 3-4.--SUMMARY OF SIGNIFICANT COUPLER CONCEPTS (CONTINUED)

| CONCEPT NUMBER | CONCEPT IDENTIFICATION                        | MECHANICAL FUNCTION CATEGORY       |                                         |                                            |                                     |
|----------------|-----------------------------------------------|------------------------------------|-----------------------------------------|--------------------------------------------|-------------------------------------|
|                |                                               | I<br>IMPROVE<br>AIR LINE<br>SYSTEM | II<br>IMPROVE<br>MECHANICAL<br>COUPLING | III<br>IMPROVE<br>MECHANICAL<br>UNCOUPLING | IV<br>IMPROVE<br>GENERAL<br>SYSTEMS |
| 434a           | Cobb "Horn-Funnel" Air Connector              | X                                  |                                         |                                            | X                                   |
| 434b           | Francis "Cone-Ring" Air Connector             | X                                  |                                         |                                            | X                                   |
| 448a           | Ohio Brass Form 8 Coupler                     |                                    | X                                       |                                            |                                     |
| 448b           | Ohio Brass Form 9 Coupler                     |                                    |                                         |                                            |                                     |
| 449            | Alternator-Battery Electrical Power System    |                                    |                                         |                                            |                                     |
| 450a           | Ohio Brass Form 8A Coupler and Control System |                                    |                                         | X                                          | X                                   |
| 450b           | Microwave Transmission Control System         |                                    |                                         | X                                          | X                                   |
| 451a           | National "Ball-Funnel" Air Connector          |                                    |                                         |                                            |                                     |
| 451b           | Robinson "Pin-Funnel" Air Connector           | X                                  |                                         |                                            | X                                   |
| 451c           | Roberts "Spread-Wing" Air Connector           | X                                  |                                         |                                            | X                                   |
| 451d           | Johnson "Scoop-Knob" Air Connector            | X                                  |                                         |                                            | X                                   |
| 451e           | Comptimatic* "Spread-Wing" Air Connector      | X                                  |                                         |                                            | X                                   |
| 451f           | American "Horn-Funnel" Air Connector          | X                                  |                                         |                                            | X                                   |
| 452            | Dresser "ESACS" Control System                |                                    |                                         |                                            |                                     |
| 457            | Dowty Automatic Central Coupler               |                                    |                                         |                                            |                                     |
| 458            | Robinson "Spread-Wing" Air Connector          | X                                  | X                                       |                                            | X                                   |
| 501            | A.S.F. Coupler Knuckle Contour Change         | X                                  | X                                       |                                            | X                                   |
| 502a           | National Castings I.G.R. Coupler Knuckle      | X                                  | X                                       |                                            | X                                   |
| 502b           | National Castings "Comptimatic" Coupler       | X                                  | X                                       |                                            | X                                   |
| 502c           | National Castings Air/Electrical Connector    |                                    |                                         | X                                          | X                                   |
| 502d           | Willison Mine Car Coupler                     | X                                  |                                         |                                            | X                                   |
| 503a           | Ohio Brass Form 70 Coupler and Control System |                                    | X                                       |                                            | X                                   |
| 503b           | Ohio Brass Form 29 Coupler System             | X                                  | X                                       |                                            | X                                   |
| 503c           | Ohio Brass Form 73 Coupler System             |                                    | X                                       |                                            | X                                   |
| 503d           | Ohio Brass Form 5 Coupler System              |                                    | X                                       |                                            | X                                   |
| 511a           | WABCO M-2 Mass Transit Coupler System         |                                    | X                                       |                                            | X                                   |
| 511b           | WABCO Train Air Line Connector                | X                                  |                                         |                                            | X                                   |
| 511c           | WABCO Train Line Electrical Connector         | X                                  |                                         |                                            | X                                   |
| 516a           | Walton Automatic Coupler                      |                                    |                                         | X                                          | X                                   |
| 516b           | Walton Electrical Control Box Systems         | X                                  | X                                       |                                            | X                                   |
| 601            | Campagna - Electrical Connector               |                                    |                                         |                                            |                                     |
| 603            | Automatic Service Line Connector              | X                                  |                                         |                                            | X                                   |
| 605            | Automatic Trainline Connector                 |                                    |                                         |                                            | X                                   |
| 606            | Dresser Electric Coupler                      |                                    |                                         |                                            |                                     |
| 610            | Midland Ross Retractable Trainline Connector  | X                                  |                                         |                                            | X                                   |
| 611            | Midland Ross Retractable Trainline Connector  | X                                  |                                         |                                            | X                                   |
| 650            | Automatic Uncoupling Recoiling Mechanism      | X                                  |                                         |                                            | X                                   |
| 670            | Westinghouse Automatic Hose Connector         | X                                  |                                         | X                                          | X                                   |
| 671            | ACF Trainline Valve Means                     | X                                  |                                         |                                            | X                                   |
| 672            | Automatic Air Coupling Structure              | X                                  |                                         |                                            | X                                   |

Note: (\*) Developed by National Castings Division, Midland Ross Corporation.

TABLE 3-4.-SUMMARY OF SIGNIFICANT COUPLER CONCEPTS (CONTINUED)

| CONCEPT NUMBER | CONCEPT IDENTIFICATION                              | MECHANICAL FUNCTION CATEGORY                |                                         |                                            |                                     |
|----------------|-----------------------------------------------------|---------------------------------------------|-----------------------------------------|--------------------------------------------|-------------------------------------|
|                |                                                     | I<br>IMPROVE<br>TRAIN<br>AIR LINE<br>SYSTEM | II<br>IMPROVE<br>MECHANICAL<br>COUPLING | III<br>IMPROVE<br>MECHANICAL<br>UNCOUPLING | IV<br>IMPROVE<br>GENERAL<br>SYSTEMS |
| 674            | Dresser Coupling Valve Actuator                     |                                             |                                         |                                            |                                     |
| 676            | Automatic Coupling System for Freight Cars          |                                             |                                         | X                                          |                                     |
| 678            | Dresser Automatic Pneumatic Coupling System         |                                             |                                         |                                            |                                     |
| 680            | Midland-Ross Trainline Connector                    |                                             |                                         | X                                          |                                     |
| 682            | Dresser Brake Line Coupler                          |                                             |                                         |                                            |                                     |
| 686            | Armsted Automatic Air Line Connector                | X                                           |                                         |                                            |                                     |
| 702            | Armsted Railway Coupler                             | X                                           |                                         |                                            |                                     |
| 703            | Indian Automatic Coupler                            | X                                           |                                         |                                            |                                     |
| 705            | Midland Ross Automatic Coupler                      |                                             | X                                       |                                            | X                                   |
| 740            | Armsted Ross Railway Coupler                        |                                             | X                                       |                                            |                                     |
| 760            | Midland Ross Car Coupler                            |                                             | X                                       |                                            |                                     |
| 761            | Midland Ross Car Coupler                            |                                             |                                         | X                                          |                                     |
| 890            | Armsted Knuckle Structure                           |                                             |                                         | X                                          |                                     |
| 891            | Armsted Knuckle Structure                           |                                             | X                                       |                                            |                                     |
| 892            | Midland Ross Knuckle Contour                        |                                             | X                                       |                                            |                                     |
| 895            | Midland Ross Knuckle Contour                        |                                             | X                                       |                                            |                                     |
| 900            | Midland Ross Coupler Shelf                          |                                             | X                                       |                                            |                                     |
| 901            | Coupler Knuckle                                     |                                             | X                                       |                                            |                                     |
| 910            | Interlocking Coupler                                |                                             |                                         |                                            |                                     |
| 912            | Midland Ross "P" Coupler Hood                       |                                             | X                                       |                                            |                                     |
| 913            | Armsted Interlocking Coupler                        |                                             | X                                       |                                            |                                     |
| 940            | Southern Pacific Brush Uncoupler                    |                                             | X                                       |                                            |                                     |
| 943            | Dresser Fluid Uncoupling Mechanism                  |                                             |                                         | X                                          |                                     |
| 960            | Holland Uncoupling Lever                            |                                             | X                                       |                                            |                                     |
| 1020           | Japanese Robot Uncoupler                            |                                             |                                         | X                                          |                                     |
| 1043           | Nippon Automatic Release                            |                                             |                                         | X                                          |                                     |
| 1044           | Nippon Car Disconnecter                             |                                             |                                         | X                                          |                                     |
| 1045           | Hines Remote Control Uncoupler                      |                                             |                                         | X                                          |                                     |
| 1046           | Syngton Fluid Operated Uncoupler                    |                                             |                                         | X                                          |                                     |
| 1061           | Keystone Uncoupling Mechanism                       |                                             |                                         | X                                          |                                     |
| 1063           | Railway Car and Coupling Device                     |                                             |                                         | X                                          |                                     |
| 1070           | Spanish Wheel Guidance Actuating Device             |                                             |                                         | X                                          |                                     |
| 1100           | Coupler-Positioning Device for Railway Car-Couplers |                                             | X                                       |                                            |                                     |
| 1101           | Coupler-Positioning Device for Sliding Sill         |                                             |                                         | X                                          |                                     |
|                | Cushioned Underframe Cars                           |                                             |                                         |                                            |                                     |
| 1140           | Bissett Magnetic Coupler                            |                                             |                                         |                                            | X                                   |
| 1150           | Southern Pacific Coupler Opener                     |                                             |                                         |                                            |                                     |
| 1160           | Electrical Circuit Control Apparatus                |                                             |                                         |                                            |                                     |
| 1190           | Keystone Coupler Centering Draft Gear               |                                             |                                         |                                            |                                     |
| 1200           | MABCO Hose Connector                                |                                             |                                         |                                            |                                     |

4) The interviews indicate that no recognized industry supplier is working on any revolutionary new concepts.

5) Significant development effort has been applied in Europe over the last 25 years for the development of a standard coupler to meet the requirements of the UIC Synthesis coupler standards.

6) A great deal of the European development effort has been aimed at developing transitional components needed for "mixed" couplers of the old hook and screw type as they would mate the new UIC Synthesis couplers.

7) Most of the European coupler effort has been aimed at modifications of the basic Willison coupler design, a rigid-knuckle type.

8) Most of the European development work for air or electrical connectors has been associated with their use as an integral part of the final rigid coupler design. This differs from the U.S. developments in this area, which have been concentrated in the area of separate air connection devices.

A sufficient number of new coupler concepts has been uncovered to derive coupling systems which represent a significant improvement over the present system.

#### 4. OPERATIONAL CHARACTERISTICS OF CONCEPTS

##### 4.1 DESCRIPTION AND EVALUATION OF SIGNIFICANT COUPLER CONCEPTS

Each of the significant coupler concepts listed in Table 3-4 were subjected to a detailed evaluation. This evaluation was based upon the primary bibliography reference to the concept and, in addition, the secondary or other bibliography references including information on this same concept.

A detailed data sheet was established to show both the description of the system and an evaluation of the significant coupler concepts included in the basic system. These data sheets are shown in Appendix C.3 of this volume. These evaluation data sheets included a brief description of the basic concept, an indication of compatibility with the basic AAR type "E" coupler system, related bibliography reference numbers, and an engineering evaluation of the concept as related to each of the previously defined operational characteristic categories. In the evaluation section for each category a check was made of each of the pertinent functional characteristics impacted within that category by the concept. Appendix C.1 defines the functional characteristics by category. In this evaluation, wherever there appears a potential operating or safety problem inherent in the concept, the evaluation comment is preceded by a double asterisk (\*\*).

An explanatory note is in order concerning the compatibility of each concept with the AAR Type "E" system. It is recognized that every coupling system concept could be made to "fit" into a Type "E" system by the use of an adapter system. From this viewpoint, each concept is "compatible." For this study, however, four levels of compatibility are defined as follows.

- 1) Can be added to Type "E" - results in a separate attached unit (like an air connector)
- 2) Modification of Type "E" - requires a change to the coupler which does not interfere with mating with regular "E" units.
- 3) Requires head adapter for Type "E" - A different type or style of coupler which would require an adapter system to couple with an "E" unit.
- 4) Incompatible with Type "E" - A totally different coupling system requiring a complete adapter system to couple with an "E" unit.

#### 4.2 ENGINEERING EVALUATION OF OPERATIONAL CHARACTERISTICS OF ALTERNATIVE CONCEPTS

As the next step in the assessment of the coupling concepts, the evaluation data noted above were subjected to an engineering review to define the effects of the concepts on operational characteristics. These effects were then analyzed in terms of impact of the functional characteristics upon the separate system categories previously established. This engineering review and analysis is summarized below.

##### 4.2.1 Train Airline System (Category I)

It is desirable to have a system which provides an automatic air-tight connection between adjacent cars coincident with the mechanical coupling process. The system should be adequately mounted to be able to withstand the abuse that occurs in rail freight service. In addition, it is desired that the air connection system automatically operate the train air valves to provide

continuity of the air line system at coupling. The system should apply emergency brakes during any unintentional uncoupling while maintaining control of braking during intentional uncoupling.

#### 4.2.1.1 Air Connector (Add-On Unit)

1) Location: Because of the requirement for coupling on curves, it was determined that air connectors located at any point lateral to the center line of the coupler were subject to potential malfunctions resulting from damage as a result of a coupling bypass.

Positioning the air connector above the coupler head is not deemed to be a feasible alternative. In piggyback applications, it is an operational requirement in circus loading that trailers be driven horizontally from the top of one flatcar to the next. This requires a dock plate or other platform to be laid across the top sills of adjacent cars. Although the wheels of the trailers will straddle the area immediately above the coupler head, there is potential for trailer parts or pieces to extend very close to the bottom of the trailer. Railroad operating personnel have neither control nor advance knowledge of devices hanging down beneath the trailers. Any external air connector mounted above the coupler head would thus be in jeopardy of damage during such trailer loading operations. Since piggyback operations are expected to be an increasingly important segment of rail freight cargo, any attached air connector unit should be located below the coupler head.

A lower suspended unit does present problems. In this position, the air connector will be subject to an excessive

amount of dust, dirt, or other material emanating from the roadbed between the tracks. The air connectors must therefore be designed to be free of close-tolerance or sliding components which would have a tendency to bind or seize as a result of a buildup of this road grime.

2) Mounting: There are three optional methods for mounting or attaching the air connector: direct attachment of the connector to the coupler head; attachment of the connector to the end of the car body, cantilevered for total self support; or attachment of the connector by means of an attachment to the coupler head.

The second alternate design is not found to be feasible because of problems of extreme weight and potential harmonic vibration damage to the air connector. Either of the other two methods of support seem feasible.

In general, a coupler-supported air connector should weigh less and be shorter than an air connector supported by the end of the car and guided by the coupler.

Designs of both types have been proven to work acceptably. As a general rule, however, good cost-effective design engineering dictates the use of the lighter, simpler coupler-head-attached system.

The design of the connector attachment and support system must be such that no pulling pressure is applied to the air connection hose system as a result of vibration or oscillations of the coupled units. In addition, the design of the mounting brackets must allow the free movement of the connector head back against the seating spring without any rubbing or interference between the air pipe or hose system and the mounting brackets.

3) Type: Two basic types of gathering devices have proven feasible: spread-wing type and pin-funnel type (including ball-funnel, horn-funnel, and cone-funnel). Designs of both of these types have passed development tests and indicate a feasibility for rail freight application.

It has been found that the design of the gathering mechanism must be as symmetrical as possible and as free of points of discontinuity or other abrupt curvature changes. Rectangular shaped pin-funnel type connectors, in general have a greater number of changes in curvature and slope with a resulting large number of points at which the horn can bind at the time of entering the funnel. Any point of significant binding will result in a propensity to gall or score the surfaces of the gathering pieces. The end result will be that the air connectors will have a tendency to stick open or to bind up and then "jump into place" after the galling forces are overcome by the spring pressures.

The latest designs of the spread-wing type, on the other hand, have gathering faces which are "clean" in design. Thus there is a smooth movement during gathering, which reduces the possibility for a hang-up of one of the gathering elements with the mating unit.

The spread-wing type air connector is thus judged to be the best of the design alternatives which were reviewed. The current connectors of this type are somewhat smaller and lighter than those tested in the mid-1930's by the AAR Technical Center. Wing design improvements have been made to achieve a better taper of the leading edges to minimize the frictional resistance while mating. Current designs using high alloy steel are also stronger than earlier tested units.

4) Gathering: The gathering mechanism of the air connector must be sufficiently rugged to withstand both the lateral gathering forces and the longitudinal coupling forces without deformation. The design of the mounting and gathering elements must be such that, during normal coupling operations, the knuckle of the "E" coupler head will touch first to absorb the majority of the coupling forces prior to the air connectors coming into contact.

For air connectors designed for use with the "E" type coupler, both the mounting and the gathering must have increased range. That is, the "E" type coupler has a large vertical movement as well as 0.78 inch of free slack. Thus, an airline connector designed for use with an "E" system must have greater flexibility and gathering range than one designed for use with the "F" type coupler system, which has a better vertical gathering capability and a highly limited movement of joined couplers. In the case of the "F" type air connector, the coupler accomplishes almost all the gathering and the "wings" of the air connector must only complete the final centering or gathering of the airline connector.

Another requirement for air connectors is that their gathering action must be completed in front of the air seals such that any lateral gathering motion is completed prior to the final seating of the air seals. Because of the tremendous forces involved in the mechanical coupling of freight cars, any lateral gathering motion within the air connector after the air seals have made contact will result in an undue and excessive scrubbing force applied laterally to the compression seals.

5) Sealing: Two types of air seals were reviewed: butt faced seal, in which the air seal is placed at right angles to

the center line of the car; and an angular faced seal, in which the seal faces are placed at an angle (usually 45 degree) to the center line of the car, such that both longitudinal and lateral movement is required for the seals to come into complete contact. The butt type seal was determined to be the only type having consistent and reliable operation.

The "E" type coupler has a significant amount of free slack, and, to a lesser extent, the "F" type coupler (0.37 inch free slack). Even the "rigid" type coupler systems (such as concepts 6a, 9, 36, 30lb must have some amount of free slack in order to allow proper coupling under conditions of ice and snow buildup. Thus air connectors (as well as electric connectors) must have their own compression-loading capability in order to compensate for this free slack or movement between coupled units. It has been determined that both a pliable compressible seal unit and a backup spring-type system are required to make good initial sealing and to maintain sealing throughout the coupling and environmental changes. To compensate for wear of the connector seal (expected as a result of impact erosion or gathering arm wear) or buildup of road grime, the air connector seals should have a compression of a least 0.25 inch and have backup springs having at least 1.5 inches of compression which would force the air connector seal in the forward position at all times to compensate for uneven mating couplers.

6) Maintenance: For ease of maintenance during road or switching operations, it is desirable that the air connector gaskets be removable from mated units. Thus, the air connector design must logically provide for removal of the sealing elements from the rear of the air connector units. Since each removal would involve a severe bending or moving of the entire air line system, it follows that the air connection system should have a

minimum number of joints in order to minimize the possibility of leakage following such seal repair efforts.

It is necessary to provide for the adaptation of an automatic-air-connector-equipped car to an unequipped car. Additionally, this attachment of a "mixed" air connector system should be accomplished without the aid of special tools or the need for a second workman. Some of the "mixed" connection systems were heavy and bulky, resulting in considerable difficulty experienced by trainmen in maneuvering and attaching the "mixed" air connector systems. In addition, it is necessary that the air connector head allow for sufficient flexibility to avoid excessive distortion or twisting of the air hose on the unequipped car. Thus, if the air connector is to provide for adapting directly against the air connector head, it is necessary that the air connector unit have some form of horizontal pivot in order to provide for the required flexibility. Considering the complexity of the separately detachable "mixed" connector heads and the potential for a poor air seal resulting from pivoted air connector heads, it is concluded that the best possible "mixed" air connector system involves the use of a separate air hose/glad hand unit which operates in the same way as the current air hose connector system. (Concepts 1192 and 1193.)

The most simple and readily adaptable proven system for accomplishing the requirements for connecting "mixed" air connector systems is the separate air hose/glad hand system incorporated in Concept 22. In this system the "mixed" adapting unit is identical to the standard train air line hose and is connected to the basic air pressure line system by use of a standard train air line valve. Thus the system is simple, relatively maintenance free, and consists of components of proven reliability.

7) Summary: Several air connector concepts which were reviewed incorporated the basic operating principles determined to be important for proper operation of the system. These include Concepts 22, 451e, 502c, and 511b, which are all currently designed units. These all represent second-generation units utilizing the basic design concepts of the Robinson spread-wing air connector (Concept 458).

None of the preferred air connector designs contain all of the desired features intended for a railroad operating environment. There is no reason to believe, however, that each of these designs could not be modified and the design improved as necessary to make an acceptable air connector system.

#### 4.2.1.2 Air Connector (Integral Unit)

In the "E" type of coupler system, there is no room within the face of the coupler head to build in an integral air connector unit. In addition, there would be problems in maintaining the seal of an air connector unit because of the allowable vertical and lateral movements of the connected type "E" coupler systems using the AAR type "F" head. Thus, air connectors for use with the present free knuckle coupler system must be of the add-on type as noted above.

An alternate concept of coupler system is the "rigid" type (such as Concepts 9, and 36). By definition, the "rigid" type of coupler head system does not have a relative movement or free slack between the joined couplers (considering wear and other field usage problems, free slack may be a few one-thousands of an inch). This type of "rigid" coupler head system can utilize an integral air connector unit.

1) General Design: This type of air connector unit could be located anywhere within the general outline of the "rigid" coupler head. To compensate for any possible free slack in the system which might result from wear, it seems desirable to have the air connector located on the vertical centerline of the coupler head and as near as possible on the horizontal centerline. This will minimize any relative movement between the connector seals which might result because of wear or misalignment in the coupler head system.

The mounting location for the air connector preferably should be recessed within the face of the coupler head. This location is desired for two reasons:

(a) The air connector seals are better protected from accidental damage while they are in the uncoupled condition.

(b) The connector seals should be recessed sufficiently deep in the face of the coupler head so that all lateral and vertical gathering movements are completed and the coupler heads are moving only in a tangent position one to the other before the faces of the air connector seals come in contact.

In this type of integral air connector system, the entire movement for gathering is accomplished by the coupler head. Therefore, the air connector has no gathering features by itself.

The type of seal for the integral unit should have the same general characteristics as for the add-on unit. In particular, this means that the seal should be of a compressible resilient type of material and that it should be backed up by a spring-type compressing seal. In a similar sense, it was determined that a butt type of seal was required for a good sealing reliability.

This type of air connector design is similar in maintenance

requirements in that it should provide for replacement of the sealing elements from the rear of the coupler head to allow for maintenance of air connector gaskets from mated coupler units. Flexible joints are desirable to connect the air seal portion to the rigid air pipe system mounted on the car. From a cost engineering viewpoint, it is desirable that the air seal system be a detachable self-contained unit which would not require machining to be done on the coupler head to achieve sealing faces. This type of air seal connection design could possibly allow the use of a cast coupler head without additional machining in this area.

Should a semirigid type of coupler head system be adopted, a good type of compression seal would be a double concentric ring seal (Concept 45). This type of seal unit would give a decided increase in reliability of the system particularly in the case of some anticipated relative movements of semirigid mated coupler heads.

2) Summary: Three integral type air connector units exhibited essentially all of the desired characteristics. These are Concepts 9, 448b, and 503a. It is believed that they would be equally adaptable to an air connector system which was required for adaptation to a "rigid" coupler head system.

#### 4.2.1.3 Air Valve Operation (Add-On Unit)

1) Mechanical Operation: As noted in Section 4.2.1.1 above, it is desirable that the add-on air connector unit be located on the center line below the coupler head. In this exposed position, the air connectors will be subject to road contamination, corrosion and mechanical damage. To minimize maintenance problems, the air valve operation should be simple and have a minimum of

required moving parts. For highest reliability, the valve operation should be initiated by the final seating forces involved in coupling the air connector. The most desired concept would include a direct push-rod type of initiation of the air valve at the time of coupling.

2) Control System: Since airline pressure must be available for proper control of a moving train, it seems realistic to utilize this airline pressure as part of the force used to turn the train airline valve on and off. Airline pressure regulator units are universal in train application and are simple and reliable devices. The most practical combination for operation of the train airline valve therefore seems to be the direct movement of a push rod in the air connector head acting to operate a small pilot airline valve which, through an air pressure reducer, operates the train airline valve.

An unintentional parting of cars must leave the air lines open to ensure automatic emergency braking. Thus, automatically closing ball-type valves in the face of the connector that would automatically close with uncoupling appear to introduce a potential safety hazard with unintentional uncoupling. The use of a separate pilot line/airline valve provides for a better fail-safe system in which a positive action must be taken in order to change the train line valve once it has been opened.

To control the train air valve during intentional uncoupling, it is desirable that the operation of the standard uncoupling rod (and more particularly, moving out of the lock-set position) should operate through the pilot airline valve to close the train line valve. In the present system, the operation of the uncoupling lever is the only positive indication of a desired uncoupling.

3) Summary: Of the train air valve control systems associated with an add-on air connector system, only Concept 22 meets the desired criteria as outlined above.

#### 4.2.1.4 Air Valve Operation (Integral Unit)

The air connector system described in Section 4.2.1.2 defines an integral air connector unit contained within a rigid type of coupling system. This type of rigid coupler system is generally considered to be associated with the adaptation of a train electrical control system. However, it is feasible that this type of coupler unit could be utilized without an electrical system and therefore the control mechanism for the air valve operation should assume both electrical and pneumatic options as well as direct mechanical operation.

1) Mechanical Operation: This integral type of air valve operation should likewise be direct, simple, and have fail-safe provisions. Initial operation of the airline valve should be initiated by a direct push rod actuated at the time that the coupler comes into the mating position. The most desirable operation would be a direct push rod from the coupler head to the first valve as compared to a more complicated system involving movement of cam shafts, linkages, or a more complicated connecting device.

The valve operation should be such that, once the airline valve is open, the valve remains in the open condition unless there is a positive indication of uncoupling such as operation of the uncoupling rod or other remote signal. A fail-safe provision for an emergency brakeset condition is mandatory for an unintentional uncoupling situation.

2) Control System: If only air pressure is available in the train line systems, the pilot line/train airline valve system noted in Section 4.2.1.3 seems to be the most direct and reliable system. A pneumatic control system that depends upon vacuum differential pressures would seem to be of doubtful reliability as applied to a full long train under expected adverse environmental conditions. This type of system (Concept 45a) depends on small vacuum differentials to accomplish certain valve operations with larger vacuum differentials (or longer time durations) operating the valves for a different mode of control. Such a system would be less reliable and have less fail-safe potential than a positive pressure system operating from reduced pilot line pressures.

Where a train electrical line system is available for control, the basic valve operation system should still be based on the pneumatic control valve operation. In such a system the electric solenoid valve would operate the pilot valve only for those situations involving a remote control signal for uncoupling. In all other respects, this system would be most reliable if the remaining elements were identical to the pneumatic system described above.

Several references reported difficulties with proper operation of electric solenoids when the solenoid plungers became rusty or free movement of the plunger was restricted by environmental contamination. Thus, any system involving electric solenoids should include a total environmental protection of the unit in a sealed retaining system.

Direct operation of the train airline valves by electric solenoids was reported to be subject to difficulty where sticking valves required undue force to operate, demanding an excessive

amount of electrical current from the electric solenoid control system. Thus the all-electric valve control system presents the potential for significant reliability problems.

3) Summary: Several system concepts reviewed utilized some portion of the desired characteristics noted above. Concepts 9 and 503a shared the same concepts presented by the electro-pneumatic control system Concept 254 which is chosen as the most desirable control system. It encompasses the need for an all-pneumatic control system and an electropneumatic system while retaining the mechanical control features of direct operation from a coupler rod or uncoupling lever.

#### 4.2.2 Mechanical Coupling (Category II)

Before evaluating the applicability of various coupling concepts, it is appropriate to review some of the basic requirements for coupling systems. The coupler must provide for automatic coupling and uncoupling and must have adequate load carrying capability as required for general freight service. The coupler system must be mechanically rugged and capable of withstanding the full range of environment, temperature, and element extremes. For both universal application and safety reasons, the coupler system should not require any external energy (pneumatic or electrical) for completing the coupling process. It is desirable that the basic coupler system be adaptable for later modification to include air or electrical functions.

The basic coupler concepts are readily grouped into two distinctly different design types. These are represented by a "free" coupler system and a "rigid" type system. Schematic outlines of these two systems are shown in Figures 4-1 and 4-2.

In the "free" automatic coupler system (as depicted in Figure 4-1), two connected couplers are free to slide vertically in relation to each other and are not securely held together in a manner which prevents any free slack or play between the connected units. This free movement between the couplers allows for the coupler head to slide in a vertical direction to compensate for differences in car heights or intercar movements caused by normal train operation. The AAR Type "E" coupler system is the basic "free" coupler system concept which was used as the basis for all other coupler concept comparisons. Automatic connection of airlines cannot be accomplished with a "free" coupler head.

Of course, it should be realized that very few coupling concepts fall 100 percent in either one of these two types. However, the basic "free" and "rigid" designation appears quite realistic as a natural grouping of two types of connection systems.

#### 4.2.2.1 Noncompatible With Type "E" System

Several design concepts were reviewed which were not compatible with the current "E" coupler system. These all fall in the "rigid" or "semirigid" type of coupler systems.

Within this basic type of coupler, there are two distinct design types: flat-faced and spread-claw type. Each of these two types of couplers are unique in their ability to utilize integral air and electrical connections. Since this noncompatible type of coupler would represent a radical departure from the Type "E" system currently in use, it is believed appropriate that a more severe design requirement should be placed on such a

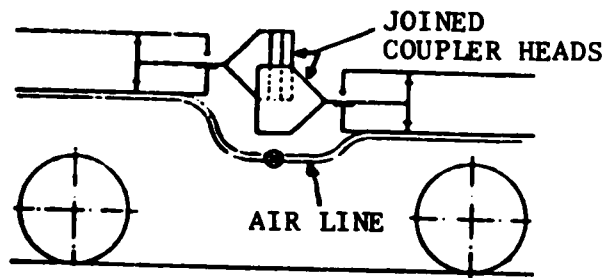


FIGURE 4-1. "FREE" COUPLER

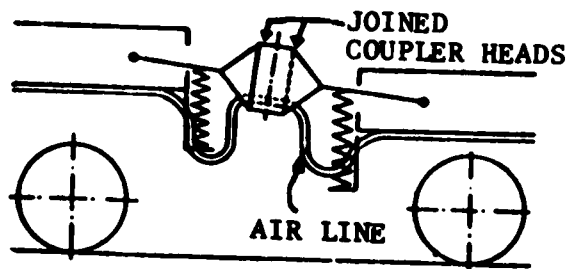


FIGURE 4-2. "RIGID" COUPLER

new unit with respect to its adaptability to the use of an air or electrical connection system which might be added at a later time.

A general summary of user comments relating to the flat type "rigid" coupler indicates this type of design to be more readily adaptable to integral air and electrical connections. On the other hand, this type of design is inherently more expensive because of the added complexity and machining. This type also appears more susceptible to malfunction because of the sensitivity of the machined edges to impact damage upon coupling. This type of unit also apparently requires greater overall weight in order to achieve an equal strength.

The spread-claw type of "semirigid" units all represent a modification of the basic Willison coupling principle. The basic design of the Willison involves a discontinuous lateral movement at the time of coupling. This concept presents a potential for difficulty in integral attachment of air and electric connectors as will be noted below. In other respects this design type appears to offer a more cost effective design in terms of the use of large single cast units with a minimum of machining and represents a stronger design in strength to weight ratio.

Flat switching operations compose approximately 80 percent of all coupling operations. Although most hump yards are highly automated, a tower operator normally watches the humping operation and has the power to override the computer system (for control over the retarders) if he has reason to think that the electronic control will not give the car proper speed. The incentive in both a flat switching and hump switching operation is to insure positive coupling rather than to allow a car to fall short. The inevitable result is coupling at excessive speed.

Sample test programs have shown average impact speeds for yard operations to be within the "rough" range of 5 to 9 mph.

In Willison type couplers having a discontinuous coupling movement, the higher coupling speeds are transmitted as greater impact energy both tangent to the line of car movement and laterally. This lateral energy is imparted to both the fixed elements of the coupler head and to any associated air or electric connector units which are an integral part of the coupler head. Thus, the potential for damage (particularly to electrical connector units) is significant if any portion of the lateral movement of the discontinuous coupling takes place after the initial engagement of the electrical or air connector.

Some of the most recent modified Willison designs (Concept 309), do make provisions for completion of the lateral discontinuous coupling movement before a final longitudinal movement to complete coupling. In this case the problem noted above is minimized if not deleted.

Pictorial outlines of the two basic types of "rigid" and "semirigid" coupler systems are shown in Figures 4-3 and 4-4.

1) Increased Gathering Range: Both the flat-face and spread-claw type of couplers present opportunities for a much greater gathering range than is possible with the present Type "E" coupler head.

The spread-claw design utilizes wide diagonal gathering faces which force the opposing coupler into both vertical and lateral alignment. The greatest basic gathering range was for Concept 309, which had a 17.4 inch lateral, 11.0 inch vertical gathering range (which is approximately 4 times the standard

ranges). Next in order of decreasing gathering range were Concepts 457 and 301b.

The flat-face design depends upon a protruding horn (or hook) being guided into an opposite recessed funnel to achieve lateral and vertical gathering. This gathering, although larger than the Type "E" system, is limited by the cross-section of the horn. The two largest gathering ranges were exhibited by Concepts 6a and 9 which were approximately 2.5 times the standard ranges.

Some designs utilized protruding external guide arms or guide pins in order to facilitate a greater gathering range. It was determined that this concept, although quite workable in low force situations such as rapid transit applications, does not have the design strength and ruggedness required for the relatively uncontrolled rail freight service. In some designs the coupler would experience a blocking in which the guard arms would interlock to prevent coupling. These concepts were set aside for consideration in the candidate coupling systems.

2) Positive Locking: It is desirable that the mating units come into complete locked coupling solely as a result of the mechanical coupling forces. It is also desirable that some means other than gravity be utilized to lock the mated couplers together. It is absolutely required that positive locking be achieved without the requirement for additional air or electrical energy to the coupler head. In addition, it is desirable that the lock be retained even with the subsequent loss of air or electrical power, should this be an added feature.

Of the flat-face type of couplers, Concept 9 exhibited the best locking action with hinged locking hooks, a positive spring

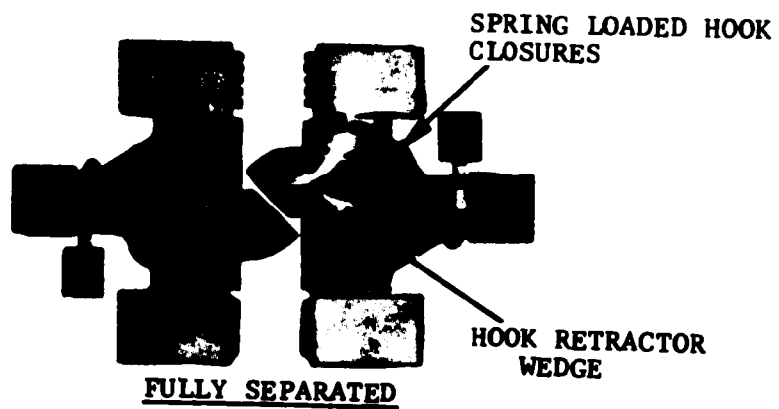
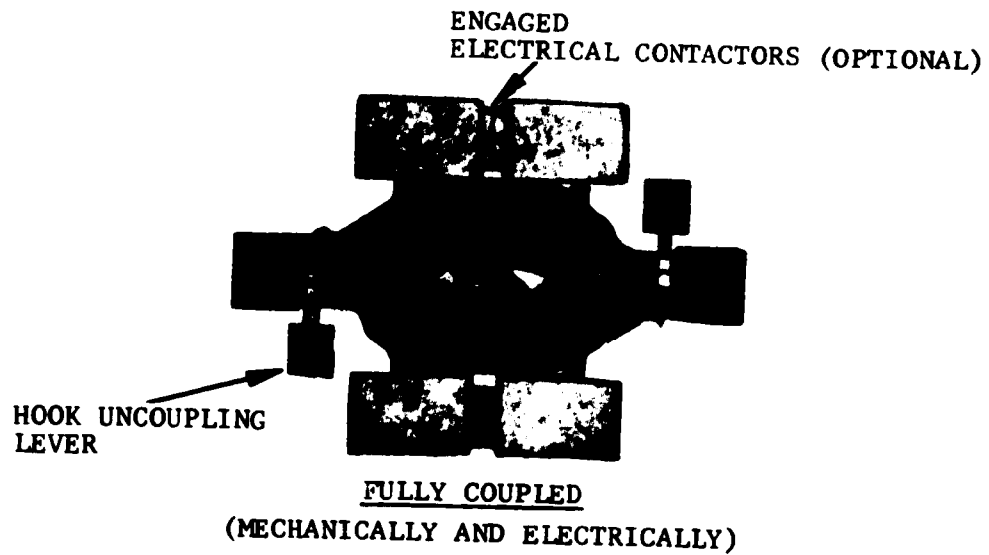
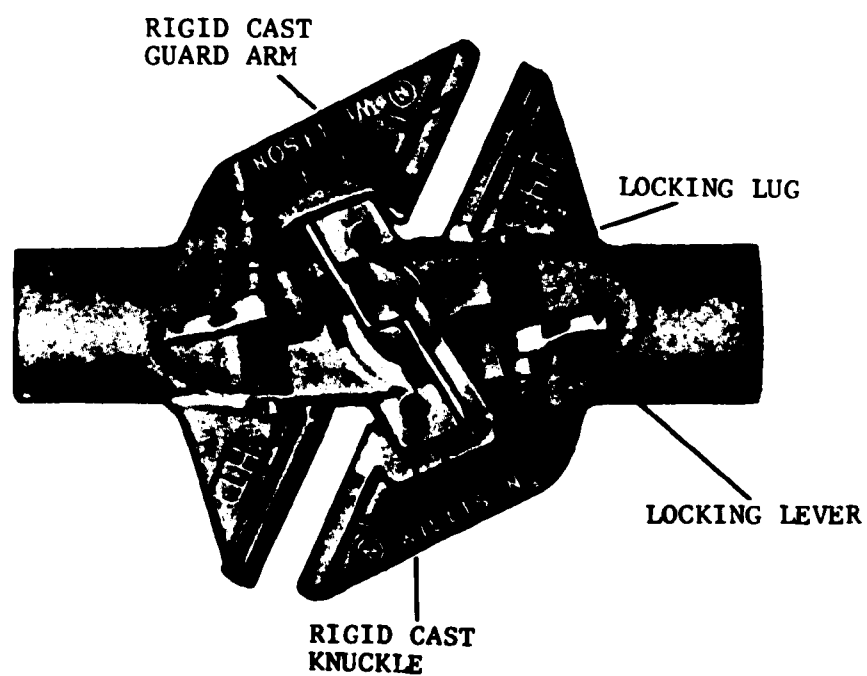


FIGURE 4-3. RIGID, FLAT-FACE, HORN-FUNNEL COUPLER



**FIGURE 4-4. SEMIRIGID, DISCONTINUOUS MOVEMENT,  
SPREAD-CLAW COUPLER**

loaded interlock, and a direct coupler locking action as a result of compression of guide pins located on the coupler face.

Of the spread-claw type, Concept 309 exhibited the best locking mechanism with a spring-loaded hinged locking hook. In addition, Concept 309 exhibited a cost-effective locking mechanism design composed of six unmachined steel castings assembled with one locking spring.

3) Reduced Free Slack: The flat-face type of coupler unit generally exhibited the least amount of free slack. This was the result of the design concept requiring a flat machined face as the joining surface between mated couplers. The one exception to this (Concept 6a) utilized a cast front face with minimal machining while still achieving a minimum free slack of 0.125 inch. There is not general agreement concerning the potential problems resulting from damage to the edges of the front machine faces on this type of coupler. It is recognized, however, that there is a potential for damage to these machined edges and/or warpage of the front machine face, which could cause a decided increase in free slack and potential problems with completion of the coupler locking.

With the spread-claw type of couplers, only one unit exhibited a very small amount of free slack. This unit (Concept 33) depends upon an extensive amount of machining to achieve this low free slack and represents a rather complicated coupler system, which would not be cost effective. The free slack of 0.31 inch exhibited by Concept 309 represents the typical free slack available with a cast forged head design of this type of coupler. Concept 36 exhibited a wedge type takeup device used in the locking mechanism which resulted in reducing excess slack as the couplers came into a locked position. This design concept

should be considered for later potential; however, its use has been restricted to a very light-duty rapid transit system.

4) Vertical Interlock and Entrapment: Several acceptable concepts were noted to achieve coupler interlock, to prevent vertical movement after coupling and to trap a mated broken coupler. The primary locking mechanism for all "rigid" types of couplers is the movement of the locking horn into a funnel or recess in the mating coupler. After the couplers have been securely locked, the overlapping of the adjacent hinged locking hooks accomplishes the desired interlocking.

In the flat face type of coupler, other interlocking devices used included a guide pin/dowel interlock (Concept 9) and cast overlapping external flanges (Concept 6a).

In the spread-claw type of coupler, the basic additional interlock (in addition to the hinged locking hook) is accomplished by the tongue and groove effect of the interlocking spread claws. This concept is typified by Concept 309 or 301a.

5) Summary: Although no one system embodies all of the desired features, two coupling systems stand out as having the best overall combination of these features. These are: Concept 309 in the spread-claw type design and Concept 9 in the flat-face design.

#### 4.2.2.2 Compatible With "E" System

As noted in Section 3 above, there has been a scarcity of new development efforts applied in the U.S. over the last several years for new rail freight coupling systems. It is therefore not surprising that the concepts which were compatible

with the "E" system related exclusively to modifications of the "E," "F," or "H" coupler systems which had been in service for several years in either freight or passenger service. The improvements in total coupler systems are therefore much more modest in these compatible units than is the case with the noncompatible units above.

1) Increased Gathering Range: The lateral gathering range for a type "E" coupler is 2 inches with one knuckle open and 4 inches with both mating coupler knuckles open. Of all the concepts relating to increased gathering range, only one type of concept was applicable to couplers which mate with the "E" type system. This concept is the increased gathering range due to a change in the coupler knuckle contour. The technical relationship of knuckle contour to overall gathering range is as follows:

In the "E" type of coupling system, the lateral gathering range is a function of two basic components: (1) one or both knuckles being open, and (2) the amount of engaging force exerted by the open knuckle as it comes against the face of the opposing closed knuckle or guard arm forward contour.

The final alignment of the couplers is the result of the forces exerted at the knuckle faces during the initial and subsequent sliding contacts. The lateral forces supplied by this sliding contact must be sufficient to overcome the friction required to move the entire coupler head and shank into alignment while, at the same time, allowing a sliding of the knuckle faces without causing the knuckle of the open coupler to close prematurely before it passes beyond the tip of the opposing coupler nose and into the closure pocket. Should the open knuckle close prematurely, the resulting closed knuckle cannot enter into a coupled

engagement of the opposing coupler is simultaneously in the knuckle-closed condition.

The coupler knuckle contour changes are intended to reshape the forward and outer surfaces of both the coupler knuckle and guard arm faces such that the contours will come into direct sliding contact. The desired contours would force the opposing components to be in sliding lateral motion along the entire length of contact. The closing forces would thus be incapable of forcing the knuckle to rotate from the open to the closed position until the tip of the knuckle had passed the tip of the mating coupler. The net result is an increase in total gathering range.

Concepts 501 and 502a both concern a coupler knuckle contour change. Concept 501 achieves the greater increase in lateral gathering range to a total of 6.875 inches, which is 1.7 times the standard total gathering range for the Type "E" system of 4 inches (assuming that both knuckles are open).

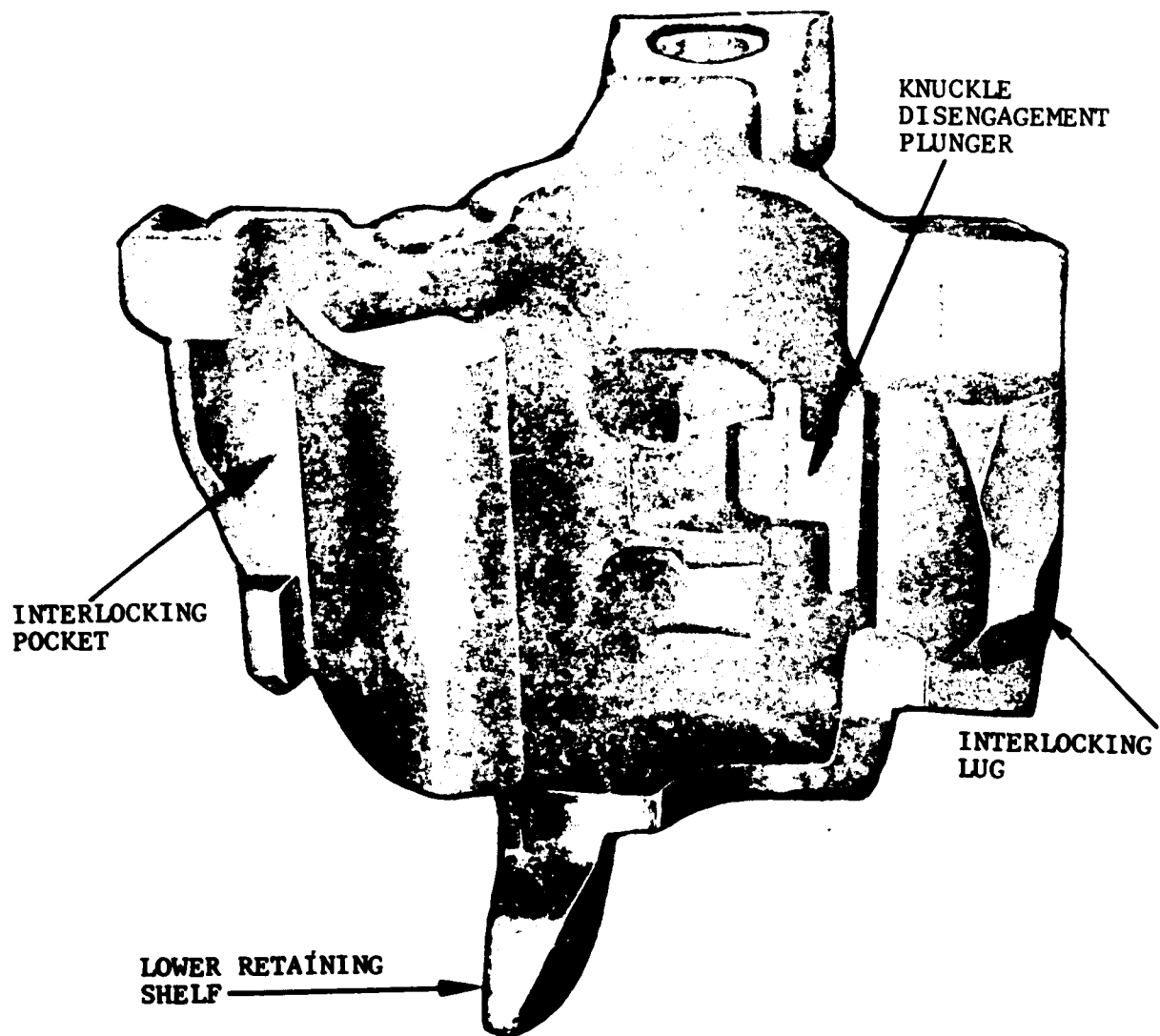
In the area of increased vertical gathering range, the only concept giving an absolute increase in range was the use of the Type "F" coupler as given in Concept 428b. This type of coupler head increases the vertical gathering range from the AAR Interchange Standard requirements of 3 to 4.5 inches. It should be noted that the "E" type of coupler head has no restrictions for vertical movement and, in fact, will allow maximum vertical movement of approximately 7.25 inches before the mated couplers drop out of connection. There is actually a potential for a coupling of a "E" type of coupler head above the standard 3 inches vertical gathering height up to the 7.25 inches knuckle vertical height at which point there is a bypass rather than a completed

coupling. Therefore, the use of "F" type of coupler head guarantees a capability of 4.5 inches in vertical gathering height, but may in fact represent a lesser vertical coupling gathering range than can be accomplished with the unrestricted "E" coupler system.

Concept 702 describes a technique for adding guard-arm extension faces at the top and bottom on an "E" double-shelf coupler in order to achieve an increase in vertical gathering range. Such extensions, however, are viewed with caution, since they must have considerable strength and rigidity in order to withstand the normal coupling forces. For example, there were problems reported from railroad users concerning the damage or complete breakage of the side-extending interlocking lug or pocket, which is a design feature of the Type "F" coupler head system. (See Figure 4-5 for an example of the Type "F" coupler head geometry.) Concept 702 is therefore included as a significant concept; however, field testing may indicate strength deficiencies in this concept.

2) Positive Locking: No concepts of significance uncovered in the literature and patent search gave a positive locking technique for the "E" type of coupler system similar to the locking mechanisms available for the noncompatible "rigid" type of system noted in Section 4.2.2.1. The only significant concept which approached a positive locking feature was Concept 502b. This concept has been developed and field tested and has been proven to be fully interchangeable (or "compatible") with the standard Type "E" or "F" couplers. The operating characteristics are:

A spring loaded mechanism maintains the knuckle in the open position when the coupler is uncoupled. The knuckle disengagement plunger is forced rearward by the knuckle of the mating coupler and thus disengages the automatic spring loaded knuckle opening



**FIGURE 4-5. AAR TYPE "F" COUPLER WITH "KNUCKLE OPEN" MODIFICATION (CONCEPT 502b)**

feature permitting the coupler to close and operate normally. The positive forceful disengagement of the knuckle locking spring results in a positive release of the knuckle locking mechanism allowing it to drop into place under gravitational force.

This does result in a more positive locking of the closed knuckle than is the case with the standard "E" coupler head. Figure 4-5 pictures Concept 502b as applied to a Type "F" interlocking coupler head.

3) Reduced Free Slack: Two different AAR coupler designs currently in field use have a reduced free slack as compared to the Type "E" system. These are: The AAR Type "F" (Concept 428b), which has a free slack of 0.37 inch, and the AAR Type "H" (Concept 428a), which has a free slack of 0.25 inch. These compare to the basic Type "E" system free slack of 0.78 inch. The only other significant concept which has the potential for reducing free slack is Concept 501. In this concept, a coupler knuckle contour change was developed in conjunction with the addition of fronting material on the face of the knuckle to add approximately 0.078 inch to the front of the Type "E" knuckle. Concept 501 therefore results in a free slack of 0.62 inch for two mated Type "E" couplers or approximately 0.3 inch for two mated Type "F" couplers.

The Type "H" coupler head described in Concept 428a requires extensive machining in order to achieve the minimum free slack. This coupler was developed for use with passenger cars and has potential problems of inadequate strength if applied to freight car service. It is thus summarized that the most logical concept for improvement in free slack would be the utilization of the Type "F" system of Concept 428b used in conjunction with the modified knuckle contour and front face buildup as exhibited in

Concept 501.

4) Vertical Interlock And Entrapment: The AAR Type "F" interlocking coupler (Concept 428b) was designed to achieve an interlocking of mated couplers to prevent the drop-off of a broken coupler in a derailment situation. This interlocking coupler design is currently used on tank cars or long cars or those designated for dangerous application. This coupler system, however, provides a full interlock only when mated with another Type "F" coupler. When mated with a Type "E" unit, the Type "F" coupler will allow the mating coupler to ride over the top and become disengaged should derailment or other forces cause the vertical movement of the Type "E" coupler.

Two concepts have been developed to correct this "ride-over" possibility: Concept 52 which applies a top shelf to the Type "F" coupler, and Concept 54, in which a top and bottom shelf is added to the standard Type "E" coupler. These and other related references report that both concepts will achieve a vertical interlock and entrapment of a broken mated coupler. Concept 702 applies to Concept 54, the added concept of an additional guard-arm extension at the top and bottom shelf faces of the double shelf Type "E" coupler to achieve a purported increase in lateral and vertical gathering range in addition to achieving the interlocking features.

It is recognized that the Type "F" coupler of Concepts 428b and 52, although having less free slack and interlocking features, is still not sufficiently rigid so as to allow integral air and electrical connections. In addition, the physical space available within the confines of the coupler head (See Figure 4-5) shows that there is no space for such internal attachments. If add-on or external air and electrical connectors are to be considered, the AAR Type "F" coupler is more feasible than the Type "E" with

top and bottom shelf (Concept 54), since the Type "F" utilizes less vertical space underneath the center line of the coupler head and has less free slack. However, one universal air connector is preferable to two separate designs for reduction of both initial and maintenance costs. Therefore, an air connector designed to handle the gathering and free slack of the "E" coupler system should be chosen, since it will automatically encompass the "F" system requirements.

5) Summary: Two potential coupler systems emerge from this analysis of the compatible coupling concepts. Listed below are the concepts included in Type "F" and "E" coupler systems.

(a) A system based on the Type "F" coupler head (Concept 428b) has the following modifications.

1. Addition of a top shelf (Concept 52).
2. Increased gathering range and reduced free slack by change to knuckle face (Concept 501).
3. Positive knuckle locking and knuckle open provision (Concept 502b)

(b) A system based on the use of the standard Type "E" coupler head system includes the following modifications.

1. Addition of a top and bottom shelf (Concept 501).
2. Increased gathering range and reduced free slack by change to knuckle face (Concept 501).
3. Increased gathering by the addition of guard-arms (Concept 702).
4. Positive knuckle locking and knuckle open provision (Concept 502b)

#### 4.2.2.3 Coupler Location Control

The reasons for needing coupler location control devices

are related to the instability of long cars on curves. Instability on curves results from a high lateral component of coupler force which is brought about by high shank angles between adjacent couplers. Possible solutions to this problem are:

- 1) Reduce car length and overhang
- 2) Increase the light car weight
- 3) Lengthen the coupler to reduce the shank angle.

Car length and light car weight are dictated by economics which have been previously established. Car length overhang is dictated by the length of the car and the required radius which the car must traverse. Thus, the only practical solution is to lengthen the coupler.

The lengthening of the coupler increases the problem of "jackknifing" between mated couplers. The best practical means of avoiding such jackknifing is to use an interlocking coupler head. Such interlocking decreases the amount of play between adjacent coupler heads and therefore requires a vertical pivoting of the shank to permit the required vertical movement between the coupled heads. The long-shank couplers must also be mounted such that they pivot in their yokes to permit cars to operate on standard radius curves. Unless they are kept centered by some means, such long car couplers tend to become misaligned after being uncoupled as the result of lateral forces (such as involved in switching wherein the car transverses a sharp curve).

It should also be noted that during operating conditions encountered by loaded trains, fast or emergency braking of the train can result in an eccentric loading of the coupler such that the connected couplers have a tendency to swing laterally with resultant outward forces tending toward derailment of

the coupled cars.

Therefore, to be effective from both an operational and safety viewpoint, coupler locating devices are desirable on long cars. Moreover, to achieve maximum operating safety under emergency stop conditions, such devices should have a tendency to maintain a centering of the coupler shank in both the coupled and uncoupled condition. To have the greatest effectiveness, it is desirable that the centering device apply a greater force directed toward centering the shank when the car is under extreme buff conditions such as is encountered during emergency braking operations.

1) Types Of Location Control Devices: Concepts for two types of location control systems have been reviewed: centering and positioning devices. A coupler centering device (See Figure 4-6) assures that the coupler is centered with respect to the centerline of the track when on straight tangent track or on a slight curve. It is the consensus of the technical material reviewed that centering devices would remedy approximately 50 percent of all operating bypasses occurring on short cars (assuming the use of Type "E" couplers). On the other hand, centering devices would not be particularly effective for long cars (because of the long effective coupler length and overhang of the end of the car from the truck centers), except to the extent that they would keep the long-shank couplers from sliding to one side during uncoupled yard switching movements.

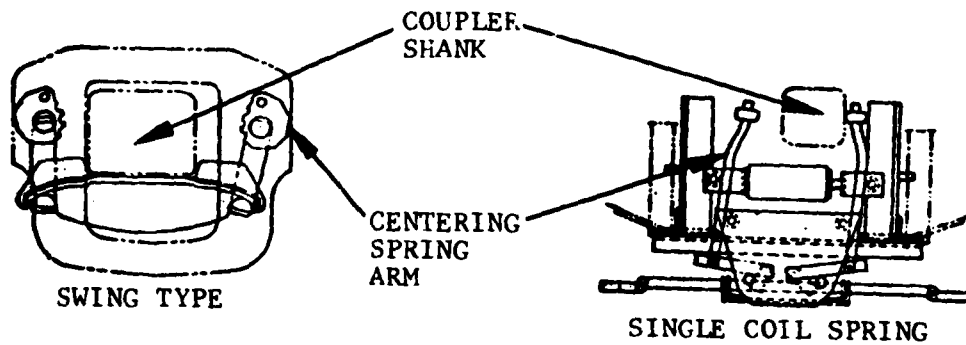
A coupler positioning device (See Figure 4-7) assures that the coupler head is centered toward the centerline of the track. The positioning device senses the change of angularity between the car trucks and the centerline of the car body upon

which the coupler mounting sill is attached) and guides the coupler head through an interconnecting device. As the car traverses a curve, the trucks follow the track and change the relative angle with the centerline of the car. This change in angle is then transmitted through a mechanical and/or hydraulic linkage to position the coupler head in the direction that the trucks are turning, thus tending to keep the coupler head in alignment ready for the next coupling operation. Although practical positioning devices cannot assure absolute track centering of the coupler head on long cars, they can function to bring the coupler head within expanded gathering ranges possible with Type "E" and Type "F" coupler heads.

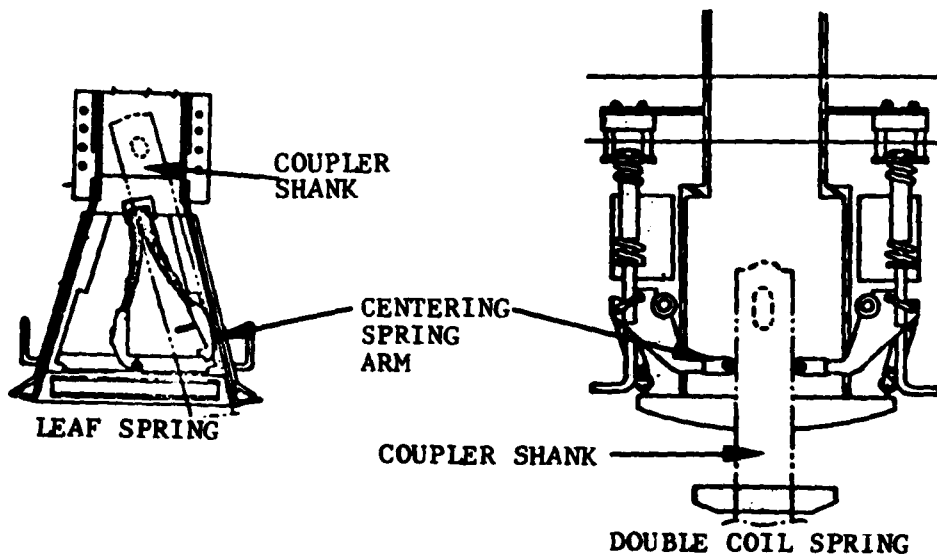
Coupler centering devices are in widespread use in rapid transit applications and, to a lesser extent, in railroad freight service. Coupler positioning devices are only in very limited use because of their high initial cost and experience with damage and maintenance problems in actual usage.

It is the consensus of technical reports that effectively designed positioning devices would eliminate from 80 to 90 percent of all bypasses occurring with long cars and approximately 95 percent of all bypasses with short cars. This consensus assumes the continuation of the same gathering capabilities as is currently available with the Type "E" coupler head in use on short cars and the Type "F" coupler head generally in use on long cars. No data were reviewed which related quantitative information showing the bypass probability when only one car of the coupled pair had a positioning device installed.

2) **Undesirable Features:** More than 25 different significant concepts were reviewed which related to centering and positioning devices. Most of these devices were shown to have

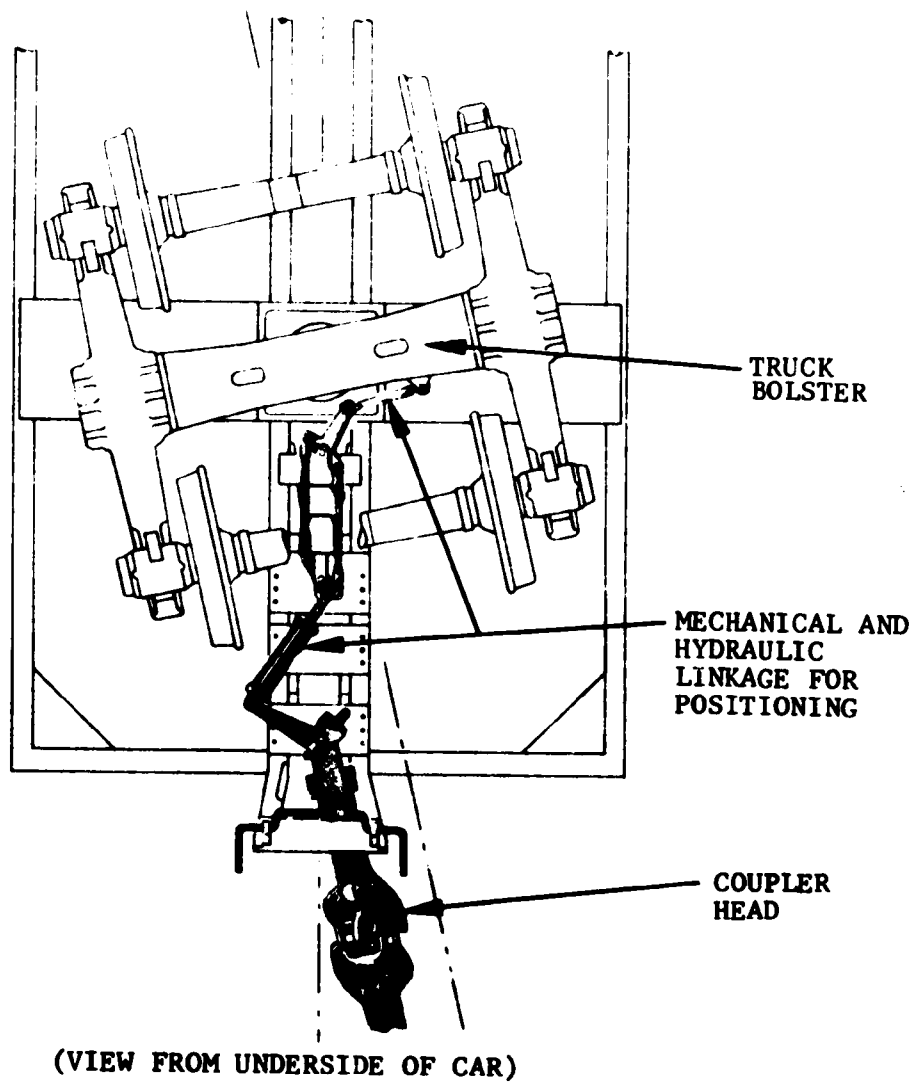


(CROSS-SECTION VIEWS FROM END OF FREIGHT CAR)



(VIEWS FROM TOP OF CAR)

**FIGURE 4-6. "TYPICAL" COUPLER CENTERING DEVICES**



**FIGURE 4-7. "TYPICAL" COUPLER POSITIONING DEVICES**

a tendency to malfunction mechanically or to be subject to excessive damage and maintenance problems in the field. These undesirable design features include:

(a) Complicated compound control linkages (field damage and replacement problems were universally associated with complicated linkage systems).

(b) Chain and cable linkage (potential problems for harmonic vibration and shock damage are inherent where light gauge chains or cables are used).

(c) Unprotected hydraulic cylinders (subject to excessive road damage and leakage).

(d) Passive air cylinders (introduce an element of system unreliability unless the air cylinders are well protected or are subject to frequent maintenance inspection for leakage).

(e) Air-inflated rubber boots (subject to environmental embrittlement and loss of centering capability).

(f) Use of rubber as the sole centering force (subject to loss of return force capabilities as a function of fatigue and environmental deterioration).

(g) Design with high leverage moments (potential for loss of control capability as expected environmental grime accumulates in the control mechanism).

(h) Light duty structural design (subject to low reliability and high maintenance due to expected wear, shock, and vibration damage).

(i) Manual disengagement under load. (During the expected coupler transition period, there will be cars which are unequipped with any centering devices which will result in the need to position the coupler head of the unequipped car manually. If the centering or positioning device does not have a force-free center location, it becomes physically difficult if not impossible for one man to disengage the location control device and position it to the center.)

3) Centering Devices: A review of the technical concepts of the various centering devices resulted in most being set aside as truly significant on the basis of shortcomings for one or more of the problem areas defined in the undesirable features section noted above. Of the remaining concepts, three types stand out as meriting potential application. These are:

(a) Self-centering with the draft gear systems. Concept 26 uses the draft gear compression force to center the shank with the centerline of the car at any angularity greater than 4 degrees. Concept 1190 uses the buffing force of the draft gear return spring to apply a bias force against lateral extended bearing surfaces on the shank butt to achieve a self-centering beyond a designed "free force" center range of approximately 4 degrees.

The 4 degree offset would tend to center a short coupler within 2 inches of the center line and within 4.2 inches for a long car. Technical literature suggests that angularity above plus or minus 4 degrees would be expected from 10 to 20 percent of the operating time.

(b) Centering aided with side springs. Concept 318 includes a concept in which the springs apply recentering force at lateral movements greater than 1.2 inches off the centerline. This concept would achieve a greater centering capability than self-centering by reason of the external spring force while maintaining the potential for easy manual release of the centering device should it be required for coupling with unequipped cars.

(c) Centering with external force wherein the centering system is automatically engaged from an external remote signal.

Concept 503a defines an air cylinder system which is automatically engaged or disengaged through a train line automatic control system. This concept is technically feasible if there is an inter-car control system, since it utilizes the readily available air line pressure for the energy to be applied to the centering cylinders. To protect against road damage, it is assumed that the operating plungers and the air cylinders would be housed within a closed area extending on both sides of the bell housing underneath the car sill.

4) Positioning Devices: The only positioning device which appears to meet the needs of the general requirements as stated above is Concept 31b. This is a simple system primarily composed of two hydraulic cylinders which operate from the relative truck/car movements to move directly the coupler shank. The cylinder plungers are protected and have short strokes which would minimize possible scoring damage from external blows. The system offers the potential for easy mechanical disengagement to allow for manual centering. It is realized that this system would primarily be used for a long coupler unit, which would be quite heavy and thus difficult to move by hand after the positioning device was disengaged. It must likewise be recognized that all positioning devices are sufficiently complicated that they should be subject to required periodic maintenance and inspection.

5) Reduced Contour Angling: As noted in the general requirements above, long cars require the use of long shank couplers, which in turn dictate the need for interlocking coupler heads. The net effect is a decrease in the required swing angle of the coupler shank and therefore a reduced contour angling.

Accordingly, a secondary benefit in the use of any of the interlocking coupler designs noted in 4.2.2.1 or 4.2.2.2, will

be reduced contour angling.

The centering device of Concept 1190 has a definite application for reducing contour angling possibilities and potential for derailments. In this concept, the unit imposes a centering force on the coupler shank with increasing magnitude as the buff forces are increased on the coupler (such as in emergency braking situations).

The draft gear impact-absorbing device includes a center return draft spring which acts through a yoke onto the coupler shank. The draft gear yoke and the coupler shank butt have spherical bearing surfaces on either side. During lateral movement of the coupler, the shank leaves the spherical bearing surfaces and abutts on one of the side extending portions in the yoke. This results in the force of the return spring in the draft gear being exerted on one side of the coupler shank, thus there is a centering force applied to the shank. A greater thrust against the return spring (as involved in greater buffing forces) results in a greater centering force being applied to the outer lip of the shank butt. The result is a reduced contour angling and a reduced lateral force vector, which lowers the probability for a derailment.

#### **4.2.2.4 Reduced Maintenance**

Each of the design concepts relating to reducing free slack or interlocking coupler heads has a secondary benefit of reducing coupler maintenance because of a reduction in wear on the coupler head. In addition, the standard manganese-steel wear plates, which are universally used at heavy friction wear points, result in reduced long-term maintenance.

The only concept which specifically addressed itself to reduced maintenance was the use of lubrication fittings as defined in Concept 503a. This is not a new engineering concept, but it represents the type of small initial cost in a coupler system which can result in extensive reduction in long-range maintenance costs. Even though the lubrication fittings may not be used in a scheduled periodic maintenance program, the use of this design concept should be applied universally at heavy wear points in coupler systems to help reduce component wear.

The use of other materials for the standard wear plates has not been included as a new concept, since the manufacturers who supply wear plate materials are continually in a program of upgrading the value of these wear plates by increasing their wear and self-lubrication properties.

#### 4.2.3 Mechanical Uncoupling (Category III)

Mechanical uncoupling system design capabilities are limited by the overall coupler design. Thus, the concepts for mechanical uncoupling are logically defined by the two design types ("free" and "rigid") of construction as outlined in Section 4.2.2. The analysis of the various uncoupling concepts was therefore grouped similar to Section 4.2.2 for those which were noncompatible with the "E" system and those which are compatible with the current basic system.

Once characterized in terms of compatability, each concept was reviewed for impact upon functional characteristics involving improvement of uncoupling or recoupling capability. In addition to examination of specific functional characteristics, emphasis was placed upon analysis of each concept concerning its potential

to operate satisfactorily under the expected environmental extremes, particularly with respect to contamination and mechanical damage.

#### 4.2.3.1 Noncompatible with "E" System

The Concepts falling into this category are generally applicable to the "rigid" type of coupling systems, which include the flat-face and spread-claw types. Some of the control systems to be discussed in the subsection "Automatic Uncoupling Release From Within Train" are potentially applicable as control mechanisms for compatible systems. This possibility will be discussed, however, in the general systems discussion of Section 4.2.4.

1) Alternate Side Lever Uncoupling: Only two systems offered concepts including the addition of an alternate mechanical side lever to initiate uncoupling. These were Concepts 301a and 309. This concept allows the potential for initiating the mechanical uncoupling from either side of the car, which would be a particular advantage for switching in flat yard operations. The concepts included a second uncoupling lever attached to the coupler head with a cable connection or a rigid joint-and-shaft system, with the latter system as shown in Concepts 309 being the more preferable as being a mirror image of the proven uncoupling system.

2) Side of Car (Push-Button) Uncoupling: For increased switchman safety, it is desirable that mechanical uncoupling could be initiated at a point outboard from the outside surface of the car. This could be accomplished by either a mechanical linkage or other remote connection device.

Concept 309 included the concept of an uncoupling release

by operating an air valve located at the extreme outside of the car. Similarly, Concept 511a included initiation of uncoupling by operating the pneumatic uncoupling system from an air valve at the side of the car. In the electropneumatic control system, Concept 254, there is an option for an electrical switch at the car exterior which would initiate uncoupling through the electropneumatic control system. Each of these concepts appears to offer an equal potential for side-of-car uncoupling; both Concepts 309 and 511a are dependent only upon an air system, while Concept 254 requires both an air and electrical control system.

3) Automatic Uncoupling Release From Within Train: Several concepts were evaluated which had a capability for initiating the uncoupling sequence by an external source. For the most part, these involved the uncoupling release from within the car being uncoupled (as required for rapid transit applications). Four different techniques of control were used. A listing of these techniques and the concept references follows:

(a) Electropneumatic system - in which the signal is generated electrically and then followed by the uncoupling force being generated from a pneumatic force cylinder. Concepts 9, 27, 33, 36, 254, and 503a are significant. The only problems noted with any of these systems was that related to excessive force required to operate the uncoupling mechanism such as is the case of Concept 33. The other systems are best characterized by Concept 254 which embodies features included in other concepts.

(b) Pneumatic switch control - in which uncoupling is initiated through an air pressure signal transmitted remote from the coupler area. This concept was included in Concepts 301b, 309, 391, and 511a. Each of these systems was limited, however, to the uncoupling signal coming from the adjacent car and is not considered generally adaptable to a long train situation pending

some sort of inter-car connection including a logic and control system. The best of these systems is characterized by Concept 309. The vacuum brake release system concept of Concept 45b could be considered for this type of uncoupling control, however, it is considered to have greater control difficulties and would likewise need a separate logic and control system.

(c) Electric switching - in which the external control signal is transmitted electrically to the coupler head with the uncoupling lever actuated by an electrical solenoid or linear actuator. This concept was embodied in Concept 301b and 450a. A review of user reports indicates a continuing problem with direct electrical solenoid operation of the uncoupling mechanism. Environmental contamination can cause a binding of the uncoupling mechanism and, if the coupler is in any force state other than free slack, there is possibility of binding due to buff or draft forces. None of the coupling concepts which were reviewed offered a solution to these potential binding problems. Therefore, the direct electrical operation of uncoupling mechanisms through electrical solenoid or linear electrical actuators is not recommended.

4) Automatic Uncoupling Release From A Point External To Train: Among the several concepts reviewed were systems for an external mechanism to operate the standard uncoupling lever. These included, for example, a rotating brush system which would force up the uncoupling lever as the brush system rotated between the cars to be uncoupled. A second system for performing the same operation was an electric eye which would detect the opening between cars and actuate an arm system which would mechanically raise the uncoupling lever. These and other totally external systems were not evaluated as being significant, since they applied to a system which was totally external to the train.

The only concept directly applicable for an external control system was Concept 450b, a microwave transmission control system. This is a viable concept for control, assuming that each car has its own logic system, and its own power generation system, or that there is an intercar electrical power connection and appropriate electric or pneumatic uncoupling devices are included in each car uncoupling system.

Concepts relating to an external electromagnetic uncoupling signal were not included as significant, since these depended upon the need of a electromagnetic coupling between cars (such as Concept 1150), which is not accepted as being a viable concept because of the extremely high force and electromagnetic currents which would be required in order to maintain the coupling of all road operating conditions.

5) Uncoupling in Draft: A basic design feature of all coupler systems reviewed was that they are designed to have increasing resistance to uncoupling as the draft loads increase. This results in an increasing bind on the unlocking components as the draft load increases, which has the tendency to prevent accidental uncoupling as the locking mechanism components become worn. This is considered to be a desirable feature as it relates to safety of operation.

Two types of unlocking mechanisms were demonstrated. Hooks forced apart by sliding rod or wedge action (such as Concepts 33, 47a, and 511a), and hooks forced apart by a rotating cam action (such as Concepts 9, 27, 301a, 391, 457, 503a). The sliding wedge or rod unlocking systems all evidenced binding and force problems with minimal draft forces. The rotating cam unlocking concepts indicated unlocking forces of about 100 (Concept 301a) to 1,000 pounds (Concept 503a) and up to a maximum of 8,800 pounds

(Concept 391) by use of a pneumatic force booster.

In summary, the concept of uncoupling in draft is not considered to be a viable concept except when it involves nominally low draft loads. Even the highest draft load uncoupling capability evidenced in Concept 391 was obtained only with the use of a full 100 psi line pressure acting through an air cylinder. Since switching operations would be enhanced by a capability for uncoupling in draft, a rotating, air-force boosted, unlocking cam (such as in Concept 391) is suggested as the most viable concept.

6) Knuckle (Or Locking Mechanism) Always Open After Uncoupling: Probably the most important feature relating to the reduction of the probability of coupler bypass is the knuckle open feature. In the noncompatible coupler systems, most of the designs included this concept. Two different techniques were utilized: a spring-loaded locking device and a gravity-drop locking device.

Those concepts offering a spring-loaded locking hook, plate or pawl included Concepts 6a, 9, 27, 33, 301b, 391, 448a, 457, 503a, 511a, and 516a. Of these, the better systems were those having a spring-loaded locking hook or pawl, with Concept 309 perhaps exhibiting the typical system in this regard. However, almost all of the other concepts share equally in this capability.

The gravity-drop type of locking system as evidenced in Concept 47a is not considered acceptable for this requirement since the unforced gravity lock drop system is subject to potential jam-up due to accumulation of environmental grime, etc.

7) Mechanism To Prevent Coupling: Two concepts indicated a capability for manual lockout of the coupler locking system in the closed position. Concept 309 contained a provision to lock open the locking pawl manually to prevent automatic recoupling upon subsequent coupler contact. Concept 457 contained a provision whereby the uncoupling lever could be locked in the position holding the locking hooks open. The provision offered by these concepts seems desirable as an aid to yard switching operations by preventing the automatic recoupling of cars for temporary car movement operations.

8) Summary: The coupler system Concept 309 has been previously identified as having the best overall features in the Category II of mechanical coupling. This system also exhibits the greatest potential for including the desirable characteristics of mechanical uncoupling. An additional desirable feature would be the addition of the rotating cam uncoupling concept as noted in Concept 391, which would increase the potential for uncoupling in draft. Where a full train-control system is desired, Concept 254 offers the greatest potential for accomplishment of automatic uncoupling from the side of the car or elsewhere within the train. If automatic uncoupling release is desired from a source external to the train, the only viable concept is Concept 450b.

#### 4.2.3.2 Compatible With "E" System

As previously indicated, there were considerably fewer concepts applicable to changes compatible with the "E" type coupler system. These did, however, address themselves to some of the more pressing problems in the present coupler system.

1) Alternate Side Lever Uncoupling: The Type "H" tight

lock coupler system (Concept 428a) offers an optional double lock lift assembly which allows for the use of a second side uncoupling lever. Concept 502b includes the provision for a rotary bottom lock set unit, which likewise allows for the use of a second side uncoupling lever. Both of these are viable concepts and have been in use in passenger car and locomotive applications.

2) Remote Uncoupling: Two types of remote uncoupling systems were reviewed, each relating to the operation of the Type "E" system uncoupling lever by use of a remotely controlled device involving the use of hydraulic or electrical forces.

Concepts 1046 and 943 refer to a hydraulically operated mechanism which directly operates the uncoupling linkage in the standard Type "E" coupler system. Since this type of uncoupling mechanism has been successfully demonstrated for the noncompatible systems (Concepts 309, 391), this approach has definite potential assuming that it is associated with an acceptable control system.

Concepts 502c and 1045 rely on operation of the uncoupling levers directly from the force of an electric solenoid. This approach is not accepted as totally feasible because of the problems of excessive power load which can possibly be required to "break loose" the uncoupling rod and mechanism when they are in a bind or locked into position from environmental factors.

Side of car pushbutton operation of the uncoupling lever could be accomplished by use of Concept 674 in which remote actuation of an air valve is made possible through the use of a flexible cable system. This concept would be used in conjunction with the hydraulic uncoupling mechanism operation of Concept 943.

For control of unlocking mechanisms from within the train, Concept 254 offers the best potential for having a combination of electropneumatic control of the various uncoupling mechanisms.

Where uncoupling is to be initiated external to the train, Concept 450b, the microwave transmission system, offers the greatest promise. In either case the use of these remote control systems would require inter-car connections and a logic and control system.

3) Uncoupling In Draft: None of the concepts reviewed were considered to be either viable or significant in terms of accomplishing uncoupling in draft for the "E" type coupler system.

4) Knuckle Always Open After Uncoupling: Only Concept 502b was considered to be viable and significant in terms of an automatic knuckle open condition at uncoupling. In this concept, the knuckle is held in the open position after uncoupling by the force of a spring-loaded lever. The spring force maintains the knuckle open to prevent accidental vibration or shock closure during switching operations. The spring loading can be removed only by the mechanical force of a mating coupler as it comes into final coupling engagement.

5) Summary: Concept 502b incorporates the knuckle open capability and provides the design potential for use of an alternate side lever. For remote uncoupling capabilities, a hydraulic or pneumatic operating lever of Concept 943 can be utilized in conjunction with the cable remote actuator, Concept 674, or with the external control mechanism Concept 254. If remote actuation control is desired, Concept 450b offers potential for control external to the train.

#### 4.2.4 General Systems (Category IV)

The various system control concepts which were reviewed were generally applicable only to noncompatible "rigid" type coupling systems or to compatible add-on systems. This was particularly true of brake control and electric train line systems. The train sensing and control systems, however, are related to the general logic and control functions, which are basically accomplished separate from the coupler. These latter concepts were therefore grouped together as being equally applicable to all types of coupling systems.

##### 4.2.4.1 Brake Control System

1) Noncompatible Integral Systems: These concepts are closely related to those listed in Sections 4.2.1.3 and 4.2.1.4 above in that brake control is interrelated with operation of the airline valves. Two system concepts were evaluated, namely: direct electrical brake control and electrical signal control to operate braking from pneumatic means. Electrical braking of freight cars (as in Concept 450a) is not considered practical because of the extreme braking energy which is required and the associated electrical power demands both at the car and in car interconnections.

Electropneumatic brake control concepts were exhibited in Concepts 9, 27, 254, and 503a. Concept 254 is assessed as having the most complete overall brake control system and with the most potential for a reliable system.

2) Compatible Add-On System: Concept 45b included a system for centrally operating brake release on all cars by way of a second airline system. Pulses of 2 psi vacuum would be made

to operate quick release valves located on each car. Such a system would be applicable to bleed all cars simultaneously in preparation for hump switching. Considering the cost, operational, and safety problems involved with a second complete airline system capable of transmitting vacuum as compared to the minimal benefits of simultaneous car bleeding for hump switching, this concept is not considered sufficiently realistic for consideration. In addition there is good reason to question the capability of maintaining a nominal vacuum throughout the interconnection system involved in a long train.

Concept 22 includes provisions for maintaining the car pressure and therefore leaving brakes unset under intentional uncoupling conditions (operation of uncoupling lever initiates the valve action) and automatically sets the brakes under unintentional uncoupling conditions.

#### **4.2.4.2 Electrical Train Line Systems Of Noncompatible Integral Types**

The concepts relating to electrical train line systems generally divide themselves among the spread-claw type of "semirigid" coupler systems where few electrical circuits were utilized and for the flat-face "rigid" coupler systems where large numbers of electrical circuits were required.

1) Automatic Connection: The concepts relating to automatic connection devices were divided into connection systems located on the top, sides, bottom, or within the face of the "rigid" coupler system.

As indicated in subsection 4.2.1.1 in the discussion of air connector systems, the attachment of electrical or air

systems above the primary coupler face is not considered an acceptable concept. This approach (Concept 301b) involves the use of space, which has too great a potential for damage from loading and operations.

Electrical connector systems located on either side of the flat faced "rigid" coupler included Concepts 254, 301b, 450a, and 511a.

Those concepts utilizing a connector system suspended below the flat coupler face included Concepts 9, 27, 391, 503d, and 511a.

Both the side-supported and lower-suspended electrical connection systems offer the potential for large numbers of contacts to be included in the electrical system. The potential advantages of support rigidity, contact protection, and insulation are considered equal for these two approaches. The primary disadvantage to the lower-suspended electrical connection system is that it is subjected to a slightly greater degree of environmental contamination, particularly with respect to water and ice thrown up from the road bed during normal operations. In several technical reports, there was reference to ice and rusting problems in the lower-suspended electrical boxes.

The side-supported electrical boxes, although in a better position with respect to environmental contamination, are subject to greater potential for bypass damage. In addition, the side-supported units have a greater problem in maintaining adequate protection of these electrical boxes from damage resulting from coupling on curves or with couplers at diverging angles.

The spread-claw type of "semirigid" coupler lends itself to electrical connections being contained within a protected

central portion of the coupler. Concepts embodying this principle included 33, 36, 45, and 309. From an environmental protection viewpoint, this concept offers greater potential in the operational environment required in freight rail service.

2) Contact Capacities: Automatic electric connectors have been subject to intensive development effort for use with rapid transit cars. This application required the transmission of significant power levels and the utilization of extensive number of circuits. On the other hand, the rapid transit application did not require capabilities for meeting severe environmental requirements, as in the case of freight rail service.

In addition, rail freight connectors for either air or electricity must withstand a greater amount of coupler motion because of manufacturing tolerances and operational wear. Electrical connectors must tolerate a sliding motion during the coupling operation and continuous vibration and shock motion during rail operations over rough track.

Two types of concepts were evaluated with respect to the technique of making the electrical connection: butt type and pin/socket type connections.

The butt type connection included Concepts 9, 27, 36, 301b, 450a, 503a, 511a, and 516b. The best of these concepts included a spring backup system with a rotating contact technique as used in Concept 450a. This technique requires the contact to rotate about its central axis while it is being forced forward by a loading spring. This offers a distinct potential for overcoming environmental buildup on the butt surface of the contactor by a wiping action while the contactor is making final connection. Silver plated contact tips (Concept 516b) or replaceable silver

contact tips are desirable for this type of butt connector.

The pin/socket type of contactor was exhibited in Concept 33, 45c, and 309, all applying to spread-claw type couplers. Problems with burning of contact surfaces while switching under load were noted with Concept 45c. This problem, however, is considered of lesser difficulty than the inherent problem of overcoming the shearing forces on electrical contacts involved in the lateral and vertical movement of mated couplers. Since long-range coupler wearing (and therefore increase in free slack) is not a controllable item, it is believed that the pin/socket concept of electrical contacting is not as feasible for rail freight service as are butt type contacts.

3) Automatic Sequencing Of Contactors: The problem of arcing between electrical contactors was evidenced in several of the technical references. Although some concepts of sequencing electrical contactors reported to make a "quick" engagement of the contacts, it is still concluded that any contact circuit completion under conditions of heavy amperage load will result in arcing or pitting of the contacts and reduced contact life and reliability. Three possible solutions are offered to this problem:

(a) All contact engagement to be made with electrically dead contacts. In such situation, the locomotive control must energize all electrical circuits after coupling and deenergize them prior to uncoupling.

(b) Use of pilot contactors which energize a very low power circuit, which in turn actuates an external contact closing mechanism (such as Concept 503b), which then closes the electrical circuit to the already mated contactors.

(c) The use of low electrical power circuits on all electrical contactors to operate solid state type electrical

switching devices which in turn energize pneumatic devices which accomplish the high energy functions. (This concept is basically embodied in Concept 516b.) This approach could be used in combination with the pilot contactor concept of (b) above.

Many different techniques have been suggested for automatically sequencing the contactors into position. The significant concepts are grouped as follows:

(a) Contact block engaged by air inflation of a piston or diaphragm (Concepts 9, 27, 254, 301b, and 516b). Of these, the more promising are Concepts 254 and 516b. A most desirable feature for manually extending or retracting the electrical contactor pins is embodied in Concept 516b. This would allow an excellent backup system in case of a malfunction of the basic control or air inflation system.

(b) Contact closure through use of mercury relays (Concept 450a and 503a) is not considered an acceptable approach since the mercury contact system has a potential for extraneous circuit completion or malfunction as a result of vibration and shock forces which are expected in all phases of rail operations.

(c) Mechanical levering of contactor during the coupling sequence (Concept 511a) is considered to have too many potential difficulties because the close interlocking tolerances required from the mating surfaces. In this concept, the electrical contacts are engaged under spring force while the coupler faces are approximately 0.625 inch apart. This increases the depth to which the insulators must engage and magnifies the problem from slight misalignment in the coupling heads which would be corrected during the final 0.625 inch travel.

Good maintenance features were noted in Concept 254 relating to the ease of removal of the contact box after engagement for

any maintenance requirements. In the spread-claw type of coupler design contact system, Concept 309 exhibited the best system for removal of the contact system from the rear of mated couplers.

4) Environmental Protection of Connectors: The performance requirement that all coupler systems must be compatible with the expected operating environment is particularly relevant to the design of electric connectors. Contact corrosion problems can be surmounted or controlled by the use of specifically designed component materials (such as silver plating in Concept 516b). Specific environmental conditions which could cause problems with electrical connectors include:

- (a) High humidity and water conditions which lead to potentially high corrosion rates created by galvanic corrosion initiated by electric potential across the dissimilar materials.

- (b) Temperature extremes varying from -50 degrees F to +140 degrees F may be encountered as the freight cars are in use or on storage tracks. This environment can have a particular impact in deterioration of rubber diaphragms or embrittlement of of plastic insulator materials.

- (c) Basic surface contamination of dust, dirt, or environmental grime can be expected to build up on the electrical contactor faces and in moving portions of the system.

- (d) Extensive vibration and shock is expected on all parts of the system during road operations. In addition, the electrical connector (and air connector if supported below the coupler head) will be subject to impact damage from flying rocks and debris while the train is in motion.

The approach taken in almost all concepts to protect against environmental damage to, or interference with, connector operation has been the use of an environmental protection cover.

The cover apparently gives good environmental protection but universally presents a problem in assuring that the cover is opened up or pushed aside prior to final coupling, in order that the electrical contacts are open. The three different approaches taken to accomplish this cover movement were:

(a) Direct retraction of a lower mounted cover by coupler movement of a guide pin or push bar (Concepts 511a and 516b) are analyzed as having distinct problems for consistent operation. In the case of Concept 511a, the door depressing pin would be subject to damage or deformation from coupling forces involved in wide angle coupling. In Concept 516b, the horizontal push bar would have a high probability of incurring damage from coupling impacts on one edge of the pushbar. Any pushbar or direct acting pin would have to be extremely strong to withstand the lateral forces of coupling while depressing smoothly as required to operate the cover mechanism. In addition, Concept 516b utilized a lower recessed track in which the box cover would slide. This concept would have a high probability of clogging up with grime or ice and thus blocking the path needed for movement of the cover.

(b) A wedging or levering aside of the cover by direct contact from the opposing cover (or a guide arm extending outward on the cover) was exhibited by Concepts 9, 27, 33, 36, 43c, 254, 309, 503a, and 516b). There were numerous reports from users as to difficulties on this type of cover mechanism in which coupling damage occurred to the cover which prevented it operating smoothly enough to be levered aside prior to the final coupling. These reports of coupling damage were particularly prevalent on the side mounted electrical connector unit.

(c) Removal of the cover after the mechanical coupling was complete was exhibited by Concepts 301b. In this system, the

completion of the mechanical coupling engaged a switching mechanism which released pneumatic pressure to lever aside the electrical contactor cover following which a separate pneumatic piston operated to move the contacts forward into electrical mating. No environmental protection cover was used as an option in Concept 516b, in which case a sealing gasket was used around the periphery of the face of the electrical contactors to provide a tight seal between opposing electrical boxes when coupled. It should be noted that a large number of rapid transit electrical box covers have been reported to be removed following damage suffered in rapid transit service.

Other refinements which were noted to have good promise include the use of nylon bushings for all pivot points on the door (Concept 36). This was found to decrease door opening resistance under environmental conditions and improve the mechanical levering aside of the cover. Electric deicing has been tried in rapid transit service and has not been found to be effective because of mechanical difficulties encountered with this system between times when the deicing system was required for use. In addition, for rail freight service, electric deicing would only be operative on the one electric box attached to the power generating system and would not be applicable for cars during yard switching operations prior to their being coupled. A concept of applying plastic covers to the inner and outer surfaces of the connector covers was used in Concept 516b to protect electrical pins from an accidental short circuit in the event of a bent or damaged cover assembly.

#### **4.2.4.3 Electrical Train Line Systems Of Compatible Add-On Types**

In terms of specific add-on systems which are compatible with the Type "E" system, a minimum of new concepts were available

able for review and analysis. These are commented upon below with reference to the particular capabilities of each concept.

1) Concept 22: This is an added electrical connection device which is attached to the air connection system which is attached under the head of an "E" type coupler system. The best features of this electrical connector is that it utilizes the basic gathering capabilities and the spring-loaded seating capabilities of the basic air connector system.

2) Concept 502c: This electrical connection system is applicable only to a "F" type of system in that it is integrally attached with the air connector and is dependent upon the basic gathering capability of the "F" type coupler head in order to achieve the primary gathering of the air/electrical connector head. The electrical portion of this system utilizes the primary spring-loaded system for both the air and electrical final seating pressure. In addition, the electrical contacts are individually spring-loaded to maintain electrical continuity regardless of relative movement between the coupled "F" heads. Four butt-faced electrical contacts are spaced concentrically with the air seal on an approximate 4-inch diameter circle. The face of the connector could accommodate four additional connectors and still have adequate space for individual insulators of approximately 1.25 inches outside diameter. This electrical connector system does not have a system of sequencing or cover protection.

3) Concept 511c: This electrical connector is used in conjunction with the airline connector, Concept 511b, which contains sufficient gathering and centering to operate with a Type "E" coupler system. This system uses butt-type electrical contacts, which are held in place by the forward thrust of a

rubber ball universal and compression joint, which also serves the air connector system. The reliability of the electrical contacts is questionable without having a separate spring-loaded contact system. This concept contains an environmental cover over the electrical contactors, which is levered out of the way by the action of the two air connectors coming into mating. This cover is as vulnerable to potential coupling damage as is the "rigid" type of electrical connector covers. The redeeming feature of this cover-levering operation is that it is utilized on a relatively small electrical connector system and is located very close to the vertical centerline of the coupler head, thus reducing the potential for damage from wide angle couplings.

4) Concept 1200: This concept consists of an add-on electrical unit to be attached to a separate air connector system (such as Concepts 511b, or 22). The final seating action of the air connector gathering mechanism operates a valve in the face of the air connector unit. This valve then channels air line pressure (as quickly as it becomes available) to actuate a piston which thrusts the set of contact pins forward into electrical mating position. Loss of air pressure immediately causes the electrical contacts to retract and disengage. The primary disadvantages noted with this concept are the complexity of the air valve system and the potential difficulty of environmental grime interfering with the proper sliding forward of the contactor cylinder. It is believed that by clustering the electrical contacts around the air connector seal a more uniform seating of the electrical contacts would result. However, the application of separate air cylinders should allow this concept to maintain good electrical contacts.

#### 4.2.4.4 Train Sensing and Control Systems

The concepts concerning sensing systems were almost universally related to the potential for such sensing systems as part of a train electrical system. The potential here is almost infinite and is a function of the amount of money which is to be spent in the sensing equipment. In rapid transit applications, the sensing systems were specifically aimed at detection of proper coupling and proper braking conditions within each individual car.

The concepts concerning control systems can best be reviewed in terms of the increasing complexity of the type of control established. In this sequence, coupling concepts included: brake control; single car uncoupling; general uncoupling; operating of uncoupling and air valves; operating of uncoupling, air valves, and centering devices; and total logic and control system.

1) Brake Control (Concept 45b): This vacuum control system would require a completely separate pneumatic line under vacuum conditions. It is considered an unreliable concept for application in freight trains because of the difficulty in maintaining a nonfluctuating vacuum throughout many inter-car connections.

2) Single Car Uncoupling (Concept 502c): This concept included electric control and operation of a single solenoid uncoupling system on the first car behind the locomotive. As such, it was not a universal system and was not deemed to be applicable to a full freight train.

3) General Uncoupling (Concept 1045): This system consisted of a locomotive control box with individual control boxes in each freight car. The system operated through a network of selecting switches, stepping switches, relays, four individual circuits through the car system, and operating switches and relays within each car. This concept, although valid, utilizes rotating and latching mechanical electrical switching devices which are subject to vibration and mechanical operational problems. Other solid state control devices are seen to be more appropriate for this type of application.

4) Operation Of Uncoupling And Air Valves (Concepts 33, 36, 301b, and 450a): These systems use electrical controls to operate electric solenoid valves and linear actuators.

5) Operation of Uncoupling, Air Valves, And Centering Devices (Concepts 27, 254, 503a, and 511a): These systems add the concept of controlling the centering device by engaging a latching lever or operating valves to activate air centering. Concept 511a utilizes an electrical device. In the other three concepts, an electropneumatic control system is utilized to energize the valves for air-operated centering devices.

6) Total Logic And Control System (Concepts 387, 450a, and 452): These systems all use solid state electronic multiplexing sensory and control systems which utilize a master control system in the locomotive and individual logic and control boxes within each freight car. This type of sensing requires a minimum of electrical interconnection lines (approximately five) in order to accomplish sensing and control functions relating to individual car uncoupling, air valve operation, centering devices, as well as having the potential for sensing inputs. These solid state

systems require a low electrical power transmission used to operate pilot valves which switch air pressure to accomplish all force functions.

#### 4.2.4.5 Improve Operational Safety

Some elements of improvement and operating safety are inherent in each of the concepts which have been reviewed. These can be summarized into three basic areas of safety improvement as follows:

1) Direct improvement of safety of operating personnel. This is accomplished by automatic air connections, automatic operation of air valves, and remote operation of uncoupling apparatus.

2) Indirect improvement in safety for operating personnel by reducing bypass probability. This is accomplished through improved gathering range of coupler head, automatic positioning of the coupler head, and provision for the knuckle to be automatically opened with the uncoupling operation.

3) Direct improvement in operating safety through a lowering of derailment probability. This is accomplished through reduction of free slack, interlocking of coupler heads, entrapment features to hold a mated broken coupler head, and reduced contour angling potential.

## 5. CANDIDATE COUPLING SYSTEMS

### 5.1 BASIC PHILOSOPHY

In order to establish the candidate coupling systems, it is necessary to define the basic functional goals to be achieved by the new coupling systems. It seems reasonable to define the ultimate fully automatic coupler as any coupler system which will, without any manual assistance, couple two or more freight cars mechanically, pneumatically, and (if necessary for full system automation) electrically. Moreover, this fully automatic coupler system should maintain the coupled integrity with highest reliability through all reasonably anticipated service operating conditions.

One of the prime requisites of the fully automatic coupling system must be the ability of the two mating coupler heads to come together, without any previous manual guiding of the coupler head, in such a way that first-time coupling is assured. It is thus fundamental that the ultimate automatic coupling system should include provisions to preclude the possibility of a bypass or miscoupling for any reason.

### 5.2 DEGREE OF AUTOMATION

It should be recognized that not all of the desired characteristics of a fully automatic coupler system are currently embodied in any one new concept or system. The ultimate coupler system can be achieved only through improvements in present basic coupling subsystems or in the addition of new subsystems which give greater capability than that available with the present Type "E" coupler system.

To establish new candidate coupling systems, three basic subsystem areas were defined: coupling and uncoupling capability, air connection and brake valve system control, and full train line electrical systems and controls. The extent of the overall coupling system improvement will be a function of the degree of automation brought about by improvements to individual concepts as they are applied to each of the subsystems noted above.

None of the candidate coupling systems contain all of the potential degrees of improvement or automation which is possible in light of current technology. Each of the candidate coupling systems noted below, however, when taken through the suggested change steps, does represent a potential for achieving a fully automated coupler system which approaches the ultimate desired system.

### 5.3 PRELIMINARY CANDIDATE COUPLING SYSTEMS

Three different coupling design concepts were established as the basic coupling approaches on which to build three candidate coupling systems. These three basic coupling concepts are:

- 1) Free knuckle type coupler, which is fully compatible with (and a modification of) the present Type "E" coupler system.
- 2) Semirigid, spread-claw design, which is not compatible with the present Type "E" system but which represents the best of the concepts utilized in the UIC European synthesis freight car coupler designs and in the majority of mine car applications.
- 3) Rigid, flat-faced, horn-funnel design, features of most current rapid transit systems and some passenger service applications.

The realization of the potential for the full candidate coupling system is achieved through major change steps. These changes are based on a logical increase in system capability and degree of automation. In addition, the change steps take into consideration the system operating problems which would be involved in the retrofit program associated with these changes.

Listed below is a general description of the three candidate coupling systems and the change steps associated with the realization of each.

#### 5.3.1 Compatible System #1

This system is based on utilization of modifications to the basic types "E" and "F" coupler head systems while maintaining the basic free knuckle coupling concepts and a total compatibility with all current U.S. freight lines.

##### 5.3.1.1 Basic System 1-1A (Basic Subsystem for Short Cars)

This subsystem concentrates on changes to the Type "E" coupler head to increase gathering range, reduce free slack, achieve more positive locking of the coupler head, attain capability for vertical interlock and broken coupler entrapment, improve self-centering capabilities of draft gear, and ensure knuckles always being open following uncoupling.

##### 5.3.1.2 Basic System 1-1B (Basic Subsystem for Long Cars)

This subsystem is primarily designed around the needs of the medium-length and longer cars, which require a longer coupler system length with its associated requirements for interlocking of the coupler head to achieve reduced contour angling. This

subsystem centers on modification of the Type "F" interlocking head to achieve the following basic improvements: increased gathering range, achievement of positive locking, attainment of vertical interlock and entrapment of broken couplers for mated coupler heads, reduction of free slack, maintenance of positioning of the coupler head, and achievement of a knuckle open capability for the uncoupled units.

#### 5.3.1.3 System Change 1-2 (Applicable to All Cars)

This change includes the addition of an automatic air connection and valve control system. The automatic air connection unit is coupler mounted and achieves connection of the air system below the coupler head. Salient features of this change are automatic air connection with coupling, automatic air valve control, push-button uncoupling capability from side of car, and provision for automatic control of train braking as a function of intentional or unintentional uncoupling action. This system retains the air hose/glad hand connection capability so that no adaptor system is required for a "mixed" car situation.

#### 5.3.1.4 System Change 1-3 (Applicable to All Cars)

This change adds an electronic and electropneumatic control system for additional capabilities above those achieved by the basic subsystems with the Change 1-2. The primary elements of this system are: the addition of an electrical connector system to the already-attached air connector, the addition of an electropneumatic control system within each car, and the addition of an electronic multiplexing sensing and control system with master unit in the locomotive and logic systems in each car.

This final change would add the following capabilities to the total coupling system: automatic engagement control of the positioning device, selective car uncoupling capability from the locomotive, time delay provisions for setting brakes after intentional uncoupling, and provision for the potential for multiple sensing and control function through an electrical line and connector system.

### 5.3.2 System #2

This system is based on the UIC version of a simplified Willison coupler with a hinged hook design. This system offers potential for an extremely wide gathering range and greater capability for uncoupling in draft while achieving the potential for integral air and electrical connections with a limited number of circuit capacities.

#### Basic System 2-1 (Applicable to All Cars)

The basic system contains the primary coupling features with automatic air connection and valve control. Specific capabilities offered with this system include automatic air connection with coupling, automatic mechanical air valve operation, improved lateral and vertical gathering of approximately four times that of the Type "E" system, positive locking of mated couplers, reduced free slack, vertical interlock and entrapment for broken couplers of mated units, automatic centering of coupler, uncoupling capability from push button located at side of car, some uncoupling capability in draft, knuckle always open after uncoupling, possibility to manually lock out couplers to prevent coupling, and automatic control of braking under intentional or unintentional uncoupling situations.

This system does require the use of an air hose/glad hand adaptor in addition to a coupler head adapter unit when used in "mixed" car coupling situations.

#### 5.3.3 System #3

This system is based on railroad adaptation of a proven rapid transit version of the Tomlinson coupler system which offers a capability for an increase in gathering range of approximately 2.5 times the Type "E" system, and the potential for addition of large numbers of electrical circuits for a sensing or control system.

##### 5.3.3.1 Basic System 3-1 (Applicable to All Cars)

The basic system contains all of the coupler mechanical features as well as an integral air connector and valve control system. Features of this system include automatic air connection with coupling, automatic mechanical air valve operation, improved lateral and vertical ranges, positive locking of mated couplers, complete elimination of free slack, vertical interlock and trapment of broken couplers, reduced contour angling, automatic positioning, provision to initiate uncoupling from a push button at the side of the car, some uncoupling capability in draft, knuckles always open after uncoupling, and automatic control of setting of brakes with intentional or unintentional coupling.

This system requires an air hose/glad hand adapter unit plus a coupler head adapter unit when used in "mixed" coupling situations.

#### 5.3.3.2 System Change 3-2 (Applicable to All Cars)

This change incorporates the addition of electropneumatic and electronic control systems which add the same capabilities as described for System Change 1-3. In addition, this system allows provisions for a great number of electrical circuits (perhaps up to 100), should this be determined to be a desirable capability for later sensing and control systems.

#### 5.4 PRELIMINARY ENGINEERING ANALYSIS

A preliminary engineering analysis of the various individual concepts was included in Section 4. The features and capabilities of each coupling system represent the total of the capabilities of the contained concepts within each system with some interaction modifications. An engineering summary of the combined features of the preliminary candidate coupling systems are included in Tables 5-1 through 5-8. The format for presentation of the three candidate systems is as follows:

- 1) Compatible System #1
  - (a) Basic System 1-1A, Short Car
  - (b) Basic System 1-1B, Long Car
  - (c) System Change 1-2, Addition of Air Connector and Valve Control System
  - (d) System Change 1-3, Addition of Electropneumatic Control System
- 2) Noncompatible System #2, Semirigid, Spread-Claw
  - (a) Basic System 2-1
  - (b) System Change 2-2, Addition of Electropneumatic Control Systems
- 3) Noncompatible System #3, Rigid, Flat-Faced
  - (a) Basic System 3-1
  - (b) System Change 3-2, Addition of Electropneumatic

## Control Systems

These tables are structured to show the following analysis about each candidate coupling system:

- 1) Operational characteristic improved or modified by this coupling system.
- 2) Concept description and operating features.
- 3) Primary bibliography reference number.
- 4) Possible alternate design realization bibliography reference numbers.
- 5) Estimated quantitative values of improvement.

### 5.4.1 Principal Operating Features

Listed below are the principle operating characteristics and features of each of the coupling systems and the changes made.

#### 5.4.1.1 Compatible System #1

This system is built around concepts which are totally compatible with the present Type "E" coupler system. For the two basic systems and each of the two system changes, there would be no requirement for separate adapters in order to make this system compatible when used in a "mixed" car system. Pertinent operating features of the systems are as follows:

- 1) Basic System 1-1A, Short Car (Table 5-1)

The Basic Short Car System 1-1A is built around the capabilities of the standard Type "E" coupler head with changes to add a top and bottom shelf with guard-arm extensions, changing

TABLE 5-1.-CANDIDATE COUPLING SYSTEMS - COMPATIBLE SYSTEM NUMBER 1-1A (BASIC SHORT CAR SYSTEM)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM                                                                                                                                                                                                                                                                                                                                   | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | BIBLIOGRAPHY<br>REFERENCE NUMBERS                                |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT                                                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | PRIMARY                                                          | POSSIBLE<br>ALTERNATE |                                                                                                                                  |
| <p>IMPROVE MECHANICAL COUPLING</p> <p><u>Automatic Engagement</u></p> <p>Lateral Gathering Range</p> <p>Vertical Gathering Range</p> <p>Positive Locking</p> <p><u>Positive Retainment</u></p> <p>Wider Coupler Speed Range</p> <p>Reduced Free Slack</p> <p>Vertical Interlock and Broken<br/>Coupler Engagement</p> <p><u>Location Control</u></p> <p>Self Centering</p> <p>Reduced Maintenance</p> | <ul style="list-style-type: none"> <li>Coupler knuckle contour change.</li> <li>Guard arm extension faces on top and bottom shelves.</li> <li>Compatimatic* coupler head (positive mechanical rotation of lockset by force of mating coupler head).</li> <li>Compatimatic* coupler head with mechanical forced unlocking.</li> <li>Revise front shape of knuckle (add 5/64" to front face).</li> <li>Top and bottom coupler shelf (self-interlocking to prevent both top and bottom slip-over).</li> <li>Self centering draft gear/shank design (draft gear compression forces act to bias shank laterally).</li> <li>Lubrication fittings at coupler head and shank wear points.</li> </ul> | <p>501</p> <p>702</p> <p>702</p> <p>502</p> <p>501</p> <p>54</p> | <p>502</p>            | <p>6.875" (1.7 x standard)</p> <p>Approximately 6" (2 x standard)</p> <p>0.625" (0.8 x standard)</p> <p>+2" (0.6 x standard)</p> |
| <p>IMPROVE MECHANICAL UNCOUPLING</p> <p><u>Decoupling Capability</u></p> <p>Knuckle Always Open</p> <p>IMPROVE GENERAL SYSTEMS</p> <p><u>Operational Safety</u></p>                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>Compatimatic* coupler head (knuckle is spring loaded in open position when uncoupled).</li> <li>Blunt and round front edges of coupler and shelves (reduced possibility of rupture of tank car in derailment situation).</li> <li>Not required.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                            | <p>502</p> <p>54</p> <p>N/A</p>                                  |                       | <p>Estimated 60% reduction of rupture probability</p>                                                                            |
| ADAPTER TO MAKE COMPATIBLE WITH<br>"A" TYPE "1" SYSTEM                                                                                                                                                                                                                                                                                                                                                | Note: (*) Developed by National Castings Division,<br>Midland Ross Corporation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                  |                       |                                                                                                                                  |

of the knuckle contour, and revision of the front shape of the knuckle. These basic changes result in the improved capabilities of increased lateral gathering range to 6.875 inches, increased vertical gathering range to approximately 6 inches, reduced free slack to 0.625 inch, and vertical interlock to prevent the slipover of mated type "E" couplers and to entrap a broken mated coupler. The capability of increased gathering is augmented by the addition of self-centering draft gear which use the force of the compressed draft gear to bear on an offset in the shank to force recentering of the shank to within 2 inches of center. The combination of an increase in lateral gathering to 6.875 inches with self-centering should properly align couplers for mating under almost all switching operations.

To achieve absolute coupling capability, a change to the Compatimatic\* coupler head has been added. This concept keeps the knuckle of an uncoupled unit in the open position by the use of a preloading spring device. The Compatimatic\* concept includes a "sensing mechanism" that disengages the knuckle open feature upon mating with another coupler. The Compatimatic\* also assures positive locking by a mechanical rotation of the lockset by the force of the mating coupler head.

The Compatimatic\* coupler concept, similar to the standard Type "E" system, has a minimal capability for uncoupling in draft. The basic design of the free knuckle type of coupler is such that a draft or tension force on the knuckle causes the pivot arms to squeeze against the locking mechanism of the coupler. Since uncoupling is initiated by mechanically lifting the lock up and away from the rear of the knuckle, the forces applied by draft are such that this type of coupler essentially cannot be uncoupled in draft.

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Note: (\*) Developed by National Castings Division, Midland  
Ross Corporation.

Two other features included in this coupling system relate to reduced maintenance and improved safety. Field reports indicate that a light greasing of the locking components exerts a greater influence on locking and unlocking reliability than does surface roughness of the locking pieces or other environmental factors. Thus, lubricated fittings are added at strategic points in the coupler head and shank wear points.

Recent safety tests have indicated that the leading edges of overriding couplers could act like a "punch" to pierce a tank car head during a derailment situation. This coupling system has an added concept of blunting and rounding the front edges of a coupler and the added shelves to increase safety.

## 2) Basic System 1-1B, Long Cars (Table 5-2)

This coupling system is built around the same basic concepts as the Short Car System 1-1A except that it utilizes the Type "F" interlocking coupler head as the basic unit. As previously discussed in Section 4, long cars require an interlocking coupler head in order to reduce the contour angling which would otherwise occur with the required long shank. The Type "E" coupler head with the double shelf addition is still inadequate in terms of needed interlocking for the long car coupler head.

The regular bell-housing for the long shank couplers allows a lateral movement of approximately plus or minus 15 inches at the coupler head. Even if absolute centering were achieved for the coupler, the 6.875 inches lateral gathering offered with this system would be inadequate to cover the approximately 15 inches of offset, which is possible as cars approach tangent at cross-overs or maximum curvature points. This candidate system therefore utilizes a positioning device to steer the coupler head

TABLE 5-2.-CANDIDATE COUPLING SYSTEMS - COMPATIBLE SYSTEM NUMBER 1-1B (BASIC LONG CAR SYSTEM)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM                                                                                                                                                                                                                                                          | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                                        |
| <p><u>IMPROVE MECHANICAL COUPLING</u></p> <p><u>Automatic Engagement</u></p> <p>Lateral Gathering Range</p> <p>Vertical Gathering Range</p> <p>Positive Locking</p> <p><u>Positive Retainment</u></p> <p>Wider Coupler Speed Range</p> <p>Reduced Free Slack</p> <p>Vertical Interlock and Broken<br/>Coupler Entrapment</p> | <ul style="list-style-type: none"> <li>. Coupler knuckle contour change.</li> <li>. Type "F" interlocking coupler head.</li> <li>. Competicmatic* coupler head (positive mechanical rotation of lockset by force of mating coupler head).</li> <li>. Competicmatic* coupler head (with mechanical forced unlocking).</li> <li>. Revise front shape of knuckle (add 5/64" to front face).</li> <li>. Type "F" interlocking coupler head (interlocking arm pocket).</li> <li>. Top coupler shelf (to prevent top slipover of type "E" mated coupler).</li> <li>. Type "F" interlocking coupler head.</li> </ul> | 501                               | 502                   | 6.875" (1.7 x standard)                                                |
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 428                               |                       | 4.5" (1.5 x standard)                                                  |
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 502                               |                       |                                                                        |
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 502                               |                       |                                                                        |
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 501                               |                       | Approximately 0.3" (0.4 x standard)                                    |
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 428                               |                       |                                                                        |
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 52                                |                       |                                                                        |
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 428                               |                       | Lateral = 3.75°<br>rocking<br>Vertical = 2°<br>rocking, 0.125" sliding |
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 31                                |                       | Eliminate estimated 907 of bypasses                                    |
|                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 25                                |                       |                                                                        |
| <p><u>Location Control</u></p> <p>Reduced Contour Angling</p>                                                                                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>. Hydraulic, direct guided coupler positioning device.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 428                               |                       |                                                                        |
| <p>Automatic Positioning</p>                                                                                                                                                                                                                                                                                                 | <ul style="list-style-type: none"> <li>. Vertical spring carrier system.</li> <li>. Lubrication fittings at coupler head and shank wear points.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 25<br>503                         |                       |                                                                        |
| <p><u>Reduced Maintenance</u></p>                                                                                                                                                                                                                                                                                            | <p>Note: (*) Developed by National Castings Division, Midland Ross Corporation.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                   |                       |                                                                        |

TABLE 5-2.-CANDIDATE COUPLING SYSTEMS - COMPATIBLE SYSTEM NUMBER 1-1B (CONTINUED)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM                                                                                                                                                                | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                                                                             | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|-------------------------------------------------------|
|                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                 | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                       |
| <p>IMPROVE MECHANICAL UNCOUPLING</p> <p><u>Recoupling Capability</u></p> <p>Knuckle Always Open</p> <p>IMPROVE GENERAL SYSTEMS</p> <p><u>Operational Safety</u></p> <p>ADAPTER TO MAKE COMPATIBLE WITH<br/>AAR TYPE "E" SYSTEM</p> | <p>• Compaticmatic* coupler head (knuckle in spring loaded in open position when uncoupled).</p> <p>• Blunt and round front edges of coupler and top shell (reduced possibility of rupture of tank car in derailment situation).</p> <p>• Not required.</p> <p>Note: (*) Developed by National Castings Division, Midland Ross Corporation.</p> | 502                               |                       | Estimated 60% reduction of rupture probability        |
|                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                 | 52                                |                       |                                                       |
|                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                 | N/A                               |                       |                                                       |

toward the center of the tracks. The combination of this positioning device and the built-in lateral gathering range of 6.875 inches should result in an elimination of approximately 90 percent of bypass situations involving long cars.

The knuckle contour change and Compatimatic\* head concepts are the same as for system 1-1A. This system also includes a top coupler shelf which is required to prevent top slipover of a Type "E" coupler which would be mated to this Type "F" coupler system.

### 3) System Change 1-2, Addition of Air Connector and Valve Control System (Table 5-3)

As the next significant step in increasing the degree of automation, this system change adds an automatic air connector and valve control system to the basic candidate coupling systems 1-1A and 1-1B.

The air connector system chosen for this candidate system is the coupler mounted, spread-wing type with butt facing air seals. The air connector has built-in 5-inch lateral and 4-inch vertical gathering range such that it will operate satisfactorily when mounted independently with the Type "E" system 1-1A as well as with the Type "F" system 1-1B. A simpler air connector system could have been chosen for application on the Type "F" equipped cars; however the use of one standard air connector system is believed much superior for both economy of production and ease of making effective air connections between "mixed" cars. The proposed air connector system, in addition, has already been subjected to several years of field trials and has a proven potential to meet all general service requirements.

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Note: (\*) Developed by National Castings Division, Midland Ross Corporation.

TABLE 3-3.-CANDIDATE COUPLING SYSTEMS - COMPATIBLE SYSTEM NUMBER 1-2 (ADDITION OF AIR CONNECTION AND VALVE CONTROL SYSTEM)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM                          | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                                                                              | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|-------------------------------------------------------|
|                                                                                              |                                                                                                                                                                                                                                                                                                                                                  | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                       |
| IMPROVE TRAIN AIR LINE SYSTEM<br><u>Automatic Control</u><br>Automatic Air Connection        | Automatic air connection system with horizontal articulation capability.                                                                                                                                                                                                                                                                         | 22<br>1,192                       | 511, 502              | Lateral = 5";<br>Vertical = 4";<br>Angular = 70       |
| Automatic Air Valve Control                                                                  | Automatic mechanical air valve operation (mechanical push rod in face of air connector initiates valve action).                                                                                                                                                                                                                                  | 22                                |                       |                                                       |
| <u>Improved Performance</u><br>Air Seal Leak Rates, Hose Reliability and Reduced Maintenance | Automatic air connection system.                                                                                                                                                                                                                                                                                                                 | 22                                |                       |                                                       |
| IMPROVE MECHANICAL UNCOUPLING<br><u>Uncoupling Capability</u><br>Push Button Release         | Remote uncoupling button at side of car (opens air valve).<br>Hydraulic uncoupling operating mechanism (direct pneumatic operation of standard uncoupling linkage).                                                                                                                                                                              | 674<br>943                        |                       |                                                       |
| IMPROVE GENERAL SYSTEMS<br><u>Automatic Train Brake Control</u>                              | Provide for nonbraking (retention of air) after intentional uncoupling.<br>Provide for emergency braking after unintentional uncoupling (immediate release of air). (Operation of uncoupling lever initiates valve action.)<br>Air hose/glad hand connection capability retained (on opposite side of coupler head) - no other adapter required. | 22                                |                       |                                                       |
| ADAPTER TO MAKE COMPATIBLE WITH<br>AAR TYPE "E" SYSTEM                                       |                                                                                                                                                                                                                                                                                                                                                  | 22                                |                       |                                                       |

The air valve control system is integrated with the air connector system to achieve automatic mechanical operation of the air valves as part of the coupling and uncoupling operation. This air valve control system consists of a low pressure line interface valve, a main air line valve (operated from a low pressure puffer cylinder), and an uncoupling valve operated by the standard uncoupling lever. The basic operation of this system is as follows:

(a) As the mechanical couplers are brought together to couple, the train line connectors gather and seat with the opposing air connector. The primary airline and pilot airline seals are butt faced and are pushed back against a loading spring which assures intimate contact for air pressure seal and retention during all normal service conditions. Coincident with final coupling, the actuator plunger on the face of each connector is contacted and depressed by the flat opposing connector face. This plunger operates a flexible cable or hydraulic line which opens the control valve (low pressure) which allows the low pressure to operate an interface valve which opens the main train airline valve.

(b) Uncoupling is initiated by the use of the standard uncoupling lever. Just after the mechanical coupler lock has reached the lock-set position, the uncoupling rod actuates an uncoupling valve which, working in conjunction with the pilot line system, closes the train main airline valve. In the event of an unintentional uncoupling, the main airline valves remain open to achieve an automatic setting of emergency brakes at the parting of the couplers.

(c) When coupling this air-connector equipped system to a nonequipped car, the coupling procedure is essentially identical to the current coupling practice. The only difference

is that the angle cock on an air-connector equipped car is relocated to the left hand side of the coupler so that the hoses are coupled directly across, eliminating any possible interference with the air connector head. Similarly, uncoupling (between mixed system cars) is carried out with the normal current procedure.

This candidate coupling system also includes the potential for a remote uncoupling release capability. This is accomplished by the addition of an uncoupling push button at the side of the car which works in conjunction with a pneumatic uncoupling operating mechanism which operates the standard uncoupling linkage.

This system retains a standard air hose/glad hand connection capability (located on the opposite side of the coupler head), which precludes the need for an interchange device should the air connector equipped car be coupled with a "mixed" car.

#### 4) System Change 1-3, Addition of Electropneumatic Control System (Table 5-4)

This change adds: an electrical connector system (as a rigid part of the air connector unit); an electropneumatic servo control system at each coupler; an electronic, solid-state multiplexed sensing and control system (master system in locomotive and logic system in each car); and an optional microwave receiving and control system in the locomotive should remote operation be desired.

The electrical connector system is rigidly attached beneath the air connector head such that the primary forward thrust for the electrical connector is obtained by the spring-loading mechanism of the air connector unit. The electrical contactor

TABLE 5-4.-CANDIDATE COUPLING SYSTEMS - COMPATIBLE SYSTEM NUMBER 1-3 (ADDITION OF ELECTRO-PNEUMATIC CONTROL SYSTEM)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM | CONCEPT DESCRIPTION                                                                                                                                                                                              | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|---------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|-------------------------------------------------------|
|                                                                     |                                                                                                                                                                                                                  | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                       |
| IMPROVE MECHANICAL COUPLING<br><u>Location Control</u>              | <ul style="list-style-type: none"> <li>Automatic disengagement of centering/positioning device at coupling and engagement at uncoupling (electro-pneumatic engagement of positioning device 316).</li> </ul>     | 254                               |                       |                                                       |
| IMPROVE MECHANICAL UNCOUPLING<br><u>Uncoupling Capability</u>       | <ul style="list-style-type: none"> <li>Electro-pneumatic control system to initiate uncoupling from electric signal within train (to operate pneumatic uncoupling mechanism Number 943).</li> </ul>              | 254                               |                       |                                                       |
| IMPROVE GENERAL SYSTEMS<br><u>Automatic Train Brake Control</u>     | <ul style="list-style-type: none"> <li>Provide time delay set provisions for brakes after intentional uncoupling (from electrical signal to timing delay system in pneumatic uncoupling control 245).</li> </ul> | 254                               |                       |                                                       |
| <u>Electrical Train Line System</u>                                 | <ul style="list-style-type: none"> <li>Add electrical connector system (rigid attached at bottom of air connector).</li> </ul>                                                                                   | 1,200                             | 502                   |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Air piston sequencing of contractors after mechanical connection.</li> </ul>                                                                                              | 1,200                             | 516, 254              |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Up to 6-8 circuits of butt face, spring loaded, rotating type.</li> </ul>                                                                                                 | 450                               |                       |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Utilize silver plated or silver button tipped contactors.</li> </ul>                                                                                                      | 516                               |                       |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide mechanical hand back-up contactor engagement.</li> </ul>                                                                                                          | 516                               |                       |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide maintenance removal potential for mated contactors.</li> </ul>                                                                                                    | 254                               | 309                   |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide environmental cover with opening by pneumatic sequencing after mechanical mating (initiated by coupling push rod).</li> </ul>                                     | 301                               |                       |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide nylon hinges for environmental cover.</li> </ul>                                                                                                                  | 36                                |                       |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide plastic insulators over environmental cover.</li> </ul>                                                                                                           | 516                               |                       |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide rubber environmental sealing gasket at edge of contactor block.</li> </ul>                                                                                        | 516                               |                       |                                                       |

TABLE 5-4.-CANDIDATE COUPLING SYSTEMS - COMPATIBLE SYSTEM NUMBER 1-3 (CONTINUED)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM      | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                                                                      | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|-------------------------------------------------------|
|                                                                          |                                                                                                                                                                                                                                                                                                                                          | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                       |
| IMPROVE GENERAL SYSTEMS (CONTINUED)<br><u>Sensing and Control System</u> | <ul style="list-style-type: none"> <li>Electro-pneumatic servo control system at each coupler.</li> <li>Electronic, solid state multiplexing sending and control system (master system in locomotive and logic system in car).</li> <li>Optional microwave receiving and control system in locomotive.</li> <li>Not required.</li> </ul> | 254                               |                       |                                                       |
|                                                                          |                                                                                                                                                                                                                                                                                                                                          | 452                               | 450, 387              |                                                       |
|                                                                          |                                                                                                                                                                                                                                                                                                                                          | 450                               |                       |                                                       |
|                                                                          |                                                                                                                                                                                                                                                                                                                                          | N/A                               |                       |                                                       |
| ADAPTER TO MAKE COMPATIBLE WITH<br>AAR TYPE "T" SYSTEM                   |                                                                                                                                                                                                                                                                                                                                          |                                   |                       |                                                       |

consists of 6 to 8 circuits of butt face, spring loaded, rotating type silver-plated contacts which are brought into engagement by the forward thrust of a piston holding unit. At the time of mating, the air connector unit makes complete seating with a mechanical push rod being closed which results in valving air pressure into a pneumatic circuit which opens the cover from the electrical contacts and then sequences the contacts into position by energizing an air piston unit which contains the electrical circuits.

A solid-state electronic multiplexing sensing and control system is utilized in the locomotive for control of car uncoupling systems and for potential use as a decoding system for sensing units which could later be placed in different cars. This solid-state electronic control unit would transmit low power signals through the electrical contact circuit using a binary coded impulse control system. In this concept, it would not be required to transmit high electrical power signals since the low power electronic signals would be used to energize servo units at each car which, in turn, would switch pilot and air valve systems which would accomplish all forcing or operating functions from pneumatic power. These low power electronic signals would be picked up by a logic sensing system located in each car.

The heart of the active control efforts would be accomplished by an electropneumatic servo control system located at the coupler. Circuits in this unit would be energized by mechanical closure devices (such as a push rod) at the time of coupling and electrical or mechanical inputs indicating a desired intentional uncoupling.

Should it be desired to exercise external control over the

various uncoupling or braking functions, an optional microwave receiving and control system would be established in the locomotive. It is not believed feasible to interject direct microwave reception into individual car units because this would require an independent power system to be available in each car with the associated unrealistic requirements for maintenance of battery power in uncontrolled freight car storage and standby conditions. With the availability of the locomotive engineer and the electronic multiplexing sensing and control system in the locomotive, it is believed more feasible to utilize the engineer and his control system as the contact point between the train and its external program input.

This electronic and electropneumatic control system does not compromise the normal inter-car connection sequence and no adaptor units are required to make this system compatible in a "Mixed" car system.

#### 5.4.1.2 Noncompatible System #2

This system is built around the basic coupling concept of the Willison principle as embodied in the Unicupler design of the UIC synthesis coupler. This is a semirigid, spread-claw design type which incorporates a large gathering range together with a capacity for internal mounting of air and electrical connectors.

##### 1) Basic System 2-1, All Cars (Table 5-5)

The Unicupler UIC Synthesis design (Concept 309) retains

TABLE 5-3.-CANDIDATE COUPLING SYSTEMS - NONCOMPATIBLE SYSTEM NUMBER 2-1 (SEMRIGID, SPREAD CLAW, BASIC SYSTEM)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM                                            | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                    | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT               |
|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|---------------------------------------------------------------------|
|                                                                                                                |                                                                                                                                                                                                                                                                        | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                                     |
| IMPROVE TRAIN AIR LINE SYSTEM<br><u>Automatic Control</u><br>Automatic Air Connection                          | <ul style="list-style-type: none"> <li>Spring loaded integral air connection.</li> <li>Double concentric compressible rubber seals.</li> <li>Automatic mechanical air valve operation (mechanical push rod in face of coupler head initiates valve action).</li> </ul> | 503<br>45<br>22                   | 448<br><br>36, 301    |                                                                     |
| Automatic Air Valve Control                                                                                    |                                                                                                                                                                                                                                                                        |                                   |                       |                                                                     |
| Improved Performance<br>Air Seal Leak Rates and<br>Hose Reliability<br>Reduced Maintenance                     | <ul style="list-style-type: none"> <li>Automatic air connection system.</li> <li>Pivoted rear removal of air connection assembly.</li> </ul>                                                                                                                           | 503<br>45<br>309                  | 448                   |                                                                     |
| IMPROVE MECHANICAL COUPLING<br><u>Automatic Engagement</u><br>Improve Lateral and Vertical<br>Gathering Ranges | <ul style="list-style-type: none"> <li>Spread claw gathering of semirigid coupler head</li> </ul>                                                                                                                                                                      | 309                               | 457                   | + 8.7" (4.3 x standard) lateral<br>+ 5.5" (3.7 x standard) vertical |
| Positive Locking                                                                                               | <ul style="list-style-type: none"> <li>Spring loaded locking hook with spring energized locking mechanism.</li> </ul>                                                                                                                                                  | 309                               |                       |                                                                     |
| <u>Positive Retainment</u><br>Wider Coupling Speed Range                                                       | <ul style="list-style-type: none"> <li>Spring loaded locking hook (positive snap lock at coupling).</li> </ul>                                                                                                                                                         | 309                               |                       |                                                                     |
| Reduced Free Slack                                                                                             | <ul style="list-style-type: none"> <li>Cast/forged coupler head with machined seating faces.</li> </ul>                                                                                                                                                                | 309                               |                       |                                                                     |
| Vertical Interlock and Broken<br>Coupler Entrapment<br><u>Location Control</u><br>Self Centering               | <ul style="list-style-type: none"> <li>Interlocking gathering claws and locked mated hooks.</li> <li>O.R.E. 11 cross beam support centering device.</li> </ul>                                                                                                         | 309<br><br>318                    | 301<br><br>41         | 0.3" (0.4 x standard)<br><br>+ 1.2" (0.34 x standard)               |
| Reduced Contour Angling<br><u>Reduced Maintenance</u>                                                          | <ul style="list-style-type: none"> <li>Vertical spring carrier system.</li> <li>Semirigid coupler head with interlocking claws.</li> <li>Lubrication fittings at coupler head and shank wear points.</li> </ul>                                                        | 25<br>309<br>503                  |                       |                                                                     |

TABLE 5-5.-CANDIDATE COUPLING SYSTEMS - NONCOMPATIBLE SYSTEM NUMBER 2-1 (CONTINUED)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM                                                                                                                                       | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|-------------------------------------------------------|
|                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                       |
| IMPROVE MECHANICAL UNCOUPLING<br><u>Recoupling Capability</u><br>Alternate Side Lever, or<br>Push Button Release<br>In Draft<br><u>Recoupling Capability</u><br>Knuckle Always Open<br>Prevent Recoupling | <ul style="list-style-type: none"> <li>Second uncoupling lever with cable connection.</li> <li>Remote uncoupling button at side of car (to operate air valve in coupler head for uncoupling release).</li> <li>Air cylinder release of rotary locking block in coupler head (provides force boost for uncoupling in draft).</li> <li>Spring loaded locking pawl (spring cocked at unloading).</li> <li>Manual lock open of locking pawls to prevent locking (to allow yard movement without automatic coupling lock).</li> <li>Provide for nonbraking (retention of air) after intentional uncoupling.</li> <li>Provide for emergency braking after unintentional uncoupling (immediate release of air). (Operation of uncoupling lever initiates valve action.)</li> <li>Air hose/glad hand adapter (plus) coupler head adapter unit is required.</li> </ul> | 309                               |                       |                                                       |
|                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 674                               |                       |                                                       |
|                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 391                               | 33, 9                 | Up to 8,000 pounds draft force                        |
|                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 309                               |                       |                                                       |
| IMPROVE GENERAL SYSTEMS<br><u>Automatic Train Brake Control</u>                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 309                               | 457                   |                                                       |
|                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 22                                |                       |                                                       |
|                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 22                                |                       |                                                       |
| ADAPTEL TO MAKE COMPATIBLE WITH<br>AAR TYPE "T" SYSTEM                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 22                                |                       |                                                       |
|                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 301                               |                       |                                                       |

the same basic Willison coupling profile (i.e., rigid cast knuckle with fixed side gathering claw) but is a larger and deeper unit such that the gathering forces are completed prior to the final longitudinal mating of the couplers. Thus there are straight butt forces involved at the final coupling which allow for butt type air and electrical connections to be designed as an integral part of the interior of the coupler. In addition, the final locking is done by a hinged locking hook which requires less lateral movement on the part of the coupler in order to achieve complete mating.

The gathering features are such that it has a capability of lateral gathering of plus or minus 8.7 inches and vertical gathering of plus or minus 5.5 inches. Both represent a significant increase of approximately four times over the gathering capabilities of the basic Type "E" coupling system.

The Unicupler has a reduced free slack of approximately 0.3 inch, which does allow the integral mounting of air and electrical connectors so long as they retain the capability of self-seating (i.e., contain compressible rubber air seals and spring back-up loading for both air and electrical). These later features have been embodied in the basic design as concepts chosen from other coupler systems.

The spring-loaded locking hooks achieve a positive snap lock at coupling which, together with the interlocking gathering claws, effectively accomplishes a vertical interlock and entrapment capability for a broken coupler. The location of the locking hooks on the upper portion of the spread-claw area allows room for the air connection system on the lower center line of the coupler. This location allows for the removal potential of the air connection assembly from the rear of the

coupler, thus offering significant opportunities for maintenance of the air seal assembly even with the couplers in the mated condition.

With the wide natural gathering of the Unicupler, only a centering device is required in order for this coupler to be in a position to make an effective coupling (without bypass) for virtually all operating situations. It is realized that a positioning device would still slightly improve the mating potential for long cars; however, it is believed that the nominal decrease in bypass probability for a small percentage of active freight cars does not outweigh the potential advantages of having an identical coupler system on all cars with the associated potential for standardization of centering control devices.

Although manual uncoupling is provided, the primary uncoupling force results from air cylinder operation of a rotary locking block. This feature provides a capability for a force boosting of the uncoupling forces to allow an coupling in draft of an 8,000 pounds draw-bar pull. This is not a significant draft force when compared to potential full train situations; however, this represents a potential for further automation of hump switching operations by providing for uncoupling under nominal draft forces. The use of an air cylinder boost for uncoupling allows an alternate uncoupling system to be used including a button type release at the side of the car. This also has the potential for significant improvement in trainman safety in hump-switching operations.

The Unicupler has the feature of the "knuckle" always being open due to a spring loaded locking pawl which is set at uncoupling. One particularly unique feature of the Unicupler is the capability for a manual "lock open" of the locking pawls in order

to prevent the coupler from locking when it comes into contact with another coupler. This allows for alternate yard switching movements in which it is possible to relocate cars without a yardman being present to uncouple the cars after movement has been completed.

This system contains another concept (Concept 22) which automatically opens or closes the main train valve as a function of mechanical forces (i.e., movement of a push rod in the face of the coupler at coupling or operation of the uncoupling lever). This feature, together with the automatic air connection, eliminates the need for a trainman to go between cars during either the coupling or uncoupling operations.

The Unicupler, being a noncompatible system, does require the use of an air hose/glad hand adapter plus a coupler head adapter unit in order to mate with nonequipped cars. The air hose/glad hand adapter is a standard feature embodied in Concept 22. This requires no extra handling or equipment on the part of the trainmen. On the other hand, the coupler head adapter unit would involve a rather complicated and heavy unit to be securely attached to the face of the Unicupler and at the same time to have a front facing head unit which would properly mate with the Type "E" coupler system. During any transition period involving a change to this system, a significant number of adapter units would be required throughout the railroad system as well as a change in procedures to fit the adapter units to those cars which are to be placed into "mixed" rail service.

## 2) System Change 2-2, Addition of Electropneumatic Control System (Table 5-6)

This system embodies all of the concepts as related in

TABLE 5-6.-CANDIDATE COUPLING SYSTEMS - INCOMPATIBLE SYSTEM NUMBER 2-2 (ADDITION OF ELECTRO-PNEUMATIC CONTROL SYSTEM)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | BIBLIOGRAPHY<br>REFERENCE NUMBERS                                      |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|---------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|-----------------------|-------------------------------------------------------|
|                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | PRIMARY                                                                | POSSIBLE<br>ALTERNATE |                                                       |
| IMPROVE MECHANICAL COUPLING<br><u>Location Control</u>              | <ul style="list-style-type: none"> <li>Automatic disengagement of centering at coupling and engagement at uncoupling (electro-pneumatic engagement of centering device 31P).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                              | 254                                                                    |                       |                                                       |
| IMPROVE MECHANICAL UNCOUPLING<br><u>Uncoupling Capability</u>       | <ul style="list-style-type: none"> <li>Electro-pneumatic control system to initiate uncoupling from electrical signal within train (to operate pneumatic uncoupling mechanism 391).</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                       | 254                                                                    |                       |                                                       |
| IMPROVE GENERAL SYSTEMS<br><u>Automatic Train Brake Control</u>     | <ul style="list-style-type: none"> <li>Provide time delay set provisions for brakes after intentional uncoupling (from electrical signal to timing delay system in pneumatic uncoupling control 254).</li> <li>Add electrical connector integral to coupler head.</li> <li>Air piston sequencing of contactors after mechanical connection.</li> <li>Up to 6-8 circuits of butt face, spring loaded rotating type.</li> <li>Utilize silver plated or silver button tipped contactors.</li> <li>Provide mechanical hand back-up contactor engagement.</li> <li>Provide maintenance removal potential for mated contactors.</li> </ul> | 254                                                                    |                       |                                                       |
| <u>Electrical Train Line System</u>                                 | <ul style="list-style-type: none"> <li>Provide environmental cover with opening by pneumatic sequence after mechanical mating (initiated by coupling push rod).</li> <li>Provide nylon blades for environmental cover.</li> <li>Provide plastic insulators over environmental cover.</li> <li>Provide rubber environmental sealing gasket at edge of contactor block.</li> </ul>                                                                                                                                                                                                                                                     | 36<br>1,200<br>450<br>516<br>516<br>309<br>301<br><br>36<br>516<br>516 | 309, 33<br>516, 254   |                                                       |

TABLE 5-6.-CANDIDATE COUPLING SYSTEMS - NONCOMPATIBLE SYSTEM NUMBER 2-2 (CONTINUED)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM       | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                                                                                                 | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|-------------------------------------------------------|
|                                                                           |                                                                                                                                                                                                                                                                                                                                                                     | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                       |
| IMPROVE GENERAL SYSTEMS (CONTINUED)<br><u>Sensing and Control Systems</u> | <ul style="list-style-type: none"> <li>• Electro-pneumatic servo control system at each coupler.</li> <li>• Electronic, solid state multiplexing sensing and control system (master system in locomotive and logic system in car).</li> <li>• Optional microwave receiving and control system in locomotive.</li> <li>• No additional adapters required.</li> </ul> | 254<br>452<br>450<br>N/A          | 450, 387              |                                                       |
| ADAPTER TO MAKE COMPATIBLE WITH<br>AAR TYPE "X" SYSTEM                    |                                                                                                                                                                                                                                                                                                                                                                     |                                   |                       |                                                       |

compatible System 1-3. Although applied to a different physical coupler system, the same concepts would evidence the same type of controlling features as previously noted. The same limitations of approximately six to eight electrical circuits applies for System 2-2 as for System 1-3. There would be adequate space for 6-8 circuits, assuming that only one of the circuits would be a power conducting unit with the other circuits being reserved for low power signals related to the use of solid state electronic multiplexed control circuits.

#### 5.4.1.3 Noncompatible System #3

This system is a rigid, flat-face, horn-funnel coupler system of the SW-800 type (Concept 9). The general features of this coupler system are shown schematically in Figure 4.3. This system represents an enlarged version of similar coupler units which have proven to be effective in rapid transit service and, to a lesser extent, in passenger rail service.

##### 1) Basic System 3-1, All Cars (Table 5-7)

The SW-800 coupler system embodies the latest features of the basic Tomlinson principle of coupling. In this system, a hook/funnel technique is used for gathering and final locking of the couplers together.

The "protruding horn" or hook is guided into a funnel shape recessed area of the adjacent coupler, which allows a lateral gathering range of approximately  $\pm 5$  inches (which is 2.5 times that of the Type "E" coupler system) and a vertical gathering range of  $\pm 5$  inches (3.3 times the rule 20 AAR interchange requirement). As the funnel guides the mating horn into position, the couplers engage final alignment pins in aligning holes with the

TABLE 5-7.-CANDIDATE COUPLING SYSTEMS - NONCOMPATIBLE SYSTEM NUMBER 3-1 (RIGID, FLAT FACE, BASIC SYSTEM)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM                                                         | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                    | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                                 | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT                   |
|-----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|---------------------------------|-------------------------------------------------------------------------|
|                                                                                                                             |                                                                                                                                                                                                                                                                                        | PRIMARY                           | POSSIBLE<br>ALTERNATE           |                                                                         |
| <u>IMPROVE TRAIN AIR LINE SYSTEM</u><br><u>Automatic Control</u><br>Automatic Air Connection<br>Automatic Air Valve Control | <ul style="list-style-type: none"> <li>• Spring loaded, compressible rubber, integral air connector.</li> <li>• Automatic mechanical air valve operation. (Mechanical push rod in face of coupler head initiates valve action.)</li> <li>• Automatic air connection system.</li> </ul> | 9<br>22<br>9                      | 503, 448<br>36, 301<br>503, 448 |                                                                         |
| <u>Improved Performance</u><br>Air Seal Leak Rates, Noise<br>Reliability and Reduced<br>Maintenance                         |                                                                                                                                                                                                                                                                                        |                                   |                                 |                                                                         |
| <u>IMPROVE MECHANICAL COUPLING</u><br><u>Automatic Engagement</u><br>Improve Lateral and Vertical<br>Gathering Ranges       | <ul style="list-style-type: none"> <li>• Horn-funnel gathering of rigid coupler head.</li> </ul>                                                                                                                                                                                       | 9                                 | 301, 6                          | $\pm 5"$ (2.5 x standard) lateral<br>$\pm 5"$ (3.3 x standard) vertical |
| Positive Locking                                                                                                            | <ul style="list-style-type: none"> <li>• Spring loaded locking hook and direct locking catch (from compression of guide pins on coupler face).</li> </ul>                                                                                                                              | 9                                 |                                 |                                                                         |
| <u>Positive Retainment</u><br>Wider Coupling Speed Range                                                                    | <ul style="list-style-type: none"> <li>• Spring loaded locking hook (positive interlock at coupling).</li> </ul>                                                                                                                                                                       | 9                                 |                                 |                                                                         |
| Reduced Free Slack                                                                                                          | <ul style="list-style-type: none"> <li>• Machined flat mating front faces and locking detents.</li> </ul>                                                                                                                                                                              | 9                                 |                                 |                                                                         |
| Vertical Interlock and Broken<br>Coupler Entrapment                                                                         | <ul style="list-style-type: none"> <li>• Interlocking horns with locked hook and aligning pin/dowel interlock.</li> </ul>                                                                                                                                                              | 9                                 | 6                               | Zero free slack<br>(design nominal)                                     |
| <u>Location Control</u><br>Reduced Contour Angling<br>Automatic Positioning                                                 | <ul style="list-style-type: none"> <li>• Rigid coupler heads with interlock.</li> <li>• Hydraulic, direct guided coupler positioning device.</li> <li>• Vertical spring carrier system.</li> </ul>                                                                                     | 9<br>31<br>25                     |                                 |                                                                         |

TABLE 5-7.-CANDIDATE COUPLING SYSTEMS - NONCOMPATIBLE SYSTEM NUMBER 3-1 (CONTINUED)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM | CONCEPT DESCRIPTION                                                                                                                                                                                    | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|---------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|-------------------------------------------------------|
|                                                                     |                                                                                                                                                                                                        | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                       |
| IMPROVE MECHANICAL COUPLING<br>(CONTINUED)                          |                                                                                                                                                                                                        |                                   |                       |                                                       |
| <u>Reduced Maintenance</u>                                          | <ul style="list-style-type: none"> <li>Lubrication fittings at coupler head and shank wear points.</li> </ul>                                                                                          | 503                               |                       |                                                       |
| IMPROVE MECHANICAL UNCOUPLING                                       |                                                                                                                                                                                                        |                                   |                       |                                                       |
| <u>Uncoupling Capability</u>                                        | <ul style="list-style-type: none"> <li>Remote uncoupling button at side of car (to operate self-contained pneumatic uncoupling release).</li> </ul>                                                    | 674                               |                       |                                                       |
| <u>Push Button Release</u>                                          | <ul style="list-style-type: none"> <li>Locking hooks forced apart by cam wedge force (from pneumatic cylinder through rotary locking block) to provide force boost for uncoupling in draft.</li> </ul> | 9<br>391                          | 33                    | Up to 8,000 pounds draft force                        |
| <u>In Draft</u>                                                     | <ul style="list-style-type: none"> <li>Spring loaded locking hook (set ready at uncoupling).</li> </ul>                                                                                                | 9                                 | 301, 6                |                                                       |
| <u>Recoupling Capability</u>                                        | <ul style="list-style-type: none"> <li>Provide for nonbraking (retention of air) after intentional uncoupling.</li> </ul>                                                                              | 22                                |                       |                                                       |
| <u>Knuckle Always Open</u>                                          | <ul style="list-style-type: none"> <li>Provide for emergency braking after unintentional uncoupling (immediate release of air) (operation of uncoupling lever initiates valve action).</li> </ul>      | 22                                |                       |                                                       |
| IMPROVE GENERAL SYSTEMS                                             | <ul style="list-style-type: none"> <li>Air hose/glad hand adapter (plus) coupler head adapter unit is required.</li> </ul>                                                                             | 9                                 |                       |                                                       |
| <u>Automatic Train Brake Control</u>                                |                                                                                                                                                                                                        |                                   |                       |                                                       |
| ADAPTER TO MAKE COMPATIBLE WITH<br>AAR TYPE "E" SYSTEM              |                                                                                                                                                                                                        |                                   |                       |                                                       |

final close tolerancing of these pins and holes giving a "slack free" characteristic to the coupler. This system thus represents a significant increase in gathering range over the Type "E" system.

The total gathering capabilities of this system are functions of the size of the hood cross-section, with the horizontal and vertical gathering ranges being equal to or slightly less than the corresponding hook dimensions. This gathering range can be increased by a factor of 1.3 to 1.4 by the addition of an extra protruding gathering horn. However, in the systems embodying this protruding horn principle, it has been determined that the horn design is marginal in its strength and resistance to impact damage. This concept is therefore not believed to be appropriate for use as a major gathering element in a freight train application.

The spring-loaded locking hook is set ready at uncoupling to achieve a "knuckle open" capability. These hooks are positively locked in place at coupling by a direct compression of a locking catch by guide pins on the coupler face. This positive locking mechanism is the best of the candidate coupling systems.

Uncoupling can be initiated by either a hand-operated lever or with air cylinder force boosting. This latter feature allows the incorporation of a side-of-car push button release as well as allowing the coupler to have uncoupling capabilities under draft forces. The uncoupling energy (from hand lever or air cylinder) forces hook retractors between opposing faces of the locking hooks. These retractors act as wedges to give leverage for hook separation under draft forces. Concept 391 has been added to include a rotary locking block actuation by the pneumatic cylinder to increase the capabilities of uncoupling in draft forces up

to about 8,000 pounds.

The same air valve control system (Concept 22) has been suggested here as for the other systems giving this system an equal capability with respect to automatic air valve control at coupling and uncoupling.

Since this coupler is totally rigid and depends on a proper seating of flat coupler faces, it is more susceptible to potential damage from oblique coupling impact than is the case for either of the other systems. It is therefore concluded that this system is required to have a positioning device in order to operate effectively on either long or short cars. The very rigid nature of the coupling also requires a vertical spring carrier system in order to provide the vertical articulation which is necessary for operating over vertical curves.

This system also requires adapter units for operations in "mixed" coupling situations. The air hose/glad hand adapter as proposed presents no problem for Concept 22. On the other hand, the coupler head adapter unit will be sophisticated and heavy and will require special handling procedures throughout any transitional period for change to this type of coupling system.

2) System Change 3-2, Addition of Electropneumatic Control System (Table 5-8)

The proposed system is identical to that suggested for System 1-3 and 2-2 and offers the same control concept capabilities although being embodied in a different physical coupler situation. The outstanding capability for this rigid type coupler system is the potential availability of an exceedingly large number of electrical circuits. Potential designs for the

TABLE 5-8.-CANDIDATE COUPLING SYSTEMS - NONCOMPATIBLE SYSTEM NUMBER 3-2 (ADDITION OF ELECTRO-PNEUMATIC CONTROL SYSTEM)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM | CONCEPT DESCRIPTION                                                                                                                                                                                              | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                             | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|---------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------------|-------------------------------------------------------|
|                                                                     |                                                                                                                                                                                                                  | PRIMARY                           | POSSIBLE<br>ALTERNATE       |                                                       |
| IMPROVE MECHANICAL COUPLING<br><u>Location Control</u>              | <ul style="list-style-type: none"> <li>Automatic disengagement of centering/positioning device at coupling and engagement of uncoupling (electro-pneumatic engagement of positioning device 31b).</li> </ul>     | 254                               |                             |                                                       |
| IMPROVE MECHANICAL UNCOUPLING<br><u>Uncoupling Capability</u>       | <ul style="list-style-type: none"> <li>Electro-pneumatic control system to initiate uncoupling from electrical signal within train (to op rate pneumatic uncoupling mechanism 9,391).</li> </ul>                 | 254                               |                             |                                                       |
| IMPROVE GENERAL SYSTEMS<br><u>Automatic Train Brake Control</u>     | <ul style="list-style-type: none"> <li>Provide time delay set provisions for brakes after intentional uncoupling (from electrical signal to timing delay system in pneumatic uncoupling control 254).</li> </ul> | 254                               |                             |                                                       |
| <u>Electrical Train Line System</u>                                 | <ul style="list-style-type: none"> <li>Add electrical connection box below face of coupler head.</li> </ul>                                                                                                      | 9                                 | 27, 391,<br>503, 511<br>516 |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Air piston sequencing of contactors after mechanical connection.</li> </ul>                                                                                               | 254                               |                             |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>From 50-100 circuits of butt face, spring loaded, rotating type.</li> </ul>                                                                                               | 450                               |                             |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Utilize silver plated or silver button tipped contactors.</li> </ul>                                                                                                      | 516                               |                             |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide mechanical hand back-up contactor engagement.</li> </ul>                                                                                                          | 516                               |                             |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide maintenance removal potential for mated contactors.</li> </ul>                                                                                                    | 254                               |                             |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide environmental cover with opening by pneumatic sequencing after mechanical mating (initiated by coupling push rod).</li> </ul>                                     | 301                               |                             |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide nylon hinges for environmental cover.</li> </ul>                                                                                                                  | 36                                |                             |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide plastic insulators over environmental cover.</li> </ul>                                                                                                           | 516                               |                             |                                                       |
|                                                                     | <ul style="list-style-type: none"> <li>Provide rubber environmental sealing gasket at edge of contactor block.</li> </ul>                                                                                        | 516                               |                             |                                                       |

TABLE 5-8.--CANDIDATE COUPLING SYSTEMS - NONCOMPATIBLE SYSTEM NUMBER 3-2 (CONTINUED)

| OPERATIONAL CHARACTERISTIC<br>WITHIN THE OVERALL<br>COUPLING SYSTEM      | CONCEPT DESCRIPTION                                                                                                                                                                                                                                                                                                                                         | BIBLIOGRAPHY<br>REFERENCE NUMBERS |                       | ESTIMATED<br>QUANTITATIVE<br>VALUES OF<br>IMPROVEMENT |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------|-------------------------------------------------------|
|                                                                          |                                                                                                                                                                                                                                                                                                                                                             | PRIMARY                           | POSSIBLE<br>ALTERNATE |                                                       |
| IMPROVE GENERAL SYSTEMS (CONTINUED)<br><u>Sensing and Control System</u> | <ul style="list-style-type: none"> <li>Electro-pneumatic servo control system at each coupler.</li> <li>Electronic, solid state multiplexing sensing and control system (master system in locomotive and logic system in car).</li> <li>Optional microwave receiving and control system in locomotive.</li> <li>No additional adaptors required.</li> </ul> | 254<br>452<br>450<br>N/A          | 450, 307              |                                                       |
| ADAPTER TO MAKE COMPATIBLE WITH<br>AAR TYPE "E" SYSTEM                   |                                                                                                                                                                                                                                                                                                                                                             |                                   |                       |                                                       |

electrical circuit utilize 50 to 100 circuits in the space which would be available. One of the compelling reasons for potential use of this candidate coupling system would be the desirability of having a large number of electrical circuits available for sensing and control functions.

The multiplexing control system, which uses binary logic pulses, can operate (in theory) with two circuits for total control of coupling sequences on a long train. One or two additional circuits are required to carry the nominal power needed in the use of the solid state electronic circuit modulars. In systems 1-3 and 2-2, this leaves only approximately two circuits available for sensing and other control systems; whereas, in system 3-2 there would be available from 40 to 90 other circuits for sensing or control uses.

The list of potential sensing circuits is nearly limitless (e.g., hot box detection, derailment detection, dragging brake, refrigeration temperature sensing). The easiest way of utilizing these sensing elements is to direct each through a separate circuit back to the locomotive control center. If such a technique is desired (due to its simplicity and low relative cost) a large number of circuits will be needed, and a system like 3-2 would be required. On the other hand, if sophisticated solid state electronic signal mixing and coding is used within each car logic system, a multiple of sensing inputs could be synthesized into one or two transmitting circuits. If this latter system were chosen (even with its greater complexity and cost), then a lesser number of electrical circuits would be required, and the circuit capability in Systems 1-3 or 2-2 would be adequate to perform all of the desired sensing and control functions. In this latter case, candidate coupling System 2-2 would appear more preferable than 3-2 because of its large gathering

range capability, rugged construction, and (probable) lesser total cost than System 3-2.

#### 5.4.2 Advantages and Disadvantages of Candidate Coupling Systems

Each of the three candidate coupling systems was developed to include concepts which would answer specific operating and safety problems outlined in the introduction of this report. Each system offers specific advantages and has some disadvantages.

System 1 has the primary advantage of being totally compatible with all freight cars currently in the U.S. rail-freight system. The basic concepts proposed in candidate system 1 include the distinct advantages of increased gathering range, knuckle open capability, and coupler entrapment and interlock features, thus overcoming the major mechanical deficiencies in the present Type "E" system. System Change 1-2 adds the automatic air connection and automatic brake valve control as a mechanical function of the coupling and uncoupling processes. These features overcome the most critical current safety problems arising from the necessity of trainman going between cars to complete the air connection system or to prepare cars for proper coupling. System Change 1-3 adds the capability of remote control by the additional electropneumatic and electronic control systems. This latter feature embodies the long-range potential for complete sensing and control of train operations from the locomotive or from some external control point. This system is limited to approximately 6 to 8 electrical circuits in the automatic electrical connector.

Candidate coupling system 2 embodies the best features of the semirigid coupler designs characterized in European operations. The primary advantage in this system is the very wide

gathering range which it offers as well as a rugged and proven system. The basic system 2-1 includes an integral air connection coupling which is protected within the face of the gathering claws of the coupler. This protection feature is the best of the three systems in that it offers significant mechanical and environmental protection to the automatic air connection face. Since the automatic air connector unit represents a most significant and critical feature in the train operating sequence, candidate system 2 offers a particular and unique advantage in this respect. System Change 2-2 is limited similar to System Change 1-3 in the number of electrical contacts which can be readily added to the system for the final step involving electrical sensing and control circuits.

Candidate coupling System 3 contains the unique advantage of being a totally rigid system, which gives an exceptionally stable platform for attaching air or electrical connectors. This advantage is accompanied by the disadvantage of a heavy coupler unit, which requires a significant amount of machining to achieve the slack-free characteristic and which likewise requires a critical positioning control in order to prevent oblique coupling forces from damaging the coupler head faces. The primary advantages in this coupling system are its increased gathering range and capability of including a greater number of electrical circuits for sensing and control.

A complete listing of the comparative advantages of the three systems is given in Table 5-9. A similar listing of the primary disadvantages of the three systems is given in Table 5-10.

TABLE 5-9.-PRIMARY ADVANTAGES OF CANDIDATE COUPLING SYSTEMS

|                                                                                                                         | COMPATIBLE              |                         |                         |                         | NONCOMPATIBLE                                |                         |                        |                         |
|-------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------------------------|-------------------------|------------------------|-------------------------|
|                                                                                                                         | SYSTEM 1                |                         |                         |                         | SYSTEM 2                                     |                         |                        |                         |
|                                                                                                                         | "FREE" KNUCKLE          |                         |                         |                         | "SEMI-RIGID,"<br>SPREAD CLAW,<br>HINGED HOOK |                         |                        |                         |
|                                                                                                                         | BASIC<br>SYSTEM<br>1-1A | BASIC<br>SYSTEM<br>1-1B | SYSTEM<br>CHANGE<br>1-2 | SYSTEM<br>CHANGE<br>1-3 | BASIC<br>SYSTEM<br>2-1                       | SYSTEM<br>CHANGE<br>2-2 | BASIC<br>SYSTEM<br>3-1 | SYSTEM<br>CHANGE<br>3-2 |
| OPERATIONAL CHARACTERISTICS                                                                                             |                         |                         |                         |                         |                                              |                         |                        |                         |
|                                                                                                                         |                         |                         |                         |                         |                                              |                         |                        |                         |
| I. IMPROVE TRAIN AIR LINE SYSTEM                                                                                        |                         |                         |                         |                         |                                              |                         |                        |                         |
| A. Automatic Control                                                                                                    |                         |                         |                         |                         |                                              |                         |                        |                         |
| 1) Automatic connection of air line and automatic opening of air valves at coupling:                                    |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (a) Removes a safety hazard to crews by eliminating the need to go between cars (for regular coupling operations).      |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (b) Speeds up the coupling operation.                                                                                   |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (c) Reduces train make-up time by permitting cars to be charged with air as they are coupled.                           |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (d) Causes no compromise of existing operating procedures.                                                              |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (e) Requires no special tools or devices to connect with non-equipped cars.                                             |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (f) Operates regardless of brake system phase of either car.                                                            |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| 2) Automatic operation of air valves at uncoupling (intentional - close valves; unintentional - open valves instantly): |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (a) Removes a safety hazard to crews by eliminating a need to go between cars to close angle cocks before uncoupling.   |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (b) Speeds up uncoupling operation.                                                                                     |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (c) Permits normal emergency brake application at unintentional uncoupling.                                             |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (d) Operates regardless of brake system phase of either car.                                                            |                         |                         | X                       |                         | X                                            |                         | X                      |                         |
| (e) System is fail safe (go to emergency brake mode).                                                                   |                         |                         | X                       |                         | X                                            |                         | X                      |                         |

TABLE 5-9.-PRIMARY ADVANTAGES OF CANDIDATE COUPLING SYSTEMS (CONTINUED)

| OPERATIONAL CHARACTERISTICS                                                                                                                                      | COMPATIBLE        |                   |                   |                   | NONCOMPATIBLE                          |                   |                                 |                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-------------------|-------------------|-------------------|----------------------------------------|-------------------|---------------------------------|-------------------|
|                                                                                                                                                                  | SYSTEM 1          |                   |                   |                   | SYSTEM 2                               |                   | SYSTEM 3                        |                   |
|                                                                                                                                                                  | "FREE" KNUCKLE    |                   |                   |                   | "SEMI-RIGID, SPREAD CLAW, HINGED HOOK" |                   | "RIGID," FLAT FACE, HINGED HOOK |                   |
|                                                                                                                                                                  | BASIC SYSTEM 1-1A | BASIC SYSTEM 1-1B | SYSTEM CHANGE 1-2 | SYSTEM CHANGE 1-3 | BASIC SYSTEM 2-1                       | SYSTEM CHANGE 2-2 | BASIC SYSTEM 3-1                | SYSTEM CHANGE 3-2 |
| I. IMPROVE TRAIN AIR LINE SYSTEM (CONTINUED)                                                                                                                     |                   |                   |                   |                   |                                        |                   |                                 |                   |
| B. Improved Performance                                                                                                                                          |                   |                   |                   |                   |                                        |                   |                                 |                   |
| 1) Automatic connection of air lines offers:                                                                                                                     |                   |                   |                   |                   |                                        |                   |                                 |                   |
| (a) Greater hose life and absence of broken train pipes resulting from air hose uncoupling forces.                                                               |                   |                   | X                 |                   | X                                      |                   | X                               |                   |
| (b) Significant improvement in integrity of train line connections.                                                                                              |                   |                   | X                 |                   | X                                      |                   | X                               |                   |
| (c) Reduced air leakage (at all temperatures) due to a positive pressure seal.                                                                                   |                   |                   | X                 |                   | X                                      |                   | X                               |                   |
| 2) Sealing gaskets are readily removable from rear for reduced maintenance.                                                                                      |                   |                   |                   |                   | X                                      |                   |                                 |                   |
| C. General Design of Air Connection System                                                                                                                       |                   |                   |                   |                   |                                        |                   |                                 |                   |
| 1) Spread-wing air connector design allows potential for later design changes to modify gathering range while retaining compatibility with units already in use. |                   |                   |                   |                   |                                        |                   |                                 |                   |
| (a) Offers potential for adding other remote control functions.                                                                                                  |                   |                   | X                 |                   |                                        |                   |                                 |                   |
| (b) Permits equipped and nonequipped cars to be operated together without need of interchange devices.                                                           |                   |                   | X                 |                   | X                                      |                   | X                               |                   |
| (c) Can be applied to existing cars on an incremental basis with minimum interruption of normal service.                                                         |                   |                   | X                 |                   |                                        |                   |                                 |                   |
| (d) Can withstand the extremes of railroad operating environment.                                                                                                |                   |                   | X                 |                   |                                        |                   |                                 |                   |
| (e) Can be readily adapted to carry an additional train air line or electric train line.                                                                         |                   |                   | X                 |                   | X                                      |                   | X                               |                   |

TABLE 3-9--PRIMARY ADVANTAGES OF CANDIDATE COUPLING SYSTEMS (CONTINUED)

| OPERATIONAL CHARACTERISTICS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | COMPATIBLE              |                         |                         |                         | NONCOMPATIBLE                                |                         |                                  |                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------------------------|-------------------------|----------------------------------|-------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | SYSTEM 1                |                         |                         |                         | SYSTEM 2                                     |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | "FREE" KNUCKLE          |                         |                         |                         | "SEMI-RIGID,"<br>SPREAD CLAW,<br>HINGED HOOK |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | BASIC<br>SYSTEM<br>1-1A | BASIC<br>SYSTEM<br>1-1B | SYSTEM<br>CHANGE<br>1-2 | SYSTEM<br>CHANGE<br>1-3 | BASIC<br>SYSTEM<br>CHANGE<br>2-1             | SYSTEM<br>CHANGE<br>2-2 | BASIC<br>SYSTEM<br>CHANGE<br>3-1 | SYSTEM<br>CHANGE<br>3-2 |
| <b>II. IMPROVE MECHANICAL COUPLING</b><br><b>A. General Design</b><br>1) "Rigid" and "semi-rigid" design allows integrally connected air and electrical connectors without separate gathering capabilities.<br>2) Compatible with type "g" system (without use of adapters).<br>3) Requires no manual preparation to couple.<br>4) Entire coupling system operates mechanically and is thus minimally affected by temperature changes or environmental wear.<br>5) Removal of the "knuckle open" device (for possible repair) does not render the coupler inoperative.<br>6) Coupler head design offers good mechanical protection of air and electrical connectors.<br>7) Embodies highest strength/weight ratio due to single cast head design and direct pulling force on centerline of coupler.<br><b>B. Automatic Engagement</b><br>1) Improvement in lateral and vertical gathering ranges.<br>(a) Minimal (1.5 to 2.0 x standard).<br>(b) Good (2.5 to 3.5 x standard).<br>(c) Significant (over 3.5 x standard). | X                       | X                       |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | X                       | X                       |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | X                       |                         |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |                         |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |                         |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |                         |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |                         |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |                         |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |                         |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |                         |                         |                         |                                              |                         |                                  |                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                         |                         |                         |                         |                                              |                         |                                  |                         |

TABLE 5-9.-PRIMARY ADVANTAGES OF CANDIDATE COUPLING SYSTEMS (CONTINUED)

| OPERATIONAL CHARACTERISTICS                                                                         | COMPATIBLE              |                         |                         |                         | NONCOMPATIBLE                                |                         |                                  |                         |
|-----------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------------------------|-------------------------|----------------------------------|-------------------------|
|                                                                                                     | SYSTEM 1                |                         |                         |                         | SYSTEM 2                                     |                         |                                  |                         |
|                                                                                                     | "FREE" KNUCKLE          |                         |                         |                         | "SEMI-RIGID,"<br>SPREAD CLAW,<br>HINGED HOOK |                         |                                  |                         |
|                                                                                                     | BASIC<br>SYSTEM<br>1-1A | BASIC<br>SYSTEM<br>1-1B | SYSTEM<br>CHANGE<br>1-2 | SYSTEM<br>CHANGE<br>1-3 | BASIC<br>SYSTEM<br>CHANGE<br>2-1             | SYSTEM<br>CHANGE<br>2-2 | BASIC<br>SYSTEM<br>CHANGE<br>3-1 | SYSTEM<br>CHANGE<br>3-2 |
| II. IMPROVE MECHANICAL COUPLING (CONTINUED)                                                         |                         |                         |                         |                         |                                              |                         |                                  |                         |
| B. Automatic Engagement (Continued)                                                                 |                         |                         |                         |                         |                                              |                         |                                  |                         |
| 2) Improvement in positive locking:                                                                 |                         |                         |                         |                         |                                              |                         |                                  |                         |
| (a) Nominal (positive rotation of lockset by force of mating coupler).                              | X                       | X                       |                         |                         |                                              |                         |                                  |                         |
| (b) Good (spring loaded coupling hook and locking pawl).                                            |                         |                         |                         |                         |                                              |                         |                                  |                         |
| (c) Significant (spring loaded coupling hook and direct locking catch forced by coupler guide pin). |                         |                         |                         |                         | X                                            |                         |                                  |                         |
| C. Positive Retainment                                                                              |                         |                         |                         |                         |                                              |                         |                                  |                         |
| 1) Coupling at wider speed range.                                                                   |                         |                         |                         |                         |                                              |                         |                                  |                         |
| (a) Nominal (mechanical forced rotation of lockset).                                                | X                       | X                       |                         |                         |                                              |                         |                                  |                         |
| (b) Good (spring loaded locking hook).                                                              |                         |                         |                         |                         |                                              |                         |                                  |                         |
| 2) Reduced free slack;                                                                              |                         |                         |                         |                         |                                              |                         |                                  |                         |
| (a) Nominal (0.8 x standard).                                                                       | X                       |                         |                         |                         |                                              |                         |                                  |                         |
| (b) Good (0.4 x standard).                                                                          |                         |                         |                         |                         |                                              |                         |                                  |                         |
| (c) Significant ("zero" free slack nominal).                                                        |                         | X                       |                         |                         | X                                            |                         |                                  |                         |
| 3) Vertical interlock and coupler entrapment:                                                       |                         |                         |                         |                         |                                              |                         |                                  |                         |
| (a) Nominal (limited vertical movement to prevent slipover).                                        | X                       |                         |                         |                         |                                              |                         |                                  |                         |
| (b) Good (interlocking gathering arms - acceptable for long cars).                                  |                         |                         |                         |                         |                                              |                         |                                  |                         |
| (c) Significant (interlocking hooks and pin/dowel interlock).                                       |                         | X                       |                         |                         | X                                            |                         |                                  |                         |

TABLE 3-9.-PRIMARY ADVANTAGES OF CANDIDATE COUPLING SYSTEMS (CONTINUED)

| OPERATIONAL CHARACTERISTICS                                                                                                                                                                      | COMPATIBLE              |                         |                         |                         | NONCOMPATIBLE                                |                         |                                  |                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------------------------|-------------------------|----------------------------------|-------------------------|
|                                                                                                                                                                                                  | SYSTEM 1                |                         |                         |                         | SYSTEM 2                                     |                         |                                  |                         |
|                                                                                                                                                                                                  | "FREE" KNUCKLE          |                         |                         |                         | "SEMI-RIGID,"<br>SPREAD CLAW,<br>HINGED HOOK |                         |                                  |                         |
|                                                                                                                                                                                                  | BASIC<br>SYSTEM<br>1-1A | BASIC<br>SYSTEM<br>1-1B | SYSTEM<br>CHANGE<br>1-2 | SYSTEM<br>CHANGE<br>1-3 | BASIC<br>SYSTEM<br>CHANGE<br>2-1             | SYSTEM<br>CHANGE<br>2-2 | BASIC<br>SYSTEM<br>CHANGE<br>3-1 | SYSTEM<br>CHANGE<br>3-2 |
| II. IMPROVE MECHANICAL COUPLING (CONTINUED)                                                                                                                                                      |                         |                         |                         |                         |                                              |                         |                                  |                         |
| D. Location Control                                                                                                                                                                              |                         |                         |                         |                         |                                              |                         |                                  |                         |
| 1) Coupler location control:                                                                                                                                                                     |                         |                         |                         |                         |                                              |                         |                                  |                         |
| (a) Centering from draft gear force to within 2" (short cars only).                                                                                                                              | X                       |                         |                         |                         |                                              |                         |                                  |                         |
| (b) Centering from spring force to within 1.2" (long and short cars).                                                                                                                            |                         |                         |                         |                         |                                              |                         |                                  |                         |
| (c) Positioning to within 7" of track center (long cars).                                                                                                                                        |                         |                         |                         |                         |                                              |                         |                                  |                         |
| 2) Reduced contour angling from interlocking coupler heads.                                                                                                                                      |                         |                         |                         |                         |                                              |                         |                                  |                         |
| E. Reduced Maintenance                                                                                                                                                                           |                         |                         |                         |                         |                                              |                         |                                  |                         |
| 1) Slack free design offers better resistance of coupler system to damage from coupling shock and operating vibrations.                                                                          |                         | X                       |                         |                         | X                                            |                         | X                                |                         |
| 2) Major force requirements are accomplished by pneumatic devices to provide a common maintenance skill demand (i.e., no electro-mechanical relays or solenoids to compound maintenance skills). |                         | X                       |                         |                         | X                                            |                         | X                                |                         |
| 3) Major electro-pneumatic control devices are contained in environmentally protected housings.                                                                                                  |                         |                         | X                       |                         |                                              | X                       |                                  | X                       |
| 4) Lubrication fittings at coupler head and shank wear points.                                                                                                                                   | X                       | X                       |                         |                         | X                                            |                         | X                                |                         |

TABLE 5-9.-PRIMARY ADVANTAGES OF CANDIDATE COUPLING SYSTEMS (CONTINUED)

| OPERATIONAL CHARACTERISTICS                                                                                                                    | COMPATIBLE              |                         |                         |                         |                        | NONCOMPATIBLE                                |                        |                                       |  |
|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|------------------------|----------------------------------------------|------------------------|---------------------------------------|--|
|                                                                                                                                                | SYSTEM 1                |                         |                         |                         |                        | SYSTEM 2                                     |                        | SYSTEM 3                              |  |
|                                                                                                                                                | "FREE" KNUCKLE          |                         |                         |                         |                        | "SEMI-RIGID,"<br>SPREAD CLAW,<br>HINGED HOOK |                        | "RIGID,"<br>FLAT FACE,<br>HINGED HOOK |  |
|                                                                                                                                                | BASIC<br>SYSTEM<br>1-1A | BASIC<br>SYSTEM<br>1-1B | SYSTEM<br>CHANGE<br>1-2 | SYSTEM<br>CHANGE<br>1-3 | BASIC<br>SYSTEM<br>2-1 | SYSTEM<br>CHANGE<br>2-2                      | BASIC<br>SYSTEM<br>3-1 | SYSTEM<br>CHANGE<br>3-2               |  |
| III. IMPROVE MECHANICAL UNCOUPLING                                                                                                             |                         |                         |                         |                         |                        |                                              |                        |                                       |  |
| A. <u>Uncoupling Capability</u>                                                                                                                |                         |                         |                         |                         |                        |                                              |                        |                                       |  |
| 1) System can provide an alternate side lever (but is not needed).                                                                             | X                       | X                       |                         |                         | X                      |                                              | X                      |                                       |  |
| 2) System offers push button uncoupling release from side of car.                                                                              |                         |                         | X                       |                         | X                      |                                              | X                      |                                       |  |
| 3) System provides for automatic remote release from within train.                                                                             |                         |                         |                         | X                       |                        | X                                            |                        | X                                     |  |
| 4) Uncoupling capability under nominal (less than 8,000 lbs.) draft force through the use wedge or rotating leveraging of unlocking mechanism. |                         |                         |                         |                         | X                      |                                              | X                      |                                       |  |
| 5) Manual uncoupling (through operation of uncoupling rigging) is possible regardless of availability of air or electrical power.              |                         |                         |                         |                         |                        |                                              |                        |                                       |  |
| B. <u>Recoupling Capability</u>                                                                                                                |                         |                         |                         |                         |                        |                                              |                        |                                       |  |
| 1) Uncoupling system sets or locks the "knuckle" open for automatic recoupling capability.                                                     | X                       | X                       |                         |                         |                        |                                              | X                      |                                       |  |
| 2) Provision to manually lock open the locking mechanism to prevent automatic recoupling.                                                      |                         |                         |                         |                         | X                      |                                              |                        |                                       |  |
| IV. IMPROVE GENERAL SYSTEMS                                                                                                                    |                         |                         |                         |                         |                        |                                              |                        |                                       |  |
| A. <u>Brake Control</u>                                                                                                                        |                         |                         |                         |                         |                        |                                              |                        |                                       |  |
| 1) System provides time delay set provisions for applying brakes (to the cut car or cars) under intentional uncoupling conditions.             |                         |                         |                         | X                       |                        | X                                            |                        | X                                     |  |
| 2) System provides for emergency set of brakes under unintentional uncoupling conditions.                                                      |                         |                         | X                       |                         | X                      |                                              | X                      |                                       |  |

|                                                                                                                                  | COMPATIBLE              |                         |                         |                         | NONCOMPATIBLE                                |                                  |                                  |                                       |
|----------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------------------------|----------------------------------|----------------------------------|---------------------------------------|
|                                                                                                                                  | SYSTEM 1                |                         |                         |                         | SYSTEM 2                                     |                                  | SYSTEM 3                         |                                       |
|                                                                                                                                  | "FREE" KNUCKLE          |                         |                         |                         | "SEMI-RIGID,"<br>SPREAD CLAW,<br>HINGED HOOK | BASIC<br>SYSTEM<br>CHANGE<br>2-1 | BASIC<br>SYSTEM<br>CHANGE<br>2-2 | "RIGID,"<br>FLAT FACE,<br>HINGED HOOK |
|                                                                                                                                  | BASIC<br>SYSTEM<br>1-1A | BASIC<br>SYSTEM<br>1-1B | SYSTEM<br>CHANGE<br>1-2 | SYSTEM<br>CHANGE<br>1-3 | BASIC<br>SYSTEM<br>CHANGE<br>2-1             | BASIC<br>SYSTEM<br>CHANGE<br>2-2 | BASIC<br>SYSTEM<br>CHANGE<br>3-1 | BASIC<br>SYSTEM<br>CHANGE<br>3-2      |
| IV. IMPROVE GENERAL SYSTEMS (CONTINUED)                                                                                          |                         |                         |                         |                         |                                              |                                  |                                  |                                       |
| B. Electrical Train Line System                                                                                                  |                         |                         |                         |                         |                                              |                                  |                                  |                                       |
| 1) Provides for automatic connection make and break between cars.                                                                |                         |                         |                         |                         |                                              |                                  |                                  |                                       |
| (a) Electrical contact principal is well understood and should present no major problem in instruction of maintenance personnel. |                         |                         |                         |                         |                                              |                                  |                                  |                                       |
| (b) Contactors are held in position by gathering action of air connector.                                                        |                         |                         |                         |                         |                                              |                                  |                                  |                                       |
| (c) Contactors are held in position by locking action of coupler heads.                                                          |                         |                         |                         |                         |                                              |                                  |                                  |                                       |
| 2) Provides for multiple circuit capacities.                                                                                     |                         |                         |                         |                         |                                              |                                  |                                  |                                       |
| (a) Six-eight circuits capability (including two redundant power circuits, and one or two train sensing circuits).               | X                       |                         |                         |                         |                                              | X                                |                                  | X                                     |
| (b) Fifty-one hundred circuits capability (including multiple power circuits and unlimited train sensing circuits).              |                         |                         |                         | X                       |                                              | X                                |                                  | X                                     |
| (c) Good electrical contact assured through the use of butt faced, silver tipped, individually spring loaded rotating contacts.  |                         |                         |                         |                         |                                              | X                                |                                  | X                                     |
| (d) Long life contacts are assured by multiplexing signals of low power demand from solid state electrical control circuits.     |                         |                         |                         | X                       |                                              | X                                |                                  | X                                     |

TABLE 5-9--PRIMARY ADVANTAGES OF CANDIDATE COUPLING SYSTEMS (CONTINUED)

| OPERATIONAL CHARACTERISTICS                                                                                                                                           | COMPATIBLE              |                         |                         |                         | NONCOMPATIBLE                                |                         |                        |                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------------------------|-------------------------|------------------------|-------------------------|
|                                                                                                                                                                       | SYSTEM 1                |                         |                         |                         | SYSTEM 2                                     |                         |                        |                         |
|                                                                                                                                                                       | "FREE" KNUCKLE          |                         |                         |                         | "SEMI-RIGID,"<br>SPREAD CLAW,<br>HINGED HOOK |                         |                        |                         |
|                                                                                                                                                                       | BASIC<br>SYSTEM<br>1-1A | BASIC<br>SYSTEM<br>1-1B | SYSTEM<br>CHANGE<br>1-2 | SYSTEM<br>CHANGE<br>1-3 | BASIC<br>SYSTEM<br>2-1                       | SYSTEM<br>CHANGE<br>2-2 | BASIC<br>SYSTEM<br>3-1 | SYSTEM<br>CHANGE<br>3-2 |
| IV. IMPROVE GENERAL SYSTEMS (CONTINUED)                                                                                                                               |                         |                         |                         |                         |                                              |                         |                        |                         |
| B. Electric Train Line System (Continued)                                                                                                                             |                         |                         |                         |                         |                                              |                         |                        |                         |
| 3) Provides for automatic sequencing of contactors.                                                                                                                   |                         |                         |                         |                         |                                              |                         |                        |                         |
| (a) All switching of electrical power is accomplished by master control after contact has been completed - thus no arcing of contacts.                                |                         |                         |                         | X                       |                                              | X                       |                        | X                       |
| (b) No exposure of "live" electrical contacts is uncoupled condition - thus no causing a safety hazard.                                                               |                         |                         |                         | X                       |                                              | X                       |                        | X                       |
| (c) Contactor block is moved forward into contact by pneumatic cylinder after mechanical coupling is complete (and environmental cover is pneumatically moved aside). |                         |                         |                         | X                       |                                              | X                       |                        | X                       |
| (d) Mechanical (hand) back-up of contactor engagement is provided.                                                                                                    |                         |                         |                         | X                       |                                              | X                       |                        | X                       |
| 4) Provides for environment protection of contactors by:                                                                                                              |                         |                         |                         |                         |                                              |                         |                        |                         |
| (a) Cover over contactors when uncoupled.                                                                                                                             |                         |                         |                         | X                       |                                              | X                       |                        | X                       |
| (b) Electrical insulation between contactors and cover.                                                                                                               |                         |                         |                         | X                       |                                              | X                       |                        | X                       |
| (c) Cover moved aside pneumatically after mechanical coupling is complete.                                                                                            |                         |                         |                         | X                       |                                              | X                       |                        | X                       |
| (d) Contactor block has a compressible seal around outside edges to protect the mated contacts from environment.                                                      |                         |                         |                         | X                       |                                              | X                       |                        | X                       |
| (e) Coupler head design offers physical protection of electrical contactor prior to coupling.                                                                         |                         |                         |                         | X                       |                                              | X                       |                        | X                       |

TABLE 5-9.-PRIMARY ADVANTAGES OF CANDIDATE COUPLING SYSTEMS (CONTINUED)

| OPERATIONAL CHARACTERISTICS                                                                                                                                                               | COMPATIBLE              |                         |                         |                         | NONCOMPATIBLE                                 |                         |                                        |                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-----------------------------------------------|-------------------------|----------------------------------------|-------------------------|
|                                                                                                                                                                                           | SYSTEM 1                |                         |                         |                         | SYSTEM 2                                      |                         | SYSTEM 3                               |                         |
|                                                                                                                                                                                           | "FREE" KNUCKLE          |                         |                         |                         | "SEMI-RIGID,"<br>SPREAD CLAW,<br>HINGED W/OOK |                         | "RIGID,"<br>FLAT FACE,<br>HINGED W/OOK |                         |
|                                                                                                                                                                                           | BASIC<br>SYSTEM<br>1-1A | BASIC<br>SYSTEM<br>1-1B | SYSTEM<br>CHANGE<br>1-2 | SYSTEM<br>CHANGE<br>1-3 | BASIC<br>SYSTEM<br>CHANGE<br>2-1              | SYSTEM<br>CHANGE<br>2-2 | BASIC<br>SYSTEM<br>CHANGE<br>3-1       | SYSTEM<br>CHANGE<br>3-2 |
| IV. IMPROVE GENERAL SYSTEMS (CONTINUED)                                                                                                                                                   |                         |                         |                         |                         |                                               |                         |                                        |                         |
| B. Electric Train Line System (Continued)                                                                                                                                                 |                         |                         |                         |                         |                                               |                         |                                        |                         |
| 5) Provides for a sensing and control system having functional units consisting of:                                                                                                       |                         |                         |                         |                         |                                               |                         |                                        |                         |
| (a) An electro-pneumatic servo system is a sealed unit located at each coupler (to transmit low power electronic signals to pneumatic force actuators).                                   |                         |                         |                         | X                       |                                               | X                       |                                        | X                       |
| (b) A multiplexing master system (solid state electronic) can be located at any position in train and could negate the need for a caboose in some operating situations.                   |                         |                         |                         | X                       |                                               | X                       |                                        | X                       |
| (c) An electronic logic and sensing unit is located in each car.                                                                                                                          |                         |                         |                         | X                       |                                               | X                       |                                        | X                       |
| 6) Specific features of the electronic control system include:                                                                                                                            |                         |                         |                         |                         |                                               |                         |                                        |                         |
| (a) Use of proven solid state electronic principles.                                                                                                                                      |                         |                         |                         | X                       |                                               | X                       |                                        | X                       |
| (b) Components are housed in sealed units.                                                                                                                                                |                         |                         |                         | X                       |                                               | X                       |                                        | X                       |
| (c) Modular electronic units are readily maintained and replaceable.                                                                                                                      |                         |                         |                         | X                       |                                               | X                       |                                        | X                       |
| (d) Solid state electronic units are insensitive to mechanical environment.                                                                                                               |                         |                         |                         | X                       |                                               | X                       |                                        | X                       |
| (e) Electronic control is not dependent on transmission of large electrical power signals and therefore is not susceptible to malfunction due to poor grounding through the train wheels. |                         |                         |                         | X                       |                                               | X                       |                                        | X                       |
| 7) Electro-pneumatic control system combines the versatility of low power electronic controls with pneumatic power for performing operating functions.                                    |                         |                         |                         | X                       |                                               | X                       |                                        | X                       |



TABLE 5-10.--PRIMARY DISADVANTAGES OF CANDIDATE COUPLING SYSTEMS (CONTINUED)

| OPERATIONAL CHARACTERISTICS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | COMPATIBLE        |                   |                   |                   | NONCOMPATIBLE                         |                   |                  |                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-------------------|-------------------|-------------------|---------------------------------------|-------------------|------------------|-------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | SYSTEM 1          |                   |                   |                   | SYSTEM 2                              |                   |                  |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | "FREE" KNUCKLE    |                   |                   |                   | "SEMI-RIGID" SPREAD CLAY, HINGED HOOK |                   |                  |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | BASIC SYSTEM 1-1A | BASIC SYSTEM 1-1B | SYSTEM CHANGE 1-2 | SYSTEM CHANGE 1-3 | BASIC SYSTEM 2-1                      | SYSTEM CHANGE 2-2 | BASIC SYSTEM 3-1 | SYSTEM CHANGE 3-2 |
| <b>II. IMPROVE MECHANICAL COUPLING (CONTINUED)</b><br><b>A. General Design (Continued)</b><br>5) Lower half on type "g" coupler results in a lower position of the air/electrical unit than is desired for damage susceptibility from road debris.<br>6) Coupler head design does not offer any significant mechanical protection for air seals or electrical connectors.<br>7) Coupler embodies a discontinuous coupling movement which could cause an accelerated wear on lateral moving members.<br>8) Coupler does not provide adequate interlock as required for long cars.<br>9) Flat face "rigid" coupler design requires a positioning device to prevent excessive damage to coupler head and aligning pins from coupling at oblique angles. | X                 |                   |                   |                   |                                       |                   |                  |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | X                 | X                 |                   |                   |                                       |                   | X                |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | X                 |                   |                   |                   |                                       |                   |                  |                   |
| <b>III. IMPROVE MECHANICAL UNCOUPLING</b><br><b>A. General Design</b><br>1) Remote pneumatic uncoupling is susceptible to possible malfunction due to the excessive force required to operate frozen or stuck uncoupling rigging.<br><b>B. Uncoupling Capability</b><br>1) A side-of-car push button uncoupling capability is subject to potential vandalism and undesired uncoupling.                                                                                                                                                                                                                                                                                                                                                               |                   |                   |                   |                   |                                       |                   |                  |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                   |                   |                   |                   |                                       |                   |                  |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                   |                   |                   |                   |                                       |                   |                  |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                   |                   | X                 | X                 | X                                     | X                 | X                | X                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                   |                   | X                 |                   | X                                     |                   |                  |                   |

TABLE 5-10.-PRIMARY DISADVANTAGES OF CANDIDATE COUPLING SYSTEMS (CONTINUED)

| OPERATIONAL CHARACTERISTICS                                                                                                             | COMPATIBLE              |                         |                         |                         | NONCOMPATIBLE                                |                         |                                       |                         |
|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------------------------|-------------------------|---------------------------------------|-------------------------|
|                                                                                                                                         | SYSTEM 1                |                         |                         |                         | SYSTEM 2                                     |                         | SYSTEM 3                              |                         |
|                                                                                                                                         | "FREE" KNUCKLE          |                         |                         |                         | "SEMI-RIGID,"<br>SPREAD CLAW,<br>HINGED HOOK |                         | "RIGID,"<br>FLAT FACE,<br>HINGED HOOK |                         |
|                                                                                                                                         | BASIC<br>SYSTEM<br>1-1A | BASIC<br>SYSTEM<br>1-1B | SYSTEM<br>CHANGE<br>1-2 | SYSTEM<br>CHANGE<br>1-3 | BASIC<br>SYSTEM<br>CHANGE<br>2-1             | SYSTEM<br>CHANGE<br>2-2 | BASIC<br>SYSTEM<br>CHANGE<br>3-1      | SYSTEM<br>CHANGE<br>3-2 |
| IV. IMPROVE GENERAL SYSTEMS                                                                                                             |                         |                         |                         |                         |                                              |                         |                                       |                         |
| A. <u>Electrical Train Line System</u>                                                                                                  |                         |                         |                         |                         |                                              |                         |                                       |                         |
| 1) The addition of an electric system adds the requirement for another skill to maintenance requirements.                               |                         |                         |                         | X                       |                                              | X                       |                                       | X                       |
| (a) An inter-car contact system requires periodic cleaning and maintenance (i.e., more frequent than current coupling systems).         |                         |                         |                         | X                       |                                              | X                       |                                       | X                       |
| (b) An electric contact system is subject to damage and malfunction of the intended sensing and control functions.                      |                         |                         |                         | X                       |                                              | X                       |                                       | X                       |
| (c) The control system is subject to tampering.                                                                                         |                         |                         |                         | X                       |                                              | X                       |                                       | X                       |
| (d) The contact system is subject to vandalism.                                                                                         |                         |                         |                         | X                       |                                              | X                       |                                       | X                       |
| (e) No data is available concerning the expected lifetime of this type of contact system under full rail freight service.               |                         |                         |                         | X                       |                                              | X                       |                                       | X                       |
| 2) The number of electrical circuits is limited (6-8 circuits) and this potentially limits the number of sensing circuits.              |                         |                         |                         | X                       |                                              | X                       |                                       | X                       |
| B. <u>Sensing and Control System</u>                                                                                                    |                         |                         |                         |                         |                                              |                         |                                       |                         |
| 1) Proper operation of the control system is dependent on reliable inter-car contacts.                                                  |                         |                         |                         | X                       |                                              | X                       |                                       | X                       |
| 2) All pneumatic valving and mechanical operating units (platoons, etc.) must be protected from clogging by an effective filter system. |                         |                         | X                       | X                       |                                              | X                       | X                                     | X                       |

## **6. PRELIMINARY COSTING**

### **6.1 INTRODUCTION**

Each of the Candidate Coupling Systems defined in Section 5 was subject to a preliminary engineering evaluation as relating to costing. This evaluation was directed at determination of a reasonable estimate for the cost of each of the separate subsystem elements.

The preliminary costs for each system's elements were derived by using a combination of the following inputs:

- 1) Review of technical literature for past cost estimates.
- 2) Discussions with railroad industry suppliers and users for verification of concept production potentials.
- 3) Preliminary engineering evaluation of complexity of new concepts as compared with the basic type "E" system.
- 4) Evaluation of present costing as a function of the complexity of concept design and relative quantities produced.
- 5) Engineering estimate of potential replacement life of new concepts as compared to reported field problems with similar systems.

### **6.2 GENERAL LIMITATIONS**

Several assumptions were made for both technical and cost aspects as applicable to the various subsystem elements. These assumptions were made to define more adequately or constrain the possible variations in the preliminary cost estimates. These constraints are shown on the following page.

#### 6.2.1 Cost Constraints

1) All costs are based on constant 1975 dollars and include an estimate of the total of labor and material costs.

2) Projections of costs assume that full quantity production would be made at a level of at least 50,000 car sets per year.

3) Costs are estimated as an "order of merit" based on a preliminary understanding of the potential for a final design. As such, the cost estimates are believed consistent in the costing approach but should be considered to have an uncertainty level for any specific item of  $\pm$  25 percent.

4) No calculation was made for estimated inventory costs, since these are subject to unique control by each railroad.

5) Annual maintenance and replacement costs were estimated on the basis of the estimated replacement life of each listed equipment item including estimated replacement labor and upkeep labor.

6) No costs were included for preparation or repair of old cars prior to installation of the new coupler system (or subsystem). It is assumed that all cars to be modified would be in a state of full repair at the time of coupler modifications.

Significant design work has been accomplished by European railroads to determine the potential costs for both car preparation and coupler changeover. Concept 49 included an estimate of approximately \$1100 for the average cost of preparation of old cars to insure an adequate anchoring and sill strength for mounting of new center-buffer coupler units. No technical data were available to allow a reasonable basis for estimating a comparable preparation cost for an "average" U.S. rail car.

7) It is assumed that an average of one Interchange Adapter

unit would be required for each car with a System 2 or 3 coupler.

8) Initial system costs for a new car system are estimated as additional to the cost for the basic car equipped with the standard coupler and draft gear system. If the new system element is not estimated to increase the cost over the basic car system, this estimate is indicated by a "N.I." notation (for NO INCREASE).

9) Initial system costs for modified cars are estimated as an addition to the cost for a new basic coupler and draft gear system.

10) No cost estimate is included for value of the revenue time loss by each car during the coupler modification program.

11) No costs are included for any peripheral safety or back-up equipment which might be designated by AAR or Governmental agencies as required to be used in conjunction with any new coupler system.

#### 6.2.2 Technical Constraints

1) It is assumed that the maximum utilization would be made of casting as opposed to welding or machining. In particular, this applies to shelves or guard-arm extensions, which are assumed to be manufactured as a one-piece casting as compared to weldment additions to the basic coupler heads.

2) Grade "C" steel is assumed as the standard for coupler castings.

3) It is assumed that the AAR rules would be modified to allow tapping into the main air system to attain pressure for operation of valves and force boosting of uncoupling and valve operation. Cost estimates have been included in sub-systems 1-2, 2-1, and 3-1 for the check valves and holding reservoirs necessary to safely accomplish this operation.

### 6.3 PRELIMINARY COST ESTIMATES

Included as Tables 6-1 through 6-8 are the individual preliminary cost estimates for each of the separate candidate coupler subsystems. The format for the presentation of the preliminary cost estimates for the three candidate systems is as follows:

- 1) Compatible System #1
  - (a) Basic System 1-1A, Short Car (Table 6-1)
  - (b) Basic System 1-1B, Long Car (Table 6-2)
  - (c) System Change 1-2, Addition of Air Connector and Valve Control System (Table 6-3)
  - (d) System Change 1-3, Addition of Electropneumatic Control Systems (Table 6-4)
- 2) Noncompatible System #2, Semirigid, Spread-Claw
  - (a) Basic System 2-1, (Table 6-5)
  - (b) System Change 2-2, Addition of Electropneumatic Control Systems (Table 6-6)
- 3) Noncompatible System #3, Rigid, Flat-Faced
  - (a) Basic System 3-1, (Table 6-7)
  - (b) System Change 3-2, Addition of Electropneumatic Control Systems (Table 6-8)

Each of these tables include the following information about each subsystem:

- 1) Concept number
- 2) Concept identification
- 3) Preliminary cost estimates for:
  - (a) Initial system cost - with new car
  - (b) Initial system cost - modify old car
  - (c) Continuing annual estimated maintenance and replacement cost.

TABLE 6-1.-PRELIMINARY COST ESTIMATE FOR CANDIDATE COUPLING SYSTEM 1-1A

| CONCEPT NUMBER                                                                                                                                                                  | CONCEPT IDENTIFICATION                                                           | COST ESTIMATES(1) PER CAR SYSTEM |                           |                                                                         |                                      | REMARKS<br>(ESTIMATED AVERAGE REPLACEMENT LIFE) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------|---------------------------|-------------------------------------------------------------------------|--------------------------------------|-------------------------------------------------|
|                                                                                                                                                                                 |                                                                                  | INITIAL SYSTEM COSTS             |                           | CONTINUING ANNUAL ESTIMATED MAINTENANCE AND REPLACEMENT COST DOLLARS(4) |                                      |                                                 |
|                                                                                                                                                                                 |                                                                                  | WITH NEW CAR DOLLARS(2)          | MODIFY OLD CAR DOLLARS(3) |                                                                         |                                      |                                                 |
| 501                                                                                                                                                                             | Coupler knuckle contour change and revised front knuckle shape.                  | N.I.(5)                          | N.I.                      | N.I.                                                                    | (Same as "E")                        |                                                 |
| 702                                                                                                                                                                             | Guard arm extension faces on top and bottom shelves (in addition to Concept 54). | 10                               | 10                        | N.I.                                                                    | (Same as "E")                        |                                                 |
| 502b                                                                                                                                                                            | Compatimatic* coupler head.                                                      | 90                               | 90                        | 20                                                                      | (Six years for locking hardware)     |                                                 |
| 54                                                                                                                                                                              | (Revised operating rod.)                                                         | 10                               | 60                        | N.I.                                                                    | (Same as "E")                        |                                                 |
| 26                                                                                                                                                                              | Top and bottom coupler shelf.                                                    | 50                               | 50                        | N.I.                                                                    | (Same as "E")                        |                                                 |
| 503a                                                                                                                                                                            | Self centering draft gear.                                                       | 10                               | 10                        | N.I.                                                                    | (Same as "E")                        |                                                 |
|                                                                                                                                                                                 | Lubrication fittings.                                                            | 50                               | 50                        | 20                                                                      | (Maintenance at six-month intervals) |                                                 |
| 54                                                                                                                                                                              | Blunt and round front edges of coupler and shelves.                              | N.I.                             | N.I.                      | N.I.                                                                    | (Same as "E")                        |                                                 |
|                                                                                                                                                                                 | Total cost estimates(1) per car:                                                 |                                  |                           |                                                                         |                                      |                                                 |
|                                                                                                                                                                                 | Basic system equipment                                                           | 220                              | 270                       | 40                                                                      |                                      |                                                 |
|                                                                                                                                                                                 | Installation                                                                     | -                                | -                         | -                                                                       |                                      |                                                 |
|                                                                                                                                                                                 | Total costs                                                                      | 220                              | 270                       | 40                                                                      |                                      |                                                 |
| Notes: (1) All costs are estimated based on constant 1975 dollars.                                                                                                              |                                                                                  |                                  |                           |                                                                         |                                      |                                                 |
| (2) All costs are in addition to the costs for the basic short car with the complete type "E" basic coupler and draft gear system.                                              |                                                                                  |                                  |                           |                                                                         |                                      |                                                 |
| (3) Installation of system 1-1A onto an existing short car would include the installed cost for a basic type "E" coupler and draft gear system in addition to this system cost. |                                                                                  |                                  |                           |                                                                         |                                      |                                                 |
| (4) These maintenance and replacement cost estimates are in addition to the basic costs for the type "E" system.                                                                |                                                                                  |                                  |                           |                                                                         |                                      |                                                 |
| (5) No increase.                                                                                                                                                                |                                                                                  |                                  |                           |                                                                         |                                      |                                                 |
| (*) Developed by National Castings Division, Midland Ross Corporation.                                                                                                          |                                                                                  |                                  |                           |                                                                         |                                      |                                                 |

TABLE 6-2.-PRELIMINARY COST ESTIMATE FOR CANDIDATE COUPLING: SYSTEM 1-1B

| CONCEPT NUMBER                                                                                                                                                                 | CONCEPT IDENTIFICATION                                                  | COST ESTIMATES(1) PER CAR SYSTEM |                           |                                                                         |                                                                         | REMARKS<br>(ESTIMATED AVERAGE REPLACEMENT LIFE) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|----------------------------------|---------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------|
|                                                                                                                                                                                |                                                                         | INITIAL SYSTEM COSTS             |                           | CONTINUING ANNUAL ESTIMATED MAINTENANCE AND REPLACEMENT COST DOLLARS(4) |                                                                         |                                                 |
|                                                                                                                                                                                |                                                                         | WITH NEW CAR DOLLARS(2)          | MODIFY OLD CAR DOLLARS(3) |                                                                         |                                                                         |                                                 |
| 501                                                                                                                                                                            | Coupler knuckle contour change and revised front knuckle shape.         | N.I.(5)                          | N.I.                      | N.I.                                                                    | (Same as "F")                                                           |                                                 |
| 428b                                                                                                                                                                           | Type "F" interlocking coupler head.                                     | Basic System 100                 | Basic System 100          | N.I.                                                                    | (Same as "F")                                                           |                                                 |
| 502b                                                                                                                                                                           | Compatimatic* coupler head.                                             |                                  |                           | 20                                                                      | (Six years for locking hardware)                                        |                                                 |
| 52                                                                                                                                                                             | (Revised operating rod.)                                                | 10                               | 60                        | N.I.                                                                    | (Same as "F")                                                           |                                                 |
| 31b                                                                                                                                                                            | Top coupler shelf.                                                      | 40                               | 40                        | N.I.                                                                    | (Same as "F")                                                           |                                                 |
|                                                                                                                                                                                | Coupler positioning device (hydraulic).                                 | 2,000                            | 2,000                     | 200                                                                     | Wide mouth bell housing assumed as part of long car (estimate 12 years) |                                                 |
| 25                                                                                                                                                                             | Vertical spring carrier system                                          |                                  |                           |                                                                         | (Estimate six years)                                                    |                                                 |
| 503a                                                                                                                                                                           | Lubrication fittings                                                    | 120                              | 120                       | 30                                                                      | (Maintenance at six-month intervals)                                    |                                                 |
| 52                                                                                                                                                                             | Blunt and round front edges of coupler, top shelf and guard arm/pocket. | 50                               | 50                        | 20                                                                      |                                                                         |                                                 |
|                                                                                                                                                                                | Total cost estimates(1) per car:                                        | N.I.                             | N.I.                      | N.I.                                                                    | (Same as "F")                                                           |                                                 |
|                                                                                                                                                                                | Basic system equipment                                                  | 2,320                            | 2,370                     | 270                                                                     |                                                                         |                                                 |
|                                                                                                                                                                                | Installation                                                            | 250                              | 450                       | -                                                                       |                                                                         |                                                 |
|                                                                                                                                                                                | Total costs                                                             | 2,570                            | 2,820                     | 270                                                                     |                                                                         |                                                 |
| Notes: (1) All costs are estimated based on constant 1975 dollars.                                                                                                             |                                                                         |                                  |                           |                                                                         |                                                                         |                                                 |
| (2) All costs are in addition to the costs for "F" the basic long car with the complete type "F" basic coupler and draft gear system.                                          |                                                                         |                                  |                           |                                                                         |                                                                         |                                                 |
| (3) Installation of system 1-18 onto an existing long car would include the installed cost for a basic type "F" coupler and draft gear system in addition to this system cost. |                                                                         |                                  |                           |                                                                         |                                                                         |                                                 |
| (4) These maintenance and replacement cost estimates are in addition to the basic costs for the type "F" system.                                                               |                                                                         |                                  |                           |                                                                         |                                                                         |                                                 |
| (5) No increase.                                                                                                                                                               |                                                                         |                                  |                           |                                                                         |                                                                         |                                                 |
| (*) Developed by National Castings Division, Midland Ross Corporation.                                                                                                         |                                                                         |                                  |                           |                                                                         |                                                                         |                                                 |

Notes: (1) All costs are estimated based on constant 1975 dollars.  
(2) All costs are in addition to the costs for the basic long car with the complete type "F" basic coupler and draft gear system.  
(3) Installation of system 1-1B onto an existing long car would include the installed cost for a basic type "F" coupler and draft gear system in addition to this system cost.  
(4) These maintenance and replacement cost estimates are in addition to the basic costs for the type "F" system.  
(5) No increase.  
(\*) Developed by National Castings Division, Midland Ross Corporation.

TABLE 6-3.-PRELIMINARY COST ESTIMATE FOR CANDIDATE COUPLING SYSTEM 1-2

| CONCEPT NUMBER | CONCEPT IDENTIFICATION                                                                                                                          | COST ESTIMATES(1) PER CAR SYSTEM |                           |                                                                         |                       | REMARKS<br>(ESTIMATED AVERAGE REPLACEMENT LIFE) |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|---------------------------|-------------------------------------------------------------------------|-----------------------|-------------------------------------------------|
|                |                                                                                                                                                 | INITIAL SYSTEM COSTS             |                           | CONTINUING ANNUAL ESTIMATED MAINTENANCE AND REPLACEMENT COST DOLLARS(3) |                       |                                                 |
|                |                                                                                                                                                 | WITH NEW CAR DOLLARS(2)          | MODIFY OLD CAR DOLLARS(2) |                                                                         |                       |                                                 |
| 22             | Automatic air connection.                                                                                                                       | 300                              | 300                       | 85                                                                      | (Estimate six years)  |                                                 |
| 22             | Automatic air valve control (mechanical).                                                                                                       | 600                              | 600                       | 70                                                                      | (Estimate ten years)  |                                                 |
| 674            | Remote uncoupling button at side of car.                                                                                                        | 40                               | 40                        | 10                                                                      | (Estimate ten years)  |                                                 |
| 943            | Pneumatic uncoupling operating mechanism.                                                                                                       | 200                              | 200                       | 30                                                                      | (Estimate ten years)  |                                                 |
| 22             | Air hose/glad hand connection (relocated).                                                                                                      | 50                               | 50                        | M.I.(4)                                                                 | (Estimate five years) |                                                 |
| -              | Air control system (tap off air brake line).                                                                                                    | <u>300</u>                       | <u>300</u>                | <u>35</u>                                                               | (Estimate 20 years)   |                                                 |
|                | Total cost estimates(1) per car:                                                                                                                | 1,490                            | 1,490                     | 230                                                                     |                       |                                                 |
|                | Basic system equipment installation                                                                                                             | <u>500</u>                       | <u>1,000</u>              | -                                                                       |                       |                                                 |
|                | Total costs                                                                                                                                     | <u>1,990</u>                     | <u>2,490</u>              | <u>230</u>                                                              |                       |                                                 |
|                | Notes: (1) All costs are estimated based on constant 1975 dollars.                                                                              |                                  |                           |                                                                         |                       |                                                 |
|                | (2) All costs are in addition to the basic uncoupling and air system equipment standard on all cars, (and assumed to be in place and operable). |                                  |                           |                                                                         |                       |                                                 |
|                | (3) These maintenance and replacement cost estimates are offset by savings from the normal air and uncoupling system upkeep.                    |                                  |                           |                                                                         |                       |                                                 |
|                | (4) No increases.                                                                                                                               |                                  |                           |                                                                         |                       |                                                 |

Notes: (1) All costs are estimated based on constant 1975 dollars.  
(2) All costs are in addition to the basic uncoupling and air system equipment standard on all cars, (and assumed to be in place and operable).  
(3) These maintenance and replacement cost estimates are offset by savings from the normal air and uncoupling system upkeep.  
(4) No increase.

TABLE 6-4--PRELIMINARY COST ESTIMATE FOR CANDIDATE COUPLING SYSTEM 1-3

| CONCEPT NUMBER                                                                                                                                  | CONCEPT IDENTIFICATION                                           | COST ESTIMATES(1) PER CAR SYSTEM |                           |                                                                         |                            | REMARKS<br>(ESTIMATED AVERAGE REPLACEMENT LIFE) |
|-------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|----------------------------------|---------------------------|-------------------------------------------------------------------------|----------------------------|-------------------------------------------------|
|                                                                                                                                                 |                                                                  | INITIAL SYSTEM COSTS             |                           | CONTINUING ANNUAL ESTIMATED MAINTENANCE AND REPLACEMENT COST DOLLARS(4) |                            |                                                 |
|                                                                                                                                                 |                                                                  | WITH NEW CAR DOLLARS(2)          | MODIFY OLD CAR DOLLARS(3) |                                                                         |                            |                                                 |
| 254                                                                                                                                             | Electro-pneumatic servo control system at each coupler.          | 1,600(4)                         | 1,600(4)                  | 200(5)                                                                  | (Estimate ten years)       |                                                 |
| 1200                                                                                                                                            | Electrical connector system (attached to air connector) with:    |                                  |                           |                                                                         | (Estimate four years)      |                                                 |
| 450a                                                                                                                                            | Six-eight butt face, spring loaded, rotating contacts.           |                                  |                           |                                                                         |                            |                                                 |
| 516b                                                                                                                                            | Silver plated contacts and mechanical back-up.                   |                                  |                           |                                                                         |                            |                                                 |
| 254                                                                                                                                             | Maintenance removal potential.                                   |                                  |                           |                                                                         |                            |                                                 |
| 516b                                                                                                                                            | Environmental sealing gasket.                                    |                                  |                           |                                                                         |                            |                                                 |
| 1200                                                                                                                                            | Air piston sequencing of contactors after mating.                | 200                              | 200                       | 30                                                                      | (Estimate ten years)       |                                                 |
| 301b                                                                                                                                            | Environmental cover opened pneumatically after mating, with:     | 400                              | 400                       | 275                                                                     | (Estimate two years)       |                                                 |
| 36                                                                                                                                              | Nylon hinges.                                                    |                                  |                           |                                                                         |                            |                                                 |
| 516b                                                                                                                                            | Plastic cover insulators.                                        |                                  |                           |                                                                         |                            |                                                 |
| 452                                                                                                                                             | Electronic, solid state multiplexing sensing and control system. |                                  |                           |                                                                         | (Estimate six-eight years) |                                                 |
|                                                                                                                                                 | Intra-car electrical conduit system                              | 1,500                            | 1,500                     | 275                                                                     | (Estimate 20 years)        |                                                 |
|                                                                                                                                                 | Total cost estimates(1) per car:                                 | <u>125</u>                       | <u>125</u>                | <u>5</u>                                                                |                            |                                                 |
|                                                                                                                                                 | Basic system equipment                                           | 4,225                            | 4,225                     | 910                                                                     |                            |                                                 |
|                                                                                                                                                 | Installation                                                     | <u>575</u>                       | <u>1,150</u>              | <u>-</u>                                                                |                            |                                                 |
|                                                                                                                                                 | Total costs                                                      | <u>4,800</u>                     | <u>5,375</u>              | <u>910</u>                                                              |                            |                                                 |
| Notes: (1) All costs are estimated based on constant 1975 dollars.                                                                              |                                                                  |                                  |                           |                                                                         |                            |                                                 |
| (2) All costs are in addition to the basic uncoupling and air system equipment standard on all cars, (and assumed to be in place and operable). |                                                                  |                                  |                           |                                                                         |                            |                                                 |
| (3) These maintenance and replacement cost estimates are offset by savings from the normal air and uncoupling system upkeep.                    |                                                                  |                                  |                           |                                                                         |                            |                                                 |
| (4) Electro-pneumatic control system would replace mechanical air valve control and save \$600 in system 1-2.                                   |                                                                  |                                  |                           |                                                                         |                            |                                                 |
| (5) Electro-pneumatic control system would replace mechanical air valve control and save \$70 in system 1-2.                                    |                                                                  |                                  |                           |                                                                         |                            |                                                 |

TABLE 6-5.-PRELIMINARY COST ESTIMATE FOR CANDIDATE COUPLING SYSTEM 2-1

| CONCEPT NUMBER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | CONCEPT IDENTIFICATION                                                                                                                                                                                                                                                                                                                   | COST ESTIMATES (1) PER CAR SYSTEM               |                           |                                                                         | REMARKS<br>(ESTIMATED AVERAGE REPLACEMENT LIFE)                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|---------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                          | INITIAL SYSTEM COSTS<br>WITH NEW CAR DOLLARS(2) | MODIFY OLD CAR DOLLARS(2) | CONTINUING ANNUAL ESTIMATED MAINTENANCE AND REPLACEMENT COST DOLLARS(3) |                                                                                         |
| 309                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Basic semirigid, spread claw coupler system with draft gear and uncoupling levers.                                                                                                                                                                                                                                                       | 40                                              | 40                        | 20                                                                      | (Estimate six years for locking hardware, remainder same as "G") (Estimate eight years) |
| 503a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Integral air connection system within coupler with: Double concentric compressible rubber seals. Pivoted rear removal of air connection assembly. Automatic air valve control (mechanical). O.R.E.II cross beam centering device with: Vertical spring carrier system. Air control system (tap off air brake line). Lubrication fittings | 150                                             | 150                       | 30                                                                      |                                                                                         |
| 309                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                          | 600                                             | 600                       | 60                                                                      | (Estimate 12 years)                                                                     |
| 318                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                          | 120                                             | 120                       | 30                                                                      | (Estimate six years)                                                                    |
| 25                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                          | 300                                             | 300                       | 35                                                                      | (Estimate 20 years)                                                                     |
| 503a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                          | 50                                              | 50                        | 20                                                                      | (Maintenance at six-month intervals)                                                    |
| 674                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Remote uncoupling button at side of car.                                                                                                                                                                                                                                                                                                 | 40                                              | 40                        | 10                                                                      | (Estimate ten years)                                                                    |
| 391                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Air cylinder release of locking block.                                                                                                                                                                                                                                                                                                   | 200                                             | 200                       | 30                                                                      | (Estimate ten years)                                                                    |
| 22                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Air hose/glad hand connection (relocate).                                                                                                                                                                                                                                                                                                | 50                                              | 50                        | N.I.(4)                                                                 | (Same as "E")                                                                           |
| 301a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Coupler head interchange adapter (assume one/car)                                                                                                                                                                                                                                                                                        | 250                                             | 250                       | 10                                                                      | (Six years for locking hardware, remainder same as "E")                                 |
| Total cost estimates(1) per car:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                          | 1,800                                           | 1,800                     | —                                                                       |                                                                                         |
| Basic system equipment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                          | 465                                             | 930                       | 245                                                                     |                                                                                         |
| Installation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                          | —                                               | —                         | —                                                                       |                                                                                         |
| Total costs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                          | 2,265                                           | 2,730                     | 245                                                                     |                                                                                         |
| <p>Notes: (1) All costs are estimated based on constant 1975 dollars.</p> <p>(2) All costs are in addition to the costs for a basic car system including the standard type "G" coupler and draft gear system (including wide mouth bell housings as required for long cars).</p> <p>(3) These maintenance and replacement cost estimates are in addition to the basic costs for the type "G" coupler system but are offset by savings from the normal air and uncoupling system upkeep.</p> <p>(4) No increase.</p> |                                                                                                                                                                                                                                                                                                                                          |                                                 |                           |                                                                         |                                                                                         |

TABLE 6-6.-PRELIMINARY COST ESTIMATE FOR CANDIDATE COUPLING SYSTEM 2-2

| CONCEPT NUMBER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | CONCEPT IDENTIFICATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | COST ESTIMATES(1) PER CAR SYSTEM |                           |                                                                         | REMARKS<br>(ESTIMATED AVERAGE REPLACEMENT LIFE) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|---------------------------|-------------------------------------------------------------------------|-------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | INITIAL SYSTEM COSTS             |                           | CONTINUING ANNUAL ESTIMATED MAINTENANCE AND REPLACEMENT COST DOLLARS(3) |                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | WITH NEW CAR DOLLARS(2)          | MODIFY OLD CAR DOLLARS(2) |                                                                         |                                                 |
| 254                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Electro-pneumatic servo control system at each coupler. Electrical connector system integral (located within coupler head) with:<br>Six-eight butt face, spring loaded, rotating contacts. Silver-plated contacts and mechanical back-up.<br>Maintenance removal potential.<br>Environmental sealing gasket.<br>Air piston sequencing of contactors after mating.<br>Environmental cover removed pneumatically after mating, with: Nylon hinges.<br>Plastic cover insulators.<br>Electronic, solid state, multiplexing sensing and control system.<br>Intra-car electrical conduit system.<br><br>Total cost estimates(1) per car:<br>Basic system equipment<br>Installation<br>Total costs | 1,600(4)                         | 1,600(4)                  | 200(5)                                                                  | (Estimate ten years)                            |
| 36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 500                              | 500                       | 100                                                                     | (Estimate six years)                            |
| 450a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                  |                           |                                                                         |                                                 |
| 516b                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                  |                           |                                                                         |                                                 |
| 309                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 200                              | 200                       | 30                                                                      | (Estimate ten years)                            |
| 516b                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 400                              | 400                       | 140                                                                     | (Estimate four years)                           |
| 1400                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                  |                           |                                                                         |                                                 |
| 501b                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1,500                            | 1,500                     | 275                                                                     | (Estimate six-eight years)                      |
| 36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 125                              | 125                       | 5                                                                       | (Estimate 20 years)                             |
| 516b                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4,325                            | 4,325                     | 750                                                                     |                                                 |
| 452                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 575                              | 1,150                     | -                                                                       |                                                 |
| -                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 4,900                            | 5,475                     | 750                                                                     |                                                 |
| Notes: (1) All costs are estimated based on constant 1975 dollars.<br>(2) All costs are in addition to the costs for a basic car system including the standard type "g" coupler and draft gear system (including wide mouth bell housings as required for long cars).<br>(3) These maintenance and replacement cost estimates are in addition to the basic costs for the type "g" coupler system but are offset by savings from the normal air and uncoupling system upkeep.<br>(4) Electro-pneumatic control system would replace mechanical air valve control and save \$600 in system 2-1.<br>(5) Electro-pneumatic control system would replace mechanical air valve control and save \$60 in system 2-1. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                  |                           |                                                                         |                                                 |

TABLE 6-7.--PRELIMINARY COST ESTIMATE FOR CANDIDATE COUPLING SYSTEM 3-1

| CONCEPT NUMBER                                                                                                                                                                                      | CONCEPT IDENTIFICATION                                                                    | COST ESTIMATES(1) PER CAR SYSTEM |                           |                                                                         |         | REMARKS<br>(ESTIMATED AVERAGE REPLACEMENT LIFE)                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|----------------------------------|---------------------------|-------------------------------------------------------------------------|---------|-----------------------------------------------------------------------|
|                                                                                                                                                                                                     |                                                                                           | INITIAL SYSTEM COSTS             |                           | CONTINUING ANNUAL ESTIMATED MAINTENANCE AND REPLACEMENT COST DOLLARS(3) |         |                                                                       |
|                                                                                                                                                                                                     |                                                                                           | WITH NEW CAR DOLLARS(2)          | MODIFY OLD CAR DOLLARS(2) |                                                                         |         |                                                                       |
| 9                                                                                                                                                                                                   | Basic rigid, flat face, hinged hook coupler system with draft gear and uncoupling levers. | 285                              | 285                       |                                                                         | 40      | (Estimate six years for locking hardware, "g") remainder same as "g") |
| 9                                                                                                                                                                                                   | Integral air connection system                                                            | 100                              | 100                       |                                                                         | 25      | (Estimate eight years)                                                |
| 22                                                                                                                                                                                                  | Automatic air valve control (mechanical).                                                 | 600                              | 600                       |                                                                         | 6       | (Estimate 12 years)                                                   |
| 31b                                                                                                                                                                                                 | Coupler positioning device (hydraulic).                                                   | 2,000                            | 2,000                     |                                                                         | 200     | (Estimate 12 years)                                                   |
| 25                                                                                                                                                                                                  | Vertical spring carrier system.                                                           | 120                              | 120                       |                                                                         | 30      | (Estimate six years)                                                  |
| 503a                                                                                                                                                                                                | Lubrication fittings                                                                      | 50                               | 50                        |                                                                         | 20      | (Maintenance at six-month intervals)                                  |
| 674                                                                                                                                                                                                 | Air control system (tap off air brake line).                                              | 300                              | 300                       |                                                                         | 35      | (Estimate 20 years)                                                   |
| 391                                                                                                                                                                                                 | Remote uncoupling button at side of car.                                                  | 40                               | 40                        |                                                                         | 10      | (Estimate ten years)                                                  |
| 22                                                                                                                                                                                                  | Air cylinder release of locking block.                                                    | 200                              | 200                       |                                                                         | 30      | (Estimate ten years)                                                  |
| 9                                                                                                                                                                                                   | Air hose/glad hand connection (relocate).                                                 | 50                               | 50                        |                                                                         | N.I.(4) | (Same as "g")                                                         |
| 9                                                                                                                                                                                                   | Coupler head interchange adapter (assume one/car).                                        | 250                              | 250                       |                                                                         | 10      | (Six year estimate for locking hardware, "g") remainder same as "g")  |
|                                                                                                                                                                                                     | Total cost estimates(1) per car:                                                          |                                  |                           |                                                                         |         |                                                                       |
|                                                                                                                                                                                                     | Basic system equipment                                                                    | 3,995                            | 3,995                     |                                                                         | 460     |                                                                       |
|                                                                                                                                                                                                     | Installation                                                                              | 465                              | 935                       |                                                                         | -       |                                                                       |
|                                                                                                                                                                                                     | Total costs                                                                               | 4,460                            | 4,930                     |                                                                         | 460     |                                                                       |
| Notes: (1) All costs are estimated based on constant 1975 dollars.                                                                                                                                  |                                                                                           |                                  |                           |                                                                         |         |                                                                       |
| (2) All costs are in addition to the costs for a basic car system including the standard type "g" coupler and draft gear system (including wide mouth bell housings as required for long cars).     |                                                                                           |                                  |                           |                                                                         |         |                                                                       |
| (3) These maintenance and replacement cost estimates are in addition to the basic costs for the type "L" coupler system but are offset by savings from the normal air and uncoupling system upkeep. |                                                                                           |                                  |                           |                                                                         |         |                                                                       |
| (4) No increase.                                                                                                                                                                                    |                                                                                           |                                  |                           |                                                                         |         |                                                                       |

TABLE 6-8.-PRELIMINARY COST ESTIMATE FOR CANDIDATE COUPLING SYSTEM 3-2

| CONCEPT NUMBER | CONCEPT IDENTIFICATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | COST ESTIMATES(1) PER CAR SYSTEM |                           |                                                                         |                            | REMARKS<br>(ESTIMATED AVERAGE REPLACEMENT LIFE) |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|---------------------------|-------------------------------------------------------------------------|----------------------------|-------------------------------------------------|
|                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | INITIAL SYSTEM COSTS             |                           | CONTINUING ANNUAL ESTIMATED MAINTENANCE AND REPLACEMENT COST DOLLARS(3) |                            |                                                 |
|                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | WITH NEW CAR DOLLARS(2)          | MODIFY OLD CAR DOLLARS(2) |                                                                         |                            |                                                 |
| 254            | Electro-pneumatic servo control system at each coupler. Electrical connector system integral (located below coupler head) with:<br>50-100 butt face, spring loaded, rotating contacts. Silver-plated contacts and mechanical back-up. Maintenance removal potential.<br>Environmental sealing gasket.<br>Air piston sequencing of contactors after mating. Environmental cover removed pneumatically after mating.<br>with:<br>Nylon hinges<br>Plastic cover insulators.<br>Electronic, solid state, multiplexing sensing and control system.<br>Intra-car electrical conduit system.<br><br>Total cost estimates(1) per car:<br>Basic system equipment<br>Installation<br><br>Total costs                    | 1,600(4)                         | 1,600(4)                  | 200(5)                                                                  | (Estimate ten years)       |                                                 |
| 9              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1,000                            | 1,000                     | 300                                                                     | (Estimate four years)      |                                                 |
| 450a           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                  |                           |                                                                         |                            |                                                 |
| 516a           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                  |                           |                                                                         |                            |                                                 |
| 254            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 200                              | 200                       | 30                                                                      | (Estimate ten years)       |                                                 |
| 516b           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 500                              | 500                       | 235                                                                     | (Estimate three years)     |                                                 |
| 301b           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                  |                           |                                                                         |                            |                                                 |
| 36             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                  |                           |                                                                         |                            |                                                 |
| 516b           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1,500                            | 1,500                     | 275                                                                     | (Estimate six-eight years) |                                                 |
| 432            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 125                              | 125                       | 5                                                                       | (Estimate 20 years)        |                                                 |
| -              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 4,925                            | 4,925                     | 1,045                                                                   |                            |                                                 |
|                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 650                              | 1,300                     | -                                                                       |                            |                                                 |
|                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 5,575                            | 6,225                     | 2,045                                                                   |                            |                                                 |
|                | Notes: (1) All costs are estimated based on constant 1975 dollars.<br>(2) All costs are in addition to the costs for a basic car system including the standard type "M" coupler and draft gear system (including wide mouth bell housings as required for long cars).<br>(3) These maintenance and replacement cost estimates are in addition to the basic costs for the type "M" coupler system but are offset by savings from the normal air and uncoupling system upkeep.<br>(4) Electro-pneumatic control system would replace mechanical air valve control and save \$600 in system 3-1.<br>(5) Electro-pneumatic control system would replace mechanical air valve control and save \$60 in system 3-1. |                                  |                           |                                                                         |                            |                                                 |

- Notes: (1) All costs are estimated based on constant 1975 dollars.
- (2) All costs are in addition to the costs for a basic car system including the standard type "m" coupler and draft gear system (including wide mouth bell housings as required for long cars).
- (3) These maintenance and replacement cost estimates are in addition to the basic costs for the type "m" coupler system but are offset by savings from the normal air and uncoupling system upkeep.
- (4) Electro-pneumatic control system would replace mechanical air valve control and save \$600 in system 3-1.
- (5) Electro-pneumatic control system would replace mechanical air valve control and save \$60 in system 3-1.

4) Remarks (estimated average replacement life)

The cost data from these eight tables are summarized in Tables 6-9 through 6-11. These tables list a summary of the three cost estimates for each of the three Candidate Coupling Systems as applicable to an "average" car. These system cost summaries are compared by the cumulative increasing costs associated with increasing automation and greater improvements brought about by three primary subsystem groupings. These groupings are:

- 1) Improvements in mechanical coupling and uncoupling.
- 2) Improvements for automatic air connection and valve control.
- 3) Improvements for full electropneumatic control.

TABLE 6-9.-SUMMARY OF COST ESTIMATES(1) FOR CANDIDATE COUPLING SYSTEMS INSTALLED ON AN "AVERAGE"(2) NEW CAR

| PRIMARY IMPROVEMENTS ACCOMPLISHED<br>BY CANDIDATE COUPLING SYSTEMS                                                                                                                                                                                                                                 | SYSTEM 1 -<br>TOTALLY COMPATIBLE<br>WITH "E" SYSTEM |                                             | SYSTEM 2 -<br>NONCOMPATIBLE SEMIRIGID,<br>SPREAD CLAW SYSTEM |                                             | SYSTEM 3 -<br>NONCOMPATIBLE RIGID,<br>FLAT FACED SYSTEM |                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|---------------------------------------------|--------------------------------------------------------------|---------------------------------------------|---------------------------------------------------------|---------------------------------------------|
|                                                                                                                                                                                                                                                                                                    | SUBSYSTEM<br>COST,<br>DOLLARS(1)                    | CUMULATIVE<br>SYSTEM COST,<br>DOLLARS(1)(3) | SUBSYSTEM<br>COST,<br>DOLLARS(1)                             | CUMULATIVE<br>SYSTEM COST,<br>DOLLARS(1)(3) | SUBSYSTEM<br>COST,<br>DOLLARS(1)                        | CUMULATIVE<br>SYSTEM COST,<br>DOLLARS(1)(3) |
| 1. Mechanical Coupling and Decoupling:<br>Increases Gathering Range<br>"Knuckle" Always Open<br>Coupler Interlock and Entrapment<br>Centering/Positioning of Coupler<br>Reduced Trailing Slack                                                                                                     | 338                                                 | -                                           | 1 and 2 are<br>combined into<br>one system                   | -                                           | 1 and 2 are<br>combined into<br>one system              | -                                           |
| 2. Automatic Air Connection and Valve Control:<br>Automatic Air Connection with Coupling<br>Automatic Mechanical Air Valve Operation<br>Push Button Decoupling from Side of Car<br>Automatic Train Brake Control at Uncoupling                                                                     | 1,990                                               | 2,328                                       | 2,265                                                        | 2,265                                       | 4,460                                                   | 4,460                                       |
| 3. Full Electro-Pneumatic Control:<br>Automatic Disengagement of Positioning<br>at Coupling<br>Remote Decoupling Capability<br>Time Delay Brake Setting at Uncoupling<br>Automatic Electrical Connection at Coupling<br>Train Condition Sensing Capability<br>Multiplexing Control from Locomotive | 4,800                                               | 6,528                                       | 4,900                                                        | 6,565                                       | 5,575                                                   | 9,435                                       |

Notes: (1) All costs are estimated based on constant 1975 dollars.  
(2) "Average" car assumes a mix of 95% short cars and 5% long cars.  
(3) Cumulative system costs assume that all modifications would be done simultaneously and include reductions for some redundant subsystems.

TABLE 6-10.--SUMMARY OF COST ESTIMATES(1) FOR CANDIDATE COUPLING SYSTEMS INSTALLED AS A MODIFICATION TO AN "AVERAGE"(2) CAR

| PRIMARY IMPROVEMENTS ACCOMPLISHED BY CANDIDATE COUPLING SYSTEMS                                                                                                                                                                                                                                  | SYSTEM 1 - TOTALLY COMPATIBLE WITH "E" SYSTEM |                                       | SYSTEM 2 - NONCOMPATIBLE SEMIRIGID, SPREAD CLAW SYSTEM |                                       | SYSTEM 3 - NONCOMPATIBLE RIGID, FLAT FACED SYSTEM |                                       |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------|--------------------------------------------------------|---------------------------------------|---------------------------------------------------|---------------------------------------|
|                                                                                                                                                                                                                                                                                                  | SUBSYSTEM COST, DOLLARS(1)                    | CUMULATIVE SYSTEM COST, DOLLARS(1)(3) | SUBSYSTEM COST, DOLLARS(1)                             | CUMULATIVE SYSTEM COST, DOLLARS(1)(3) | SUBSYSTEM COST, DOLLARS(1)                        | CUMULATIVE SYSTEM COST, DOLLARS(1)(3) |
| 1. Mechanical Coupling and Decoupling:<br>Increase Catching Range<br>"Pushble" Always Open<br>Coupler Interlock and Retraction<br>Centering/Positioning of Coupler<br>Reduced Free Slack                                                                                                         | 396                                           | -                                     | 1 and 2 are combined into one system                   | -                                     | 1 and 2 are combined into one system              | -                                     |
| 2. Automatic Air Connection and Valve Control:<br>Automatic Air Connection with Coupling<br>Automatic Mechanical Air Valve Operation<br>Push Button Decoupling from Side of Car<br>Automatic Train Brake Control at Decoupling                                                                   | 2,490                                         | 2,886                                 | 2,730                                                  | 2,730                                 | 4,930                                             | 4,930                                 |
| 3. Full Electro-Pneumatic Control:<br>Automatic Disengagement of Positioning at Coupling<br>Remote Decoupling Capability<br>Train Delay Brake Setting at Decoupling<br>Automatic Electrical Connection at Coupling<br>Train Condition Sensing Capability<br>Multiplexing Control from Locomotive | 5,375                                         | 7,663                                 | 5,475                                                  | 7,605                                 | 6,225                                             | 10,555                                |

Notes: (1) All costs are estimated based on constant 1975 dollars.  
(2) "Average" car assumes a mix of 97% short cars and 5% long cars.  
(3) Cumulative system costs assume that all modifications would be done simultaneously and include reductions for some redundant subsystems.

TABLE 6-11.-SUMMARY OF COST ESTIMATES(1) FOR CONTINUING ANNUAL MAINTENANCE OF CANDIDATE COUPLING SYSTEMS INSTALLED ON AN "AVERAGE"(2) CAR

| PRIMARY IMPROVEMENTS ACCOMPLISHED BY CANDIDATE COUPLING SYSTEMS                                                                                                                                                                                                                                | SYSTEM 1 - TOTALLY COMPATIBLE WITH "E" SYSTEM |                                       | SYSTEM 2 - NONCOMPATIBLE SEMIRIGID, SPREAD CLAW SYSTEM |                                       | SYSTEM 3 - NONCOMPATIBLE RIGID, FLAT FACED SYSTEM |                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------------------------|--------------------------------------------------------|---------------------------------------|---------------------------------------------------|---------------------------------------|
|                                                                                                                                                                                                                                                                                                | SUBSYSTEM COST, DOLLARS(1)                    | CUMULATIVE SYSTEM COST, DOLLARS(1)(3) | SUBSYSTEM COST, DOLLARS(1)                             | CUMULATIVE SYSTEM COST, DOLLARS(1)(3) | SUBSYSTEM COST, DOLLARS(1)                        | CUMULATIVE SYSTEM COST, DOLLARS(1)(3) |
| 1. Mechanical Coupling and Uncoupling:<br>Increases Gathering Range<br>"Knuckle" Always Open<br>Coupler Interlock and Entrapment<br>Centering/Positioning of Coupler<br>Reduced Free Slack                                                                                                     | 52                                            | -                                     | 1 and 2 are combined into one system                   | -                                     | 1 and 2 are combined into system                  | -                                     |
| 2. Automatic Air Connection and Valve Control:<br>Automatic Air Connection with Coupling<br>Automatic Mechanical Air Valve Operation<br>Push Button Uncoupling from Side of Car<br>Automatic Train Brake Control at Uncoupling                                                                 | 230                                           | 282                                   | 245                                                    | 245                                   | 460                                               | 460                                   |
| 3. Full Electro-Pneumatic Control:<br>Automatic Disengagement of Positioning at Coupling<br>Remote Uncoupling Capability<br>Time Delay Brake Setting at Uncoupling<br>Automatic Electrical Connection at Coupling<br>Train Condition Sensing Capability<br>Multiplying Control from Locomotive | 910                                           | 1,122                                 | 750                                                    | 935                                   | 1,045                                             | 1,445                                 |

Notes: (1) All costs are estimated based on constant 1975 dollars.  
(2) "Average" car assumes a mix of 92% short cars and 5% long cars.  
(3) Cumulative system costs assume that all modifications would be done simultaneously and include reductions for some redundant subsystems.

## 7. DEVELOPMENT RECOMMENDATIONS

### 7.1 COUPLING CONCEPTS PROGRAM REVIEW

It is desirable to place the various elements of the program for assessment of automatic coupling concepts into proper perspective. To accomplish this end, a restatement should be made of the fundamental ideas used to determine Candidate Coupling Systems.

#### 7.1.1 System Automation Versus Capabilities

Performance capabilities of automatic coupler systems are inherently associated with the degree of automation and complexity of the system. In the initial stages of increasing automation, improved system capabilities can be implemented without increasing the inter-car connections beyond the coupler and single airline system. On the other hand, some more complex degrees of automation cannot be accomplished without the addition of a complex inter-car control system and/or individual car logic systems. The changes required for this latter system are both technically complex and very costly as compared to those elements of automation which can be achieved within the present inter-car system limitations.

Increased coupling capabilities which can be accomplished within the framework of the present inter-car connection system include:

- 1) Consistent automatic coupling of cars (to achieve effective coupling, it is required to have greater coupler gathering range, some form of automatic centering or positioning, and a means of automatically interlocking the coupled units).

2) Provision for automatically leaving the coupler in the "knuckle open" position at the time of uncoupling (this requires provision of a spring loaded system which will automatically open and maintain open the knuckle after coupling pressure is released).

3) Automatic connection of airline provided by an air connection system which is attached to or an integral part of the coupler head so that air connection is made simultaneously with the mechanical coupling).

4) Automatic operation of the angle cock valve (achievable as part of a mechanical or pneumatic control system associated with the coupling of air connector and operation of the car uncoupling lever).

5) Automatic application of car brakes if an accidental uncoupling occurs (inherent with the present airline brake control system and can be associated with the controls of the automatic air valve system noted in 4 above).

The following increased coupling system capabilities are associated only with the availability of a more highly automated inter-car connection system:

1) Remote uncoupling control of any car in the train (this requires a multi-channel inter-car electrical control system and/or individual car electrical logic and pneumatic actuation systems).

2) Control of brakes on a portion of the train (this requires the complex inter-car connection system and individual car logic systems as well as the necessary pneumatic controls required to remotely actuate brake valves).

3) Train sensing systems (this requires an extensive inter-car electrical connection system as well as the required car sensory and transmission systems).

### **7.1.2 Summary of Capabilities of Candidate Coupling Systems**

The detailed listing of capabilities, advantages and disadvantages of each candidate coupling system was included in Section 5. A brief summary of the capabilities of each system follows:

#### **1) System 1 - Compatible "Free Knuckle" System**

(a) Has the primary advantage of being totally compatible with all freight cars currently in the U.S. rail-freight system. The primary capabilities of the basic Systems 1-1A and 1-1B include: increased gathering range, knuckle open capability and coupler entrapment and interlock features, thus overcoming the major mechanical deficiencies in the present Type "E" system.

(b) System change 1-2 adds the automatic air connection and automatic brake valve control as a mechanical function of the coupling and uncoupling processes. These features overcome the most critical safety needs relating to the necessity of a trainman going between cars to complete the air connection system or to prepare cars for proper coupling.

(c) System Change 1-3 adds the capability of remote control by the additional electropneumatic and electronic control systems. This latter feature embodies the long-range potential for complete sensing and control of train operations from the locomotive or from some external control point. This system is limited to approximately 6-8 electrical contacts in the automatic electrical connector.

#### **2) System 2 - Noncompatible, Semirigid, Spread-Claw, Hinged Hook System**

(a) The primary advantages in this system are the very wide gathering range which it offers. A rugged and proven system 2-1 includes an integral air connection coupling which is protected within the face of the gathering claws of the coupler.

This protection feature is the best of the three systems in that it offers significant mechanical and environmental protection to the automatic air connection face. Since the automatic air connector unit represents a most significant and critical feature in the train operating sequence, candidate system 2 offers a particular and unique advantage in this respect.

(b) System Change number 2-2 is limited, similar to System Change 1-3, to approximately 6-8 electrical contacts which can be readily added to the system for the final step involving electrical sensing and control circuits.

### 3) System 3 - Noncompatible, Rigid, Flat-Face, Hinged Hook/Funnel System

(a) The basic coupler System 3-1 contains the unique advantage of being a totally rigid system which gives an exceptionally stable platform for attaching air or electrical connectors. This advantage is accompanied by the disadvantage of a heavy coupler unit which requires a significant amount of machining to achieve the slack-free characteristic and which likewise requires a critical positioning control in order to prevent oblique coupling forces from damaging the coupler head faces. The primary advantages of the basic system are its increased gathering range, "knuckle open" capability, rigid interlocking of mated couplers and an integral air connection system.

(b) System Change 3-2 adds the capability for a large number (50-100) of electrical contacts as part of an electro-pneumatic control system.

## 7.2 LIMITS FOR ADVANCED COUPLER SYSTEM APPLICATION

There are many areas in the rail car fleet where none (or very little) of the operating problems mentioned in Section 2 are encountered. In particular, in some unit train situations

the coupled cars essentially remain as an intact unit for extended periods of time. The same is true for other specific dedicated service trains hauling such basic commodities as grain. For this type of application, there is such a small potential for any economic gain from improved operations or for improved safety, that a change to any other advanced coupler system would not have a high priority.

Unit trains set aside for dedicated service operation represent a sizable portion of business of several freight rail lines. Moreover, this type of dedicated service is anticipated to increase for these particular applications in the future.

The application potential in the immediate future for any of the advanced coupler systems noted in Section 5 above is therefore considered to be applicable only to the so called "average car."

### 7.3 DEVELOPMENT PLAN

The most fundamental decision must be that of choosing between a fully compatible system (System 1) and a noncompatible system (Systems 2 or 3). This decision must be based on an analysis of rail freight operations as impacted by the various elements of each system. The listed system advantages and capabilities should be fit into the operating model to determine the potential economic savings and/or safety improvements expected to accrue from each concept. The total of these potential savings and the imputed value of safety improvements could then be compared to the estimated system costs.

### 7.3.1 Electro-Pneumatic Control System

The basic operational model analysis will determine if the potential advantages of the full electropneumatic system outweigh the cost and complexity disadvantages. The next decision relates to the amount of sensing which might be required in the ultimate system.

If only a few sensing signals are desired, the smaller number of circuits in Systems 1-3 or 2-2 would be adequate. If a large number of circuits is desired, the capabilities of System 3-2 are superior. As an alternate to a large number of inter-car electrical circuits, the microwave/alternator/battery system, Concept 450b, could be considered as applicable for any of the systems.

If a microwave control system were used, it would add some system components and delete some. Specifically, the addition of an alternator-battery unit to each car would delete the need for an inter-car electrical connection system. The net result is an estimated increase in overall cost of \$450 per "average" car. The net cost increase is not great when compared to the overall cost for the total electropneumatic control system 1-3, 2-2, or 3-2.

It is not believed feasible, however, to interject direct microwave receiving into individual car units because this would require an independent power system to be available in each car with the attendant unrealistic requirements for maintenance of battery power in uncontrolled freight car storage and standby conditions. With the availability of the locomotive engineer and the electronic multiplexed sensing and control system in the locomotive, it is believed more feasible to utilize the

engineer and his control system as the contact point between the train and any desired external program input.

Therefore, the use of either System 1 or 2 would effectively preclude the possibility of a large number of sensing circuits. It is realized, however, that future multiplexing advancements may permit (and a change in regulations may allow) an unlimited number of sensing circuits transmitted over only two or three electrical connections. This possibility makes the smaller number of circuits (and cost) of system 1 or 2 appear the most logical of the candidate electrical system possibilities.

If the lesser number of electrical contacts is determined to be acceptable, either system 1 or 2 is preferred from a cost standpoint. The choice between these two must be made almost solely on the basis of the relative importance of the two factors:

- 1) System 1 - advantage of total compatibility with the present system couplers with no coupler head interchange adapter required during any changeover process.

- 2) System 2 - advantage of greater strength and ruggedness, built-in mechanical protection for air and electrical connectors and larger natural gathering range.

### **7.3.2 Specific System Considerations**

In the engineering analysis effort conducted during this study, several areas were noted which should be listed for specific consideration. These include:

#### **7.3.2.1 Compatible System 1**

Sub-system 1-1A proposes the use of a modified Type "E"

coupler with a top and bottom shelf as opposed to sub-system 1-1B, which proposes the use of a modified Type "F" coupler with a top shelf. This combination represents the best possible situation for obtaining the desired operational improvements with the least costly overall system.

The single deterrent to the proposed systems may be the ability of a single air connector system to operate effectively with both coupler systems. The cost advantages to the proposed systems are so great that every effort should be extended to achieve a successful development of the one "universal" air connector system.

#### 7.3.2.2 Add-On Air Connector

One of the more critical elements in the Compatible System 1 is the add-on air connector (Concept 22 or 502c). This system has not been proven to be fully capable of gathering and seating and maintaining a reliable seal under all possible conditions with two Type "E" couplers. Even with the addition of the top and bottom shelves (Concept 54), there is still a possibility for vertical slippage of approximately 6 inches between two mated Type "E" couplers. Preliminary data indicate that current air connector designs may have a limit of approximately 5.5 inches of vertical travel for reliable maintenance of the air seal. It should be recognized that these capabilities must be reconciled early in the system development program.

The addition of an automatic air connector system is so important to improvements in switching operations and safety that it might be well to limit the vertical movement between mated Type "E" couplers. This limit could be achieved by location of the top and bottom shelves with only a nominal decrease

in vertical curve negotiability of standard cars. This potential should be subject to a detailed technical analysis early in the program.

The importance of the air connector system is such that it should be covered by a separate development specification. Given in Appendix G is a Preliminary Development Specification For Automatic Train Air Line Connector. This preliminary specification addresses itself to both general requirements and specific airline and connection provisions. It is given as a preliminary document covering details reviewed in this study.

#### 7.3.2.3 Centering and Positioning

The addition of centering and/or positioning devices adds a significant cost to each coupler system as noted in the Section 6 costs for subsystems 1-1B, 2-1, and 3-1. These devices, however, offer the potential for a significant decrease in coupler bypasses with an associated increase in operating safety and decrease in maintenance costs.

It has been estimated that positioning devices on long cars would decrease bypasses by 80 to 90 percent. By increasing the coupler lateral gathering range (Concepts 501, 502a, 309, or 9), the decrease should be even greater. Railroad users have noted an "average" of \$800 cost to repair a car end every 4 to 5 years solely as the result of bypass damage. Thus, the addition of positioning devices (and coupler gathering range increases) has the potential for saving \$140 to \$150 per year in addition to increasing operational safety.

#### 7.3.2.4 Environmental Covers

The use of an environmental protective cover (over the electrical connectors) has been set aside for a separate cost estimate in Section 6 for subsystems 1-3, 2-2, and 3-2. The use of such a cover has strong supporters and critics among the railroad technical community. The majority opinion seems to be opposed to the covers as offering an unnecessary environmental protection while adding an expensive and highly unreliable component. Unless a new technical breakthrough is made to achieve a reliable cover system, the Study Team recommends that this element be deleted from the proposed Candidate Coupling Systems.

#### 7.3.2.5 Train-Coupler Dynamics

During the engineering analysis of significant coupler concepts, in several instances it was noted that a potential problem exists with the possibility of a harmonic situation being set up within a portion of the concept apparatus (e.g., within a chain linkage system of a positioning device). This same harmonic situation could be encountered in other coupling concepts as a function of the chain reaction between coupled cars. It is generally accepted that railroads which run mainly trains of homogeneous cars with the same or similar commodities on the same basic road system at the same basic speed, will have a greater potential for problems in resonance or harmonics between cars than will be the case with trains carrying mixed cargo. Since no data are available to determine these parameters, for purposes of this engineering analysis, no consideration has been given to the potential problem of inter-car resonance or harmonics. Tests to develop these data should be included in the final acceptance program for any new coupling system.

#### 7.3.2.6 General Considerations

The development program directed toward improvement in the coupler system should include a secondary study relating to the impact on rail car trucks and other rail car components. It is entirely feasible to assume that significant improvements in gathering range or reduced contour angling of a coupler head may have a deleterious impact on the ability of the draft gear or other supporting mechanism to contain the additional coupling forces which may be imposed upon them. As has been previously noted, the Type "F" interlocking coupler head (Concept 428b) was found to have significant cracking problems at the butt end of the shank, apparently brought about by the increased shank loading associated with tighter coupler interlock and reduced contour angling. This latter problem was not totally expected with the introduction of the Type "F" coupler head in long car service. Other, more dramatic improvements in coupling capabilities may well result in secondary harm to other adjacent car components. Therefore, a secondary impact study should be initiated coincident with the final development effort on a new coupler system.

#### 7.4 TIME SCHEDULE

Considering the rudimentary state of the proposed candidate coupling systems, it is not feasible to project realistic time or cost schedules for either the development or field implementation stages. Given below, however, are some concepts and background concerning the potential time schedules and implementation plan.

#### 7.4.1 Development and Evaluation

The complete development cycle, up to the point of being ready to start changeover to new coupler systems, may well be 10 to 12 years duration. This cycle might generally be composed of the following elements (and ranges of anticipated completion times):

- 1) Finalization of design concepts: 1 to 1-1/2 years.
- 2) Establishment of basic design specifications in keeping with AAR and governmental standards: 1/2 to 1-1/2 years.
- 3) Completion of hardware development as required to meet final specifications: 1 to 2 years.
- 4) Production of acceptable pilot test units by hardware suppliers: 1/2 year.
- 5) AAR qualification test program for competing supplier units: 2 to 4 years. (Note - Earlier engineering prototype tests conducted in the mid 1930's by the AAR required 4 years for testing and tabulation of the data.)
- 6) Field testing in various railroad environments to "debug" final hardware designs and for suppliers to develop reliability confidence that is required to accept ultimate product liability requirements: 3 to 5 years. (Included within this time frame is the time required for the government and/or railroads to develop total quantity needs and delivery requirements as necessary to establish ultimate production contract details.)
- 7) Establishment of production facilities, tooling and materials as necessary to begin the required deliveries: 1/2 to 2 years.

#### 7.4.2 Field Implementation

It is recognized that the changeover for any new

coupler system will involve a lengthy time cycle. The last major change by U.S. Railroads to the Type "D" coupler system was completed in 1916 after approximately 23 years in the changeover process. In Japan, a total of 8 years was spent in planning and logistics preparation in order to make a changeover of 46,000 railroad cars during one day in 1925. The U.S.S.R. spent over 10 years in planning and material preparation plus 22 years to complete the changeover to the SA-3 coupler system in 1957. Even discounting 10 years lost for World War II, over 10 years time was used in a changeover involving significantly less than 1 million cars.

It is thus anticipated that a lengthy changeover cycle will be required for full introduction of a new coupler system. The economics of excess inventory and multiplicity of handling equipment alone would tend to rule out a precipitous changeover period.

A complete logistics study should be made to determine the most economical changeover rate which would achieve the optimum balance of minimum inventory and equipment and minimum lost operational time from use of mixed systems.

#### 7.4.2.1 Conversion Sequence

The application of any new coupling system to the entire general freight system would involve a process of sequentially converting different segments of the cars on each rail line. This general sequence might logically be accomplished as follows:

- 1) Each railroad's own cars which are most often pre-blocked and used as grouped units within trains. Conversion of these cars would have the greatest impact for savings to each railroad.

2) Cars dedicated for unit train service. Unit trains are subject to the most frequent service and thus are subject to the greatest number of coupling sequences (as a group). Such unit train cars would represent the next largest group for potential savings after change to the new coupler system.

3) Cars subject to major repair involving couplers. Such cars would be readily subject to completion of the conversion program with minimum disruption of total service.

It is recognized, of course, that all new purchased cars should be equipped with the new coupler system. Such new car purchases would be coincident with the three change sequences noted above.

#### 7.4.2.2. Automatic Air Connection System

A two-stage introduction of the add-on air connection system would appear to offer the most economical phase-in plan.

In the first stage, the mechanical air connector (Concept 22 or 502c) would be added together with a train air-line valve which could be operated manually from either side of the car. The standard angle cock and air hose/glad hand would be moved to the other side of the coupler to allow for a regular coupling sequence with nonequipped cars.

In the second stage of the changeover, the required air control system would be added and the remainder of the system for automatic air valve operation (Concept 22) would be installed. The installation of the remote uncoupling button (Concept 674) and the hydraulic uncoupling operating mechanism (Concept 943) could be deferred for a third stage modification

should the development of these items lag that of the basic air connector system.

This two-stage introduction approach would provide for the minimum amount of expenditure in the initial stages of application of an automatic coupling system and would provide some considerable benefit in the elimination of the need to couple hoses between equipped cars. The second stage of applying the valves could be delayed until all cars considered for automatic coupling are equipped with the train line connector.

#### 7.5 RELIABILITY OF CANDIDATE COUPLING SYSTEMS

Virtually all of the elements of the coupling systems noted in Section 5 above are composed of concepts which are, at best, in the advanced development stage. As such, the concepts are generally devoid of any associated user data required to predict the ultimate reliability of the concept in actual rail freight service. Some concepts, such as the coupler knuckle contour change (Concepts 501 or 502a), represent such a basic design improvement that it can be predicted with assurance that the overall system reliability will not be compromised by adding this concept in any manner from that available with the present "E" coupler system. On the other hand, such concepts as the multiplexing electronic control system (Concepts 452, 450a, or 387) represent engineering concepts which have yet to be proven under the rigors of rail freight service. For these, no usage data are available to make a reliability prediction.

On balance, therefore, the development, engineering test, field test and manufacturer "field confidence test" must be completed before sufficient data will be available to predict the overall reliability of any of the coupler systems.

Once this basic coupling system reliability has been established, it is suggested that an analysis will be required to equate the cost of the coupling system versus the reliability and the labor savings which that level of reliability represents. It is conceivable that some elements of the final coupling system will be required to have a redundant (or parallel operating) system in order to achieve the best possible trade-off of basic system cost versus total system reliability. Such could well be the case for such items as valves relating to proper functioning of air brakes in that this area must be almost totally reliable as a system in order to achieve the required level of safety.

#### 7.6 DOT/AAR MANAGEMENT OVERVIEW

For the successful conversion to a new coupler system, close cooperation and open information channels will be needed among DOT, AAR, and railroad industry suppliers and users. Some specific areas of management responsibility would include the following.

An early pronouncement should be made to the railroad supplier community as to the potential for production business which could result from the proposed coupler change program. A clear message was received from this group that they will require a positive statement on the future market potential as a requisite to committing the funds needed to complete new designs.

A significant reason why new developments have not been forthcoming has been the reluctance of industry suppliers to market a new product without an overwhelming evidence of test results proving the ultimate safety and reliability of these products. The railroad industry market place has been such that

price has been the primary consideration for purchase of any new equipment such as a coupling system. This competitive situation has apparently not allowed the level of profitability to protect the industry suppliers against potential liability losses should one of the new concepts prove to be less than fully reliable. These factors contributed to the paucity of new coupling concepts being offered for volume sales through the railroad industries and should be considered in overall planning efforts directed toward introduction of a new coupling system.

To aid in supplier development efforts, it is necessary that specifications be changed or clarified as needed to define the allowable variations for new coupler systems. This applies particularly to the area of allowable changes to air lines, limitations on automatic air connectors, allowable changes to angle cock locations, etc. A concerted effort will be required to oversee the timely processing of needed changes to rules, regulations and specifications.

Engineering prototype tests should be conducted with full cognizance from the Office of Safety of the Federal Railroad Administration, designated committees of the DOT, designated representatives of the cognizant railway unions, and designated representatives of other interest groups (i.e., OSHA).

A detailed engineering analysis should be made by the cognizant AAR technical groups to establish an agreed upon standard for acceleration of the test schedules required to prove the adequacy of any new coupler design concept. Reference should be made on reliability testing techniques used by NASA in aerospace development and as currently used by the EPA for such items as automobile emission test programs. The accelerated test programs should be based on the use of statistically chosen

sample sizes and test parameters to achieve the greatest possible technical information in the least time while meeting the desired reliability and safety standards.

## APPENDIX A

### GLOSSARY OF TERMS

- 1) Automatic Coupler - (Synonymous with Coupler in AAR Terminology.)
- 2) Automatic Coupler - (European Terminology) - Full mechanical coupling upon contact; but require manual uncoupling.
- 3) Automatic Lock Set - The coupler knuckle is locked open automatically at completion of the uncoupling cycle.
- 4) Bad Order Car - A car which must be removed from a departure train due to a need for repair.
- 5) Bleed - A term commonly used for venting of car air pressure.
- 6) Bowl - The holding area for cars in a hump switching yard after switching and before train makeup.
- 7) Buff - Couplers being pushed together (train slack bunched).
- 8) Center Sill - The main longitudinal member of the underframe of a car.
- 9) Cock - A manually operated valve device used in air lines to permit or prevent the flow of air.
- 10) Coupler - An appliance for coupling cars or locomotives together.
- 11) Coupler, Type D - Adopted in 1916 by the Master Car Builders Association (predecessor to AAR) as the first standard coupler

in which the parts produced by all manufacturers were completely interchangeable.

- 12) Coupler, Type CS - (Controlled Slack Coupler), adopted by AAR in 1956 for passenger service. Incorporates the safety interlocking features and reduced free slack of the Type H while using some standard parts of Type E.
- 13) Coupler, Type E - The AAR Standard Type "E" Coupler design which was adopted as the standard design on American Railroads on March 1, 1934.
- 14) Coupler, Type F - An alternate coupler design adopted on March 1, 1954 as an alternate for use on tank cars, hazardous cargo and very long cars. Type F contains the interlocking features of Type H, is stronger than Type E and results in 52% less slack between coupler heads.
- 15) Coupler, Type H - Also known as the "AAR Tightlock Coupler," an alternate coupler designed for use on high speed passenger cars and adopted for use on March 1, 1938. This coupler improved the Type E design by having less free slack and an interlocking feature which allows no vertical movement between adjoining couplers to reduce potential for car telescoping and jackknifing. Also, the Type H has improved safety characteristics in that it will support a free mated coupler which has

- detached from an adjacent car.
- 16) Contour Angling Capability
    - Tendency of coupler to angle outward from the track center line as the car is traveling around a curve (usually expressed as the angle between coupler centerlines of adjacent cars at the time of coupling).
  - 17) Coupler Butt
    - The end of the coupler shank opposite the head.
  - 18) Coupler Centering Device
    - An arrangement for maintaining the coupler normally in the center line of the car, but allowing it to move to either side when a car is rounding a curve, while coupled to another car.
  - 19) Coupler Head
    - That portion of the coupler which houses the coupling mechanism.
  - 20) Coupler Knuckle Lock
    - The block which drops into position when the knuckle closes and holds it in place, preventing uncoupling.
  - 21) Coupler Lock Set
    - A device by which the knuckle lock when lifted is held in a raised position until the knuckle is opened, when it allows the lock to drop back into position for automatically coupling when the cars are brought together.
  - 22) Coupler Positioning Device
    - Similar to Coupler Centering Device, except that it is actuated from the relative movement between the car and trucks and maintains the coupler toward the center line of the tracks.

- 23) Coupler Shank - The back end or body of a car coupler. Also called coupler butt.
- 24) Coupler Yoke - The yoke or strap that surrounds the draft gear and is keyed to the end of the coupler shank. Also called Draft Yoke.
- 25) Crossover - Curved section of track coming into and leaving a tangent (or straight) section abruptly on opposite sides.
- 26) Departure Yard - The yard area where air hose connections are made and outbound inspections performed prior to the train departing.
- 27) DOT - U.S. Department of Transportation.
- 28) Draft - Couplers being held in tension or being pulled apart (train slack out).
- 29) Draft Gear - The name of that unit which forms the connection between the coupler rigging and the center sill. The purpose of this unit is to receive the shocks incidental to train movements and coupling of cars, and cushion the force of impact. The types of draft gear now in use are known as friction spring, rubber, and hydraulic.
- 30) Draft Yoke - Synonymous with Coupler Yoke.
- 31) Draw Bar - A term formerly used synonymously with Coupler.
- 32) Draw Bar Pull - The force exerted on the coupler between the locomotive and the car which is equal to the locomotive tractive effort less the rolling

- resistance of the locomotive.
- 33) Draw Head - The head of an AAR automatic coupler, exclusive of the knuckle, knuckle pin and lock.
  - 34) Dummy Coupling - A device designed to couple to an unused air hose to protect against damage to the hose and coupling, as well as preventing entrance of foreign matter into the hose.
  - 35) Floating Sill - Synonymous with Sliding Sill.
  - 36) Followers - Plates or blocks of metal placed inside of the coupler yoke and bearing against the ends of the draft gear. Their function is to transmit the stresses of compression to the draft gear and the center sills.
  - 37) Free Slack - The amount of unrestricted movement (or slack) resulting from accumulation of clearances and wear between coupled adjacent coupler knuckles, exclusive of draft gear slack.
  - 38) Fully Automatic Coupler - (European Technology) - Full mechanical coupling upon contact with uncoupling provisions not requiring manual assist.
  - 39) Gathering Range - The amount of horizontal or vertical distance from the coupler center line within which the coupler will operate properly when coupling.
  - 40) Glad Hand - The metal-end pieces of the air hose couplings which are joined together so that the air by which the brakes are operated can pass from one

- vehicle in a train to another. (Synonymous with Hose Coupling.)
- 41) Hose Coupling - Synonymous with Glad Hand.
  - 42) Hump Yard - A switching (or classification) yard in which a raised portion of track (or hump) is used for uncoupling cars, permitting individual cars to coast downhill into the proper classification tracks.
  - 43) Knuckle (Couplers) - The rotating coupling hook by means of which coupling is effected.
  - 44) Knuckle Pin (Couplers) - The pin holding the knuckle in the jaws of the coupler. Sometimes called pivot pin.
  - 45) Knuckle Thrower - A device which throws the knuckle of a car coupler open when the uncoupling rigging (or lever) is operated.
  - 46) Lateral Motion - The motion which takes place, cross-wise of the track, of all car parts, except the wheels and axles.
  - 47) Link and Pin - An old type of connection between cars which employed a chain link and a pin arrangement.
  - 48) Lock Set - Unlocking the coupler knuckle as required for uncoupling (usually by unlatching the lock lifter mechanism which holds the knuckle lock in the raised position).
  - 49) Manual Screw Coupling - The coupling system presently employed in Europe. An elongated link from one car is manually hooked over a draw hook on the adjacent car. The coupling is then tightened up

- by hand by turning a coupling screw at the base of the coupling link.
- 50) Master Car Builders Association - The predecessor organization to the Association of American Railroads.
  - 51) Mixed Coupling - An adapter device which enables two rail cars fitted with different types or styles of couplers to be coupled together.
  - 52) Pivot Pin - Synonymous with Knuckle Pin.
  - 53) "Push-pulled" Car Movement - The process of moving a car by other means than a coupled connection (i.e., hand pushing).
  - 54) Rip Track - An area of track set apart for repair efforts on cars.
  - 55) Self-Aligning Coupler - A coupler which has a tapered shank rather than a straight shank to prevent the jackknifing of cars.
  - 56) Shank (Coupler) Head - That part of a coupler between the butt and the head.
  - 57) Side Buffers - As applied to European rail cars - side buffers are used in conjunction with spring buffers positioned at either side of the coupling. The purpose of the side buffers is to absorb shock when vehicles come together, to transmit the compression effect in sets of vehicles being pushed, to deaden the longitudinal reaction in moving trains and to dampen the transversal movement of vehicles in fast running trains whose couplings must be tightly screwed.

- 58) Sliding Sill - The structural through member which connects the coupler to the car under frame. This unit slides or moves against a cushioning device to absorb the coupling shocks.
- 59) Spring Slack - The amount of unrestricted movement (or slack) resulting from the cushioning action of the draft gears.
- 60) Tangent Track - Track in which both the car and truck center lines of adjacent cars are on the same straight line.
- 61) Train Run-In - The distance required to move all cars in a train together until all couplers and draft gears are in buff.
- 62) Train Run-Out - The distance required to move all cars in a train together until all couplers and draft gears are in draft.
- 63) UIC - International Union of Railways.
- 64) Uncoupling Lever - A rod with a bent handle forming a lever, by which the lock of the automatic coupler is manually opened and the cars uncoupled without going between them.
- 65) Uncoupling Mechanism - (Synonymous with Uncoupling Lever.)
- 66) Uncoupling Rigging - (Synonymous with Uncoupling Lever.)
- 67) Uncoupling Rod - (Synonymous with Uncoupling Lever.)
- 68) Vertical-Knuckle Couplers - A coupler in which the knuckle rotates about a vertical axis (such as the AAR types "E" or "F").

- 69) Vertical Interlock - A coupling design (such as the AAR coupler type H) in which there is a positive holding or interlocking of couplers in the up-and-down position.

## APPENDIX B

### ABSTRACTS AND PATENTS

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## B.2 ABSTRACTS OF LITERATURE SOURCES

| Bibliography         | Retrieval         |                                                                                                                                |
|----------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------|
| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u>                                                                                               |
| 1*                   | 033032<br>(RRIS)  | <u>Technical Proceedings of the Engineering Forum.</u> Symington Wayne Corporation, Depew, New York, September 22, 1966, 53 p. |

The proceedings include eight papers from the 1966 Railroad Engineering Conference of Symington Wayne Corporation. The topics discussed are marketing, cushioning requirement trends, and engineering aspects of new car design; philosophy of car design; high speed truck design; car roll and wheel lift tests; and coupling.

One paper discussing further coupling requirements for freight cars calls for an examination into the methods of reducing slack, analysis of stress between cars; and the basic design of freight cars. A paper dedicated to engineering and operational considerations in fully automatic coupler development suggests an industry need for reconsidering total car design and construction. The paper outlines automatic coupler requirements and presents a detailed and pictorial explanation of the design issues in cars negotiating a curve.

Conference commentary and questions related to the papers are published in the proceedings.

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\* Denotes abstract for significant coupling concept.

| Bibliography         | Retrieval         |                                                                                                                    |
|----------------------|-------------------|--------------------------------------------------------------------------------------------------------------------|
| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u>                                                                                   |
| 6*                   | 037633<br>(RRIS)  | "Prototype Automatic Coupler for British Railways." <u>Railway Gazette</u> , May 31, 1957, Vol. 106, pp. 625, 628. |

The prototype A.S.F./v automatic coupler was designed for use on high-speed freight trains. The unit is one of the first to be equipped with either an automatic vacuum or air connector. The present prototype of the coupler is designed to take a drawbar pull of 40,000 lbs., but it will be tested with a load of 140 tons giving a safety factor of approximately eight to one. This second prototype has a greater range of buffer height and incorporates the hydraulic draft gear as an alternative to the rubber gear fitted to the first unit.

|    |                  |                                                                                                                                                                                       |
|----|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8* | 037721<br>(RRIS) | Cope, G. W. "Coupler Centering Devices." <u>Technical Proceedings</u> , Railroad Engineering Conference, Symington Wayne Corporation, Depew, New York, September 23, 1965, pp. 40-43. |
|----|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The geometry of car length and length of the free swinging coupler (necessary to allow for negotiating curves) is such that the possibility of a miscoupling is almost as likely as a successful coupling.

A proposed solution is a coupler centering device which would automatically position the coupler over, or sufficiently close to, the center line of track thus assuring better chance of successful coupling. Cushion underframe cars present the most difficult application of the proposed solution because the floating sill complicates the connection between the truck and the coupler.

The coupler centering design is predicated on the fact that

Bibliography      Retrieval

Reference No.      Source No.      Data Source and Reference

the only time when there is a need to center the coupler is when the car is uncoupled. When coupled, it is being centered by the other car. The stresses in the mechanism are relatively low requiring approximately 600 pounds in the top rods to move the coupler from side to side. It is expected that the maximum stress on the flange of the wheel would be 1,000 to 1,200 pounds for only a short duration on tangent points and on reverse curves.

|    |                  |                                                                                                                                                                                        |
|----|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9* | 037722<br>(RRIS) | Martin, A. "The Fully Automatic Coupler." <u>Technical Proceedings</u> , Railroad Engineering Conference, Symington Wayne Corporation, Depew, New York, September 23, 1965, pp. 43-48. |
|----|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

This paper discusses the concept of a fully automatic coupler for freight or passenger cars that would have the strength and safety of the "F" and "H" type couplers. To realize the full economic value of many innovations in railroad design and operating techniques, it is imperative that trains can be made up and broken down automatically, accordingly a fully automatic coupler is required.

Consideration and study of several alternative plans have resulted in the concept of a hook type coupler similar to that used on subways. This coupler basically is of the same general construction as a heavy duty subway coupler used in Rapid Transit operation. One of the basic improvements is the application of a positive lock. The coupler comprises the main body, a hook spring, a positive lock, an operating cam with an integral lock operating lever and linkage, a cam operating lever and an air cylinder.

This coupler is always ready for coupling, it is simply

Bibliography      Retrieval

Reference No.      Source No.      Data Source and Reference -----

brought into contact with the mating coupler and the hooks engage and lock immediately after the faces are in contact. In the coupled position, the hooks are fully engaged and the positive lock is seated behind the hook nose of the mating coupler to eliminate any possibility of an unwanted uncoupling for any reason. In order to uncouple, the air cylinder is activated and moves the cam operating lever in a counter-clockwise direction. The first increment of movement of the cam and the integral arm is used to shift the positive lock clear of the hook nose, and then the cam spreads the hooks to effect an uncoupling. Both hooks must be moved over the full limit of travel against the hook springs in order to uncouple.

Since the positive lock secures the hook of the mating coupler it is necessary to provide means to operate the positive lock of the mating coupler when uncoupling manually or under certain conditions of automatic operating. To do this, an interacting linkage has been provided which, when coupled, forms a parallelogram through the coupler to transmit the operating lever movements to the operated coupler to the mated coupler operating lever and thus, actuate both positive locks simultaneously.

|     |                  |                                                                                                                                                                                            |
|-----|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13* | 037749<br>(RRIS) | Reed, R. T. "High Speed Transit Engineering." <u>Technical Proceedings</u> , Railroad Engineering Conference, Symington Wayne Corporation, Depew, New York, September 14, 1967, pp. 50-58. |
|-----|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

When the High Speed Ground Transportation R & D Act was enacted, a committee was established by cognizant Pennsylvania Railroads Departments to establish criteria and develop specifications for a self-propelled electric multiple unit railroad

Bibliography      Retrieval

Reference No.    Source No.    Data Source and Reference

passenger car. The Pennsylvania awarded a contract for the purchase of 50 cars to the company meeting all their requirements. Details of the design are described and illustrated. Emphasis is on suspension and coupling.

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|-----|------------------|------------------------------------------------------------------------------------------------------------------------------------|
| 15* | 037851<br>(RRIS) | Bulleid, O. V. S., "Automatic Couplers and Compressed-Air Brakes." <u>Railway Gazette</u> , April 26, 1963, Vol. 118, pp. 469-472. |
|-----|------------------|------------------------------------------------------------------------------------------------------------------------------------|

The article deals with automatic couplers and compressed-air brakes. Inherent advantages are cited for automatic couplers along with refinements for the future automatic coupler.

Coupler advantages identified are:

- i) increased safety for the shunters
- ii) quicker breaking-up and reforming of trains
- iii) reduction of staff
- iv) increased strength of couplers permitting heavier train loads and increased line capacity.

The Unicupler (developed for the Russian S.A. 3 type) and the Fischer coupler designs are discussed as examples of couplers meeting U.I.C., the International Union of Railways, specifications. Coupling problems are considered and the importance of practical testing and experimentation stressed. Air brakes, electrically-controlled brakes, and coupling connections are commented on relative to coupler design considerations.

Finally, capital expenditure is discussed along with economics affected.

| Bibliography<br>Reference No. | Retrieval<br>Source No. | Data Source and Reference                                                                                                                                                                                                          |
|-------------------------------|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 22*                           | 039510<br>(RRIS)        | Punwani, S. K. "Automatic-Pneumatic Coupling for Increased Utilization." <u>Technical Proceedings</u> , Railroad Engineering Conference, Dresser Transportation Equipment Division, Depew New York, September 12, 1969, pp. 56-59. |

The Automatic Pneumatic Coupling System design by Dresser Transportation Equipment is described and illustrated. The system consists of a train line connector for making the physical connection between car ends; valves to control the air; and a means to initiate the coupling and intentional uncoupling of air and to sense unintentional uncoupling. The system is compatible with knuckle couplers already in service. Field tests were scheduled for 1970.

|     |                  |                                                                                                                                                                                               |
|-----|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 25* | 039515<br>(RRIS) | Cope, G. W. "New Coupler Concept for Long Cars." <u>Technical Proceedings</u> , Railroad Engineering Conference, Symington Wayne Corporation, Depew, New York, September 24, 1964, pp. 10-18. |
|-----|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The "LC" coupler was developed specifically as a solution to the long car tracking and curve negotiation problem.

The "LC" coupler comprises a coupler with a Type "F" Head, a shank extension having an "F" Butt, with the aligning shoulders removed, a coil spring, spring seat, retainer block, pin and two retainer plates. The Type F Head was selected to limit the amount of contour angling to avoid possible jackknifing. A 72" length was selected on the basis of calculations on stress, track curve negotiability and derailling components. Photographs show the coupling system.

| Bibliography         | Retrieval         |                                                                                                                                                                                                                              |
|----------------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u>                                                                                                                                                                                             |
| 26*                  | 039516<br>(RRIS)  | Tarbox, I. F. "A Single Standard Design Coupler for Conventional Freight Cars." <u>Technical Proceedings</u> , Railroad Engineering Conference, Symington Wayne Corporation, Depew, New York, September 24, 1964, pp. 18-24. |

Problems with "E" Rigid Shank and "E" Swivel Couplers are listed and an improved coupler is described. It is hoped that the coupler designed by Symington Wayne will be adopted as a single standard E coupler for conventional freight cars. The coupler has a controlled swivel coupler assembly which permits maximum angularity of 15 degrees. At all angularity beyond 4 degrees, a seat compresses the draft gear, which returns the coupler to the 4 degree position, when the lateral force is removed.

The article contains several detailed sketches and illustrations.

|     |                  |                                                                                                                                                                                                                                               |
|-----|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 27* | 039517<br>(RRIS) | Cope, G. W. "Development in Fully Automatic Couplers and Potential on Automated Freight Trains." <u>Technical Proceedings</u> , Railroad Engineering Conference, Symington Wayne Corporation, Depew, New York, September 24, 1964, pp. 24-30. |
|-----|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

A fully automatic coupler is defined as those which can be operated by the push of a button from a remote position to control mechanical, electrical, and pneumatic coupling and uncoupling.

The automatic coupling system developed by Symington Wayne for subway and rapid transit cars is illustrated and described. This equipment manufacturer is now considering the design of an

Bibliography      Retrieval

| <u>Reference No.</u>                          | <u>Source No.</u> | <u>Data Source and Reference</u> |
|-----------------------------------------------|-------------------|----------------------------------|
| automatic coupling system for freight trains. |                   |                                  |

The paper contains several photographs and drawings in addition to a general discussion of the need for automatic couplers and references to developmental work on these devices.

|     |        |                                         |
|-----|--------|-----------------------------------------|
| 31* | 039915 | Cope, G. W. "Innovation Potential       |
|     | (RRIS) | Inputs." <u>Technical Proceedings</u> , |
|     |        | Railroad Engineering Conference,        |
|     |        | Dresser Transportation Equipment        |
|     |        | Division, Depew, New York, Septem-      |
|     |        | ber 13, 1968, pp. 34-38.                |

The article is a discussion of problems in coupler positioning. The problems of car length and overhang require the use of positioning devices to avoid car end damage. Mechanical, hydraulic and "swing draft sill" devices are described. Seven advantages of the "swing draft sill" devices are listed and discussed.

|     |          |                                        |
|-----|----------|----------------------------------------|
| 33* | 040143   | Bobbert, G., and A. G. Salzgitter,     |
| and | (RRIS)   | "Adapting the Automatic Coupler to     |
| 303 | 844      | Future Developments on the Railways."  |
|     | (R-TRIS) | <u>Eisenbahntechnische Rundschau</u> . |
|     |          | March, 1969, Vol. 18, No. 3, pp.       |
|     |          | 94-97.                                 |

The article discusses four new development trends in European couplers:

- 1) The effect of container utilization on the introduction of center buffer coupling.
- 2) Decoupling of rail cars without manual operation using coded signal methods.
- 3) Adapting couplers to railcar characteristics--with the Russian SA-3 as an example.

Bibliography      Retrieval

Reference No.    Source No.    Data Source and Reference

4) Axial play effect on passenger comfort.

There is a brief summary with two drawings related to the eurocoupler-68 described to be a combination of the Scharfenberg coupler and the Willison-profile.

- 38\*                      044067              "Coupler Is Subject of Two Safety  
                              (RRIS)              Projects." Railway Locomotives and  
                                                                                 Cars, February, 1973, Vol. 147, No.  
                                                                                 2, pp. 18-19.

The freight car coupler's sphere of operation is one of almost constant violence. Couplers must take the brunt of crushing forces, and when problems occur, the strong coupler can damage other car components.

A key safety recommendation is that car couplers should be modified to prevent uncouplings in derailments. Both the Type F coupler, with a top shelf, and the Type E coupler, with top and bottom shelves, have the ability to reduce the probability of vertical separation. For better than two years, the Type F coupler has been required on new tank cars. It is felt the Type E coupler would not only do a better job of preventing punctures of tank cars, but would be more cost effective. Service testing of 200 car sets of the Type E coupler is now in progress. Plans call for an instrumented boxcar to be operated over 25,000 miles by more than eight railroads to produce a fair sampling of the railroad environment.

- 41\*                      050543              "High-Cube Cars Have Created a  
                              (RRIS)              Market for Coupler Positioning De-  
                                                                                 vices," Railway Locomotives and  
                                                                                 Cars, January, 1973, Vol. 147, No.  
                                                                                 1, p. 8+

Bibliography      Retrieval

| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u> |
|----------------------|-------------------|----------------------------------|
|----------------------|-------------------|----------------------------------|

Since coming on the railroad scene less than ten years ago, the high-cube parts car has shown an alarming affinity for passed coupler damage. The coupler centering and positioning devices can, in the majority of instances, prevent the passing of couplers.

Operational aspects and advantages of positioning devices were presented.

|     |                  |                                                                                                                                                                                                                                                                                                                                                   |
|-----|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 45* | 052607<br>(RRIS) | <u>Test on Automatic Couplers.</u> Work of committee B51 from January 1972 to December 1973 and the Current State of the Studies and Tests Relating to the Introduction of the Automatic Coupler. International Union of Railways, Office for Research and Experiments, Utrecht, The Netherlands, ORE Report No. B51/RP, 15/E, April, 1974, 64 p. |
|-----|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The report gives an account of the current state of the work carried out in connection with the introduction of the automatic coupler and the studies and tests made for this purpose from January 1972 to December 1973. Special attention was given to the following questions:

- 1) Studies and tests relating to the design of the basic type of the automatic coupler and completion of this work;
- 2) Studies and tests relating to the riding stability of wagons with automatic centre buffer couplers with the object of:

(a) Limiting the longitudinal compressive forces in the train by a suitable choice of elastic systems and variation of the brake characteristics.

|                      |                   |                                  |
|----------------------|-------------------|----------------------------------|
| Bibliography         | Retrieval         |                                  |
| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u> |

(b) Controlling the longitudinal compressive forces in the train by the use of a stabilizing articulation with vertical and horizontal alignment control, in short, a universal articulation.

3) Studies and tests with passenger coaches equipped with automatic couplers, mixed air couplings, intermediate parts for train ferry services and different types of electric plug contacts, relating to the question of coupler wear in service, to the need for protection covers and to shunting procedures to be used for wagons equipped with automatic couplers;

4) Current state of the work on the compilation and revision of several UIC and Joint UIC/OSJD Specification Leaflets.

|     |        |                                              |
|-----|--------|----------------------------------------------|
| 46* | 057181 | "Some Aspects of Automatic Center-           |
|     | (RRIS) | Couplers Applied to Europe," <u>Rail</u>     |
|     |        | <u>Engineering International</u> , May 1974, |
|     |        | Vol. 4, No. 4, pp. 158-160.                  |

The decision to introduce centre-automatic couplers as the sole draw and buffing gear and obviate the manual uncoupling and coupling up of trains has been the subject of a great deal of attention by railways and industry alike. A point raised by some administrations highlights the advantages obtained by controlling the train by the locomotive brakes only when this can be effected through the transmission.

Braking concepts are presented and five requirements for couplers are itemized and discussed. Drawings of a Eurocoupler and the Russian SA3 couplers are included.

| Bibliography         | Retrieval         |                                                                                                                                                                                                                                                                               |
|----------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u>                                                                                                                                                                                                                                              |
| 47*                  | 057405<br>(RRIS)  | Salmon, P. "Simplified Automatic Couplings for the Railroad Rolling Stock of Iron and Steel Plants (Attelage Automatique Simplifie Destine aux Vehicules Ferroviarires des Usimes Siderurgiques)," <u>Revue de Metallurgie</u> , February, 1974, Vol. 71, No. 2, pp. 157-182. |

The new coupling and the tests having led to its development and adoption by steel plants and other railway systems are described. The development work was a joint French and German project.

Numerous drawings and photographs illustrate the report.

|     |                  |                                                                                                                                                                              |
|-----|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 49* | 072700<br>(RRIS) | Winter, P. "Automatic Coupling of Railroad Cars (L'Introduction de L'Attelage Automatique)," <u>Bulletin Technique de la Suisse Romande</u> . Vol. 100, No. 16, pp. 330-333. |
|-----|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The article summarizes the installation procedure, cost estimates and related problems of installing the unicupler UIC automatic coupler. Winter lists three priorities of new railroad car acquisitions as related to automatic couplers. Several illustrations are included and a few cost statistics are presented in tabular form.

| Bibliography<br>Reference No. | Retrieval<br>Source No. | Data Source and Reference                                                                                                                                                             |
|-------------------------------|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 52*                           | 080337<br>(RRIS)        | Sims, R.D. <u>Couplers and Truck Se-<br/>curement, Phase 10 Report</u> . Chicago<br>Association of American Railroads,<br>September 1973, 35 p. (Final Report:<br>#RA-10-2-19 R-142). |

Phase 10 of the RPI-AAR Tank Car Safety Project was established to study the influence on tank car behavior in accidents of all nontank components of a tank car. Of these components, couplers and trucks were later selected as the only significant items for study. The influence of couplers on tank car accidents was evidenced by the accident data collected for the years 1965 through 1970. During this six-year period, 173 tank cars incurred head punctures and, of these, 148 were known to have been caused by couplers on adjacent cars. The data also showed that truck components, particularly wheels, often punctured tank car shells. Finally, of interest was the influence on the severity of derailments (i.e., number of cars derailed and degree of jackknifing) of various coupler designs and the concept of truck securement. The purpose of this report is to review and discuss the results of the studies and to draw conclusions regarding functional efficiencies of current and modified coupler and truck designs toward improving tank car safety in accidents.

|      |                                |                                                                                                                                                                                                                                                                                                                            |
|------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 254* | PB 225-934<br>Sec. 4<br>(NTIS) | Boeing Vertol Company, Surface<br>Transportation Systems Department,<br>Philadelphia, PA. <u>Detail Specifica-<br/>tion for State-of-the-Art Car</u> . Pre-<br>pared for the U.S. Department of<br>Transportation, Urban Mass Transpor-<br>tation Administration, May 1973,<br>Revision A, October, 1973 (PB 225-<br>934). |
|------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Bibliography      Retrieval

Reference No.      Source No.      Data Source and Reference

This document is the detail specification for the State-of-the-Art Car (SOAC). This specification represents the SOAC configuration as delivered to the Urban Mass Transportation Administration (UMTA) for test and demonstration.

The SOAC has been developed under UMTA's Urban Rapid Rail Vehicle and Systems program which has the objective of enhancing the attractiveness of rapid rail transportation to the urban traveler by providing him with transit vehicles that are as comfortable, reliable, safe, and economic as possible. The SOAC is one phase of this program.

This specification was prepared by St. Louis Car Division, General Steel Industries, Inc. It has been reorganized into the format of the "Guideline Specification for Urban Rail Cars" by the Boeing Vertol Company, Systems Manager for the Urban Rapid Rail Vehicle and Systems Program.

|      |          |                                               |
|------|----------|-----------------------------------------------|
| 301* | 1199     | "Provisions of a Standard Automatic           |
|      | (R-TRIS) | Coupler for Europe," <u>Railway Gazette</u> , |
|      |          | August 1, 1969, Vol. 125, No. 15, p.          |
|      |          | 572+.                                         |

The deadline for the conversion of conventional draw and buffing gear of Continental standard guage rolling stock to automatic couplings is Easter, 1976. The advantages to be gained from this change are heavier trains, reduction in shunting man-hours and enhanced train stability. Two basic designs and the problem of compatibility of variations of these are discussed.

| Bibliography         | Retrieval         |                                                                                                                                                                                     |
|----------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u>                                                                                                                                                    |
| 305*                 | 1211<br>(R-TRIS)  | Zeevenhoven, N. "Designing a European Autocoupler," <u>Railway Gazette</u> , October 20, November 3, November 17, 1967, Vol. 123, No. 20, p. 780+; No. 21, p. 825; No. 22, p. 854+. |

In Part I, the author reviews basic coupler types and analyzes the principles underlying the Willison type coupler. Four reasons for European delay in adopting automatic couplers are listed.

Part II deals with the present stage of development and the operational economies to be gained and Part III with the problems of the changeover to autocouplers and derailment considerations.

Numerous illustrations accompany the papers.

|      |                |                                                                                                     |
|------|----------------|-----------------------------------------------------------------------------------------------------|
| 306* | 82<br>(R-TRIS) | "Car Truck Movement Steers New Coupler Aligning Device," <u>Railway Age</u> , July 25, 1966, p. 58. |
|------|----------------|-----------------------------------------------------------------------------------------------------|

Reference is made to the difficult problems involved in the automatic coupling of extremely long bogie wagons. A photograph shows a device for aligning the couplings in relation to the lay-out of the track, on straight and curved sections. A set of chains, tightened by means of springs, is used to fasten the coupling device to the bogie underframe, in such a way that the movement of the bogie on curves steers the coupling, to enable automatic coupling to take place with another wagon, without any risk of the two coupling heads overriding.

|      |                 |                                                                                                                      |
|------|-----------------|----------------------------------------------------------------------------------------------------------------------|
| 308* | 411<br>(R-TRIS) | "Europe Decides on Automatic Couplers," <u>International Railway Journal</u> , January, 1966, Vol. 6, No. 1, p. 50+. |
|------|-----------------|----------------------------------------------------------------------------------------------------------------------|

|                      |                   |                                  |
|----------------------|-------------------|----------------------------------|
| Bibliography         | Retrieval         |                                  |
| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u> |

This paper is directed at the issues of adopting a standard automatic coupler in Europe. Many statistics are quoted in the body of the article including an estimated total car conversion cost of greater than two billion U.S. dollars. A photograph shows a top view of the Willison interlocking Type II coupler. The Knorr-Bremse Unicoupler and Willison designs are analyzed.

|      |          |                                              |
|------|----------|----------------------------------------------|
| 309* | 1199     | "European Centre Couplers," <u>Railway</u>   |
|      | (R-TRIS) | <u>Gazette</u> , October 15, 1965, Vol. 121, |
|      |          | No. 20, p. 809+.                             |

The paper reviews the history of center couplers on European railways. A brief summary is given for the three main design and manufacturing groups,

- 1) Unicoupler
- 2) Boirault-Sambre and Meuse and
- 3) Associated Willison

Major coupler requirements were identified as:

- 1) The automatic coupling of air-brake pipes and electric cables supplemental to the mechanical coupling in a drag-and-buffing coupler;
- 2) The practicability of coupling up with the Soviet SA3 type. The first requirement was expanded to include the possibility of air-pipe coupling when double-pipe brake systems are used. Several drawings illustrate the documentary.

|      |          |                                           |
|------|----------|-------------------------------------------|
| 318* | 861      | "ORE - The Cross-Beam Support, A          |
|      | (R-TRIS) | Principal Component of the Automa-        |
|      |          | tic Coupling, Now Standardized and        |
|      |          | Internationally Licensed," <u>Rail</u>    |
|      |          | <u>International</u> , February, 1970, p. |
|      |          | 139+.                                     |

Bibliography      Retrieval

Reference No.      Source No.      Data Source and Reference

The article deals with ORE document B51/RP7 (cross-bearer suspension), which provides an explanation of the construction and operation of cross-bearer suspension, together with details of the experiments and research which have enabled a judgment to be made of its constructive, operating and maintenance characteristics, and in which its dimensions and size, as well as diagrams of the springs, are shown.

391                      250862      Harada, R. and W. Schulte. "Effect  
(COMPENDEX) of the Center Buffer Coupling on the  
Operation of Steel Works." Stahl,  
February 19, 1970, pp. 161-167.

The article describes a rigid type, flat face, horn-funnel, heavy duty tight-lock automatic coupler capable of connecting pneumatic and electrical lines simultaneously. The authors claim the coupler is capable of use in trains made up of large railway vehicles as well as high-speed trains of locomotive traction system. The strength of the coupler is reputed to be approximately twice that of the tight-lock couplers currently used in Japan. Test and performance data are included in the written description.

405\*                      44009      "Tank Car Safety Project...Milepost  
(TRIS) in Railroad Research," Progressive  
Railroading, Murphy-Richter Publish-  
ing Company, Vol. 16, No. 2, March  
1973, pp. 57-58.

Tank cars are identified as unique relative to other freight cars due to the nature of the liquid, viscous, or gaseous materials transported. The article summarized results of a \$1.25 million research project completed by the Railroad Tank Car Safety

Bibliography      Retrieval

|                      |                   |                                  |
|----------------------|-------------------|----------------------------------|
| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u> |
|----------------------|-------------------|----------------------------------|

Research and Test Project. The research group recommended that E couplers with the top and bottom shelf be installed on all new tank cars. The nature of the shelf coupler is explained with conversion of existing cars to incorporate the shelf coupler estimated at \$97 per car.

447\*

UIC leaflet No. 522i, Requirements for European UIC Synopsis coupler, January 3, 1972.

General Information

The automatic coupler should be as simple as possible in order to minimize its cost and the installation expenses on railroad cars.

The equipment should operate under any type of weather and atmospheric conditions.

It should be compatible with the UIC coupler.

During the transitory period, an auxiliary coupler will be used for coupling with screw-coupler cars.

Operation

All the coupling and uncoupling operations can be made by one single agent without extra difficulty, as compared to the present situation.

The coupling can be performed at speeds between 0.6-9.4 mph.

The coupling can be performed automatically, without human intervention or supervision.

An unintended uncoupling is impossible.

The cars can be safely uncoupled by using a simple unbolting device accessible at both ends and from both sides of the cars.

Upon unbolting, the following functions are realized:

- 1) The heads remain unbolted until separation of the cars.

**Bibliography      Retrieval**

**Reference No.      Source No.      Data Source and Reference      \_\_\_\_\_**

2) The heads will then be maintained in a position forbidding coupling.

On both sides of the car the unbolting device should be easy to reach and to operate.

The uncoupling should be effective under traction strengths of approximately 6,600 lbs.

The coupler should be protected against the fall of materials.

The space (Berne rectangle) presently available for the operation of the screw coupler should be maintained if possible.

**Dimensions**

The principal dimensions of the coupler should be the following:

- |                                                                                    |                                      |
|------------------------------------------------------------------------------------|--------------------------------------|
| 1) width of the suspension system                                                  | 11.8 in.<br>13.8 in. maximum         |
| 2) maximum height of suspension system                                             | 11.8 in.                             |
| 3) operation range (maximum distance between the head and the car axis)            | 8.3 in.                              |
| 4) coupling range (lateral gathering range between the axis of cars to be coupled) |                                      |
| a. between automatic coupler cars                                                  | 8.7 in.                              |
| b. between a simplified coupler car and a UIC coupler car                          | 7.9 in.                              |
| 5) coupling range (vertical gathering)                                             | 5.5 in.                              |
| 6) centerline of coupler above top of rails                                        | 41.1 in. maximum<br>37.4 in. minimum |
| 7) traction resistance (strength in draft)                                         | 220,000 lb                           |
| 8) minimum compression resistance (strength in buffs)                              | 264,000 lb                           |

| Bibliography         |                   | Retrieval                                                                                                                                                                                  |
|----------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Reference No.</u> | <u>Source No.</u> | <u>Data Source and Reference</u>                                                                                                                                                           |
| 451*                 |                   | Punwani, S.K., "The Estimation of Potential Benefits from Improved Operations with Advanced Coupling Systems", 1974 Proceedings of 11th Annual Railroad Engineering Conference, pp. 61-67. |

This article introduces the topic of advanced coupling systems with a pictorial review of couplers and air line connectors. It includes tabular summaries of mechanical characteristics suggested by state-of-the-art systems and characteristics of train air lines.

One figure used in the article itemizes tasks to be accomplished by a potential contractor for work on advanced couplers. Another figure lists twelve factors in the potential benefits of advanced couplers.

Network analysis is suggested as a tool for operations planning and the writer further proposes that railroad operations need to be modeled and sampling plans developed to quantify essential elements.

### B.3 PATENT FINDINGS

| <u>Reference No.</u> | <u>Patent No.</u> | <u>Patent Title</u>               |
|----------------------|-------------------|-----------------------------------|
| 603                  | 3633762           | Automatic Service Conduit Con-    |
|                      | Class 213         | connector Devices for Railway Ve- |
|                      | Subclass 1.3      | hicle Couplings                   |

**Purpose:** To automatically connect the service conduits as the cars are coupled.

**Concept:** This invention relates to service conduit connections for the Willison type coupler. There is a mechanical level system which provides for the final interengagement of the connectors after the frontal impact between coupling heads.

|     |              |                                 |
|-----|--------------|---------------------------------|
| 610 | 3387715      | Retractable Trainline Connector |
|     | Class 213    | Apparatus                       |
|     | Subclass 1.3 |                                 |

**Purpose:** To provide a connector means to automatically connect trainlines.

**Concept:** The connector is to be carried by a railways vehicle coupler. The service line connector is retractable and moves forward to connect with a mating service line when the carrying couplers move into coupling engagement. For use with "F" or Willison type couplers.

|     |              |                                 |
|-----|--------------|---------------------------------|
| 611 | 3387714      | Retractable Trainline Connector |
|     | Class 213    | Device                          |
|     | Subclass 1.3 |                                 |

**Purpose:** To provide automatic connection of train service lines without relative movement of the connecting members even though there is considerable movement of the coupled couplers.

**Concept:** Carried on a railroad vehicle coupler. The service lines are retracted and covered until the couplers engage.

| <u>Reference No.</u> | <u>Patent No.</u> | <u>Patent Title</u>             |
|----------------------|-------------------|---------------------------------|
| 650                  | 3224601           | Mechanism for Automatically Un- |
|                      | Class 213         | cocking and Recocking Automatic |
|                      | Subclass 75       | Couplings for Railway Vehicles. |

Purpose: To provide an automatic uncocking and recocking mechanism for automatic couplings.

Concept: The actuating pawls are fixedly mounted and project into the loading gauge over the vertical height without reaching the area swept by the rolling elements of the car. A control cross element is mounted on the car chassis and is restrained by a stabilizing device. Rotation of the cross element effects the opening and closing of the coupler; the stabilizer prevents accidental shifting of the moving parts of the mechanism due to accidental impact.

|     |             |                              |
|-----|-------------|------------------------------|
| 670 | 3854597     | Automatic Hose Connector for |
|     | Class 213   | Railway Cars                 |
|     | Subclass 76 |                              |

Purpose: Automatically connect the train brake line concurrently with the coupling operation of the cars.

Concept: Mechanism delays locking and sealing of air hoses automatically until the cars are effectively coupled together. Mechanism consists of mating head beneath car coupler supporting hose connector supported in a normal, aligned position and provided with a conventional pin and gathering-funnel arrangement for guiding the head into engagement with the counterpart mating head.

|     |             |                             |
|-----|-------------|-----------------------------|
| 671 | 3812980     | Valve Means for Railway Car |
|     | Class 213   | Train Line                  |
|     | Subclass 76 |                             |

Purpose: Actuate air lines from either side of car equipped with either conventional draft gear or end of car cushioning device.

| <u>Reference No.</u>                                                                                                                                                                                                                                                                               | <u>Patent No.</u> | <u>Patent Title</u>              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------|
| <p>Concept: Ball valve to control air flow through train line is connected to shank of coupler and actuated through telescoping rods extending from universal connections to the ball valve to adjacent ends of the car.</p>                                                                       |                   |                                  |
| 672                                                                                                                                                                                                                                                                                                | 3802578           | Automatic Air-Coupling Structure |
|                                                                                                                                                                                                                                                                                                    | Class 213         | for Railway Cars                 |
|                                                                                                                                                                                                                                                                                                    | Subclass 76       |                                  |
| <p>Purpose: Automatically engage (connect and actuate) air lines of a car having just been physically coupled to another car.</p>                                                                                                                                                                  |                   |                                  |
| <p>Concept: Air chamber structure (attached to coupler shank) flexibly holds air line connection with side-opposite funnel guiding system for aligning air lines and spring-biased compression cylinder for engaging the air lines together.</p>                                                   |                   |                                  |
| 674                                                                                                                                                                                                                                                                                                | 3743110           | Coupling Valve Actuator for      |
|                                                                                                                                                                                                                                                                                                    | Class 213         | Automatic Pneumatic Coupling     |
|                                                                                                                                                                                                                                                                                                    | Subclass 76       | Systems                          |
| <p>Purpose: Consistently (regardless of the length of time between uncouplings) operate the interface valve used to depress a spring-projected plunger used in an automatic coupler.</p>                                                                                                           |                   |                                  |
| <p>Concept: Automatic uncoupling valve actuating mechanism using a noncompressible medium (such as hydraulic fluid or a flexible push-pull type cable) which will consistently (through time) be capable of actuating the automatic pneumatic coupling system without loss of actuating power.</p> |                   |                                  |
| 676                                                                                                                                                                                                                                                                                                | 3696941           | Automatic Coupling System for    |
|                                                                                                                                                                                                                                                                                                    | Class 213         | Freight Cars                     |
|                                                                                                                                                                                                                                                                                                    | Subclass 76       |                                  |
| <p>Purpose: Prevent venting of air in air line of car that is</p>                                                                                                                                                                                                                                  |                   |                                  |

| <u>Reference No.</u> | <u>Patent No.</u> | <u>Patent Title</u>                                                                                                                  |
|----------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------|
|                      |                   | charged through coupling at one end but remains uncoupled at the other end or has a faulty interface valve on the coupled other end. |

Concept: A pair of pilot-operated check valves connected in parallel to the air conduit actuate to prevent air flow from the line when it is uncoupled or coupled-but-leaking at the end of the car.

|     |             |                                     |
|-----|-------------|-------------------------------------|
| 678 | 3599803     | Automatic Pneumatic Coupling System |
|     | Class 213   |                                     |
|     | Subclass 76 |                                     |

Purpose: Improve the means of actuating the valve (of an automatic coupling system) that opens the knuckle of the coupler upon the intentional uncoupling of the rail car.

Concept: Pneumatically-actuated device with a control line connected to main air line whereby the intentional uncoupling of cars (and resulting air line) opens coupler knuckle.

|     |             |                               |
|-----|-------------|-------------------------------|
| 680 | 3589530     | Trainline Connector Apparatus |
|     | Class 213   |                               |
|     | Subclass 76 |                               |

Purpose: Automatically connect trainlines (or electrical circuit wires such as air or steam hoses) of cars being coupled.

Concept: Arm carrying a connector head below coupler that can be positioned either to automatically connect train line of one car with train line held by connector head of another car or to manually connect with train line of car not having device.

|     |             |                                                 |
|-----|-------------|-------------------------------------------------|
| 682 | 3556314     | Automatic Coupling System for Train Brake Lines |
|     | Class 213   |                                                 |
|     | Subclass 76 |                                                 |

Purpose: Automatically couple, uncouple, and valve the

| <u>Reference No.</u>                                                                                                                                                              | <u>Patent No.</u> | <u>Patent Title</u> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------|
| <p>car's brake line and differentiate between intentional and accidental uncoupling so as to either close the line to prevent braking or opening the line to produce braking.</p> |                   |                     |

Concept: Valve mechanism, involving pneumatic piping, circuit using air supply of brake line and air-actuated control valve and two pilot valves, whereby one pilot valve is responsive to coupling and thereby actuates control valve to open the brake valve and the other pilot valve is responsive only to intentional uncoupling and thereby actuates the control valve to close the brake valve.

|     |             |                               |
|-----|-------------|-------------------------------|
| 686 | 3599665     | Automatic Air Line Connection |
|     | Class 213   | System                        |
|     | Subclass 76 |                               |

Purpose: Automatically connect and disconnect air brake lines of two rail cars without requiring manual opening and closing of brake pipe anglecocks.

Concept: Device attached in a fixed position to top of coupler holds air line and connects with air line held by similar device on another car. Upon uncoupling, normally closed disconnect valves open to provide flow for brake air between cars and a second, spring-actuated valve that is manually operated from the side of the car and used to close first valve (and thereby stop flow of brake air) upon uncoupling of cars.

|     |             |                 |
|-----|-------------|-----------------|
| 702 | 3854599     | Railway Coupler |
|     | Class 213   |                 |
|     | Subclass 76 |                 |

Purpose: To reduce the number of incidences of lateral and vertical passed couplers.

Concept: Provision of an upstanding rib projecting outward from a coupler housing to inhibit twist-out of the knuckle under derailment conditions.

| <u>Reference No.</u> | <u>Patent No.</u> | <u>Patent Title</u>         |
|----------------------|-------------------|-----------------------------|
| 703                  | 3774776           | Universal Automatic Coupler |
|                      | Class 213         |                             |
|                      | Subclass 100      |                             |

Purpose: A design of a universal automatic coupler.

Concept: An automatic coupler comprising a shank and coupler head. One member is a guide member, the other is a locking and guiding member.

|     |              |                     |
|-----|--------------|---------------------|
| 705 | 3655066      | Railway Car Coupler |
|     | Class 213    |                     |
|     | Subclass 100 |                     |

Purpose: To increase the horizontal gathering range of a hook type coupler.

Concept: The coupling hook and inboard projections each have a forwardly extending tapered portion defining first and second lateral alignment. The invention provides a more compact arrangement of guiding surfaces for improving the gathering range.

|     |              |                     |
|-----|--------------|---------------------|
| 740 | 3127023      | Railway Car Coupler |
|     | Class 213    |                     |
|     | Subclass 103 |                     |

Purpose: Automatic coupler transmitting draft and buff forces, eliminating slack between mated couplers, to be used in place of hook and screw type couplers presently used in some countries.

Concept: One piece cast coupler, head of coupler having upper and lower sections that define a "throat" to receive a lock of a mated coupler, the sections extending at 45 degree angles from a horizontal plane in the form of wings to provide gathering and buff force capabilities. The unlocking mechanism includes a rotor manually operated by a rod that is used to move the lock to a lockset position.

| <u>Reference No.</u> | <u>Patent No.</u> | <u>Patent Title</u> |
|----------------------|-------------------|---------------------|
| 761                  | 3717261           | Car Coupler         |
|                      | Class 213         |                     |
|                      | Subclass 110      |                     |

Purpose: Provide a means for always keeping knuckle of uncoupled coupler in unlocked (open) position.

Concept: Spring assembly device, applied to a coupler as one unit, actuates the knuckle unlocking device when the uncoupling rod is activated or when the plunger, to the device located within the knuckle, is no longer depressed by the knuckle of the mated coupler.

|     |              |                               |
|-----|--------------|-------------------------------|
| 890 | 3872978      | Knuckle Structure for Railway |
|     | Class 213    | Vehicle Coupler               |
|     | Subclass 151 |                               |

Purpose: To increase the lateral gathering range.

Concept: The gathering face on the knuckle is in the form of a convex surface of an arc of fixed radius which approximates a portion of an equi-angular spiral. The resultant face of friction and the force normal at any point of contact along the entire length of the convex gathering surface is incapable of turning the knuckle from an open to closed position until the tip of the nose has passed the tip of the mating coupler.

|     |              |                     |
|-----|--------------|---------------------|
| 892 | 3856156      | Railway Car Coupler |
|     | Class 213    |                     |
|     | Subclass 151 |                     |

Purpose: To reduce slack.

Concept: A knuckle type coupler with a modified 10A contour. The pulling face of the knuckle is offset 5/64 inch closer to the front face of the coupler head. The heel and adjacent front face portions of the knuckle are contoured along a smooth compound convex curve to provide a tightened contour. The inner

| <u>Reference No.</u>                                                                                                                 | <u>Patent No.</u> | <u>Patent Title</u> |
|--------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------|
| side wall of the tail portion adjacent to the throat section is curved with substantial radius to prevent binding during uncoupling. |                   |                     |

|     |              |             |
|-----|--------------|-------------|
| 895 | 3670901      | Car Coupler |
|     | Class 213    |             |
|     | Subclass 151 |             |

Purpose: To increase the gathering range.

Concept: Change in knuckle nose contour to provide a gathering surface that is effective when coupler is open.

|     |              |                     |
|-----|--------------|---------------------|
| 900 | 3606032      | Railway Car Coupler |
|     | Class 213    |                     |
|     | Subclass 152 |                     |

Purpose: To promote vertical and lateral alignment.

Concept: An auxiliary lug is mounted on a shelf carried on the lower portion of the coupler head. The lug has a ramp portion to slidably engage the bottom forward edge of a shelf carried by an opposed mating coupler to permit coupler alignment.

|     |              |                 |
|-----|--------------|-----------------|
| 901 | 3121498      | Coupler Knuckle |
|     | Class 213    |                 |
|     | Subclass 152 |                 |

Purpose: Provide a means for the knuckle coupler head to absorb impact from buffing, thereby eliminating structural failure of the coupler due to buffing.

Concept: Place lugs on coupler knuckle in a manner so that mating a closed-knuckle coupler with an opened-knuckle coupler occurs tangentially, thereby increasing the amount of impact that can be taken without causing damage to the coupler knuckle.

| <u>Reference No.</u> | <u>Patent No.</u> | <u>Patent Title</u>  |
|----------------------|-------------------|----------------------|
| 910                  | 3698571           | Interlocking Coupler |
|                      | Class 213         |                      |
|                      | Subclass 153      |                      |

**Purpose:** To provide a coupler structure which will prevent a pair of mated couplers from separating by a vertical movement of one with respect to the other. This objective is accomplished if only one of the mated couplers is equipped with the invention.

**Concept:** A spring loaded dog (latch) is attached to the distal end of a coupler. The dog slips into an opening in an adjacent coupler limiting vertical coupler movement to the vertical height of the opening. The engagement between couplers is maintained and during coupler rotation due to negotiating sharp curves.

|     |              |                     |
|-----|--------------|---------------------|
| 912 | 3637089      | Railway Car Coupler |
|     | Class 213    |                     |
|     | Subclass 153 |                     |

**Purpose:** To provide a hood for an "F" coupler to afford vertical interlock between two opposed couplers when the "F" coupler is intercoupled with an AAR standard "E" coupler. A secondary objective is to prevent a worn knuckle of an "E" coupler from slipping out of the knuckle receiving access of the "F" coupler.

**Concept:** An interlock hood is integrally connected to the upper side of the "F" coupler head. The hood has a roof that overlies the vertical recess of the coupler head. The hood does not restrict normal movement of the "E" knuckle with the "F" coupler contour.

|     |              |                                 |
|-----|--------------|---------------------------------|
| 913 | 3073459      | Vertically Interlocking Railway |
|     | Class 213    | Car Coupler                     |
|     | Subclass 153 |                                 |

| <u>Reference No.</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <u>Patent No.</u> | <u>Patent Title</u>           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-------------------------------|
| <p>Purpose: To provide a knuckle type of automatic coupler (type "E") with a vertical interlock shelf having a recess for receipt of the lower auxiliary interlock lug of a type "F" coupler to permit intercoupling.</p> <p>Concept: Coupler shelves afford vertical support for the knuckle of the mating coupler to provide vertical interlock to prevent vertical separation in the event of coupler shank failure or separation of a coupler from the draft rigging of the car.</p>                                                     |                   |                               |
| 940                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 3805968           | Brush Uncoupler for Rail Cars |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Class 213         |                               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Subclass 159      |                               |
| <p>Purpose: To uncouple rolling rail cars without manual release of side levers.</p> <p>Concept: A cylindrical bristle brush is engaged with the handle of the uncoupling lever. The brush is rotated at a speed and in a direction so that the bristles move the handle to uncouple.</p>                                                                                                                                                                                                                                                    |                   |                               |
| 943                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 3491899           | Fluid-Operated Uncoupling     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Class 213         | Mechanism                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Subclass 159      |                               |
| <p>Purpose: To provide a fluid-operated uncoupling mechanism which is mechanically connected to the longitudinally swingable part of the coupler's locklift assembly to prevent accidental uncoupling.</p> <p>Concept: A mechanism applied to an "E" coupler having a fluid pressure responsive actuator mounted on the head and mechanically connected to the locklift assembly of the coupler. This will enable the coupler to be uncoupled by fluid pressure and will also positively lock the coupler against accidental uncoupling.</p> |                   |                               |

| <u>Reference No.</u> | <u>Patent No.</u> | <u>Patent Title</u> |
|----------------------|-------------------|---------------------|
|----------------------|-------------------|---------------------|

A spring-returned piston is connected to an operating shaft. On advance of the piston a crank swings the assembly in an uncoupling or locklifting direction.

The coupler can be uncoupled mechanically by applying a turning tool to the operating shaft.

|     |              |                               |
|-----|--------------|-------------------------------|
| 960 | 3834554      | Uncoupling Lever for Railroad |
|     | Class 213    | Cars with Standard Draft Gear |
|     | Subclass 166 | Cushioning                    |

**Purpose:** To provide an uncoupling lever assembly designed for use with cars with standard draft gear cushioning that avoids a substantial amount of lateral movement of the lever assembly handle. The lever is interchangeable between cars and may be applied to and removed from the car without uncoupling the car.

**Concept:** Prior to this invention, uncoupling levers on cars with draft gear cushioning have been rigid against extension and lengthwise contractor of the operating rod to the car end. This lever has an elongated rectilinear bar in which the handle section is swingably mounted on the car end by a special ore lock pivotal connection which holds the handle section against significant shifting movement under coupler side swing and impacts.

|      |              |                                |
|------|--------------|--------------------------------|
| 1020 | 3854598      | Automatic Unlocking Device for |
|      | Class 213    | Rolling Stock Couplers         |
|      | Subclass 211 |                                |

**Purpose:** To automatically unlock by lifting fastening cotter pins.

**Concept:** A base is installed at the side of a track and a boom mechanism is attached. The boom mechanism is composed of parallel links moveable along the track and tilting towards the track. A robot is hung from the boom which is lowered between cars to pull the cotter pins.

| <u>Reference No.</u> | <u>Patent No.</u> | <u>Patent Title</u>             |
|----------------------|-------------------|---------------------------------|
| 1042                 | 3532228           | Electronic Control and          |
|                      | Class 213         | Surveillance System for Railway |
|                      | Subclass 212      | Trains                          |

Purpose: Selectively control electronically by a master unit at a locomotive cab couplers or other automatically operable equipment and information supplying devices of one or more cars making up a train.

Concept: Electronic system that controls the operation of automatic devices (such as couplers) by electronically activating air cylinder units and obtains information from each car through the use of a master system (in locomotive) that hooks up with slave units in individual cars.

|      |              |                              |
|------|--------------|------------------------------|
| 1043 | 3690469      | System for Automatically     |
|      | Class 213    | Releasing Connection Between |
|      | Subclass 212 | Cars in Train                |

Purpose: Automatically uncouple any desired car of a train from the locomotive of the train.

Concept: A line providing electrical and pneumatic controls from the locomotive that disconnects any desired car of a train by the force of air under pressure.

|      |              |                              |
|------|--------------|------------------------------|
| 1044 | 3743111      | System for Disconnecting Any |
|      | Class 213    | Desired Car in a Train       |
|      | Subclass 212 |                              |

Purpose: Uncouple any desired car of a train from locomotive.

Concept: Actuating air supply line and instruction air are connected to a compressed air source in a locomotive and extends through train whereby operator in locomotive manipulates on-off valve by the number of times corresponding to the number of the car to be uncoupled, which then supplies high pressure air to

| <u>Reference No.</u>                                                        | <u>Patent No.</u> | <u>Patent Title</u> |
|-----------------------------------------------------------------------------|-------------------|---------------------|
| air conduits in the specific car which actuates a coupler unlocking device. |                   |                     |

|      |              |                                 |
|------|--------------|---------------------------------|
| 1045 | 3724680      | Remote Control System for       |
|      | Class 213    | Automatic Car Uncoupling Device |
|      | Subclass 212 |                                 |

**Purpose:** Remotely (from locomotive) perform control functions (such as automatic uncoupling) on individual railcars.

**Concept:** Train line circuitry (including stepping switching, relays, and solenoid valves) used to remotely operate from locomotive control functions such as automatic uncoupling of selective cars throughout a railway train.

|      |              |                           |
|------|--------------|---------------------------|
| 1046 | 3245553      | Fluid-Operated Uncoupling |
|      | Class 213    | Mechanism                 |
|      | Subclass 212 |                           |

**Purpose:** Provide an improved fluid-operated uncoupling mechanism which can be adapted to either manual or automatic operation, and requires no operating slack.

**Concept:** Automatically or manually (by means of conventional operating rod) operated device that opens knuckle of coupler by means of a fluid-operated lock actuator mounted on the coupler and mechanically connected to the lock.

|      |              |                              |
|------|--------------|------------------------------|
| 1061 | 3227289      | Coupler Operator for Railway |
|      | Class 213    | Cars                         |
|      | Subclass 219 |                              |

**Purpose:** To present a new and improved coupler lever to accomodate significant longitudinal and some rotational movement of the car relative to the car frame.

**Concept:** The coupler level is equipped with an impact absorbing device to allow for relative movement between the center

| <u>Reference No.</u>               | <u>Patent No.</u> | <u>Patent Title</u> |
|------------------------------------|-------------------|---------------------|
| sill of the car and the car frame. |                   |                     |

The lever is operable from the side of the car.

|      |              |                                 |
|------|--------------|---------------------------------|
| 1063 | 3117677      | Railway Car and Coupling Device |
|      | Class 213    |                                 |
|      | Subclass 219 |                                 |

**Purpose:** Provide a means for a person to manually uncouple a coupler mounted in a sliding sill underframe, regardless of the length that the coupler is extended from the underframe.

**Concept:** Attach a rod with a lever to the end of the car that runs parallel to the end of the car. Hook the end of this rod to an arm attached to the rod running parallel to the shank of the coupler that mechanically unlocks the knuckle of the coupler when the lever of the rod that is parallel to the end of the car is actuated by a person.

|      |            |                                                          |
|------|------------|----------------------------------------------------------|
| 1070 | 3249066    | Actuating Device for Combined                            |
|      | Class 105  | Wheel Guidance and Axle Orientation in Railroad Vehicles |
|      | Subclass 3 |                                                          |

**Purpose:** Provide a means for coupling or uncoupling two European rail cars that have to engage or disengage traction and orientation connections (that control the axle location relative to changes in its axis due to track curvatures).

**Concept:** A rocker and rod arrangement device disengages the coupling/uncoupling device from the guiding device (basically provided by the two side bumpers).

|      |             |                                |
|------|-------------|--------------------------------|
| 1100 | 3642149     | Coupler-Positioning Device for |
|      | Class 213   | Railroad Car Couplers          |
|      | Subclass 15 |                                |

**Purpose:** To position the coupler--center of track.

**Concept:** A swing lever is positioned between the coupler

Reference No.      Patent No.      Patent Title  
and the car truck. Cable structures extend between the respective ends of the swing lever and the coupler shank.

1101              3809251              Coupler Positioning Device for  
                    Class 213              Sliding Sill Cushion Underframe  
                    Subclass 15              Cars

Purpose: To position a coupler in the center of the track.

Concept: For use with sliding sill cushion underframe cars in which the coupler is connected to either end of a command or swing lever by an uncushioned cable connection. Cables are tensioned against the action of the shock absorber to provide the desired flexion free linkage between the swing lever and the coupler for coupler positioning.

1140              3450271              Railroad Coupling  
                    Class 213  
                    Subclass 75TC

Purpose: A coupler for use in rapid transit system.

Concept: An electromagnet is located at the outer end of a piston rod of a double acting pneumatic cylinder. The cylinder absorbs the shock of the coupling impact and also draws the cars together.

1160              3646498              Electrical Circuit Control  
                    Class 339              Apparatus  
                    Ref to 213  
                    Subclass 48-  
                    1.3

Purpose: To provide an electrical circuit control apparatus suited for railroad cars which eliminates live exposed electrical contacts when railroad cars are uncoupled.

Concept: A spring loaded contact pin assembly for making

| <u>Reference No.</u>                                                                                                 | <u>Patent No.</u> | <u>Patent Title</u> |
|----------------------------------------------------------------------------------------------------------------------|-------------------|---------------------|
| and braking electrical circuits. This invention reduces the danger of electrical shock and susceptibility to damage. |                   |                     |

## APPENDIX C

### SIGNIFICANT COUPLER CONCEPTS

|                                   | <u>Page</u> |
|-----------------------------------|-------------|
| C.1 Description of Function Codes | C - 2       |
| C.2 Descriptions of Concepts      | C - 4       |
| C.3 Data Accumulation Form        | C - 125     |

## C.1 DESCRIPTION OF FUNCTION CODES

- 1) IA1. Automatic air line connection with coupling
- 2) IA2. Provide second air line system
- 3) IA3a. Automatically open air valves upon coupling
- 4) IA3b. Automatically close air valves upon intentional uncoupling
- 5) IA3c. Automatically open air valves upon unintentional uncoupling
- 6) IB1. Improve integrity of air seal by lowering leak rates or gasket wear rates
- 7) IB2. Improve hose reliability regarding breakage, damage, or failure
- 8) IB3. Reduce hose and/or glad hand maintenance costs
- 9) IIA1. Improve lateral gathering range of mechanical coupling
- 10) IIA2. Improve vertical gathering range of mechanical coupling
- 11) IIA3. Provide positive locking of mated couplers
- 12) IIB1. Increase speed range at which positive coupling can be made
- 13) IIB2. Reduce free slack of mated couplers.
- 14) IIB3. Provide vertical interlock for mated couplers
- 15) IIB4. Absolutely entrap broken coupler
- 16) IIC1. Maintain position of coupler to center of car
- 17) IIC2. Reduce contour angling capability of coupler
- 18) IIC3. Maintain position of coupler to center of tracks
- 19) IID. Reduce required coupler maintenance
- 20) IIIA1. Improve uncoupling capability through the use of an alternate side lever
- 21) IIIA2. Improve uncoupling capability through the use of a push button release on side of car

- 22) IIIA3a. Provide means of automatically uncoupling from within train
- 23) IIIA3b. Provide means of automatically uncoupling from point external to train
- 24) IIIA4. Provide means to uncouple in draft
- 25) IIIB1. Improve recoupling capability by automatically opening knuckle at uncoupling
- 26) IIIB2. Improve recoupling capability through other means
- 27) IVA1. Automatically control brake with time delay set provisions upon intentional uncoupling
- 28) IVA2. Automatically control brake with emergency set upon unintentional uncoupling
- 29) IVB1. Provide electric train line system with automatic connection make and break
- 30) IVB3. Provide electric train line system with automatic sequencing of contactors
- 31) IVB4. Provide electric train line system with full environmental protection of contactors
- 32) IVB5. Provide electric train line system having train sensing capabilities
- 33) IVB6. Provide electric train line system having train control capabilities
- 34) IVC. Improve operational safety of coupler system

## C.2 DESCRIPTIONS OF CONCEPTS

### Concept 6a: GRIMESTHROPE ASF/V COUPLER

Primary Bibliography Reference No.: 6

|                                              |                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                  |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Description of Concept                       | Grimesthorpe ASF/V coupler (rigid type, with horn-funnel, hinged hook); Symmetrical pyramid shaped horn; Fits opposite recessed funnel; Hinged locking hooks interlock; Rigid coupling (cast finish); Top overlapping flanged and side; Tongue/groove fittings; Draft strength/coupler weight; spring loaded locking hooks automatically engage opposite horn at coupling. Automatic air connection and knuckle always open. |
| Compatibility with AAR Type "E" Coupler:     |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 1. Can be added to Type "E"                  | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                     |
| 2. Requires modification of Type "E"         | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                     |
| 3. Requires head adapter for Type "E"        | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                     |
| 4. Incompatible with Type "E"                | <input checked="" type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                          |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM   |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IA1.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IA2.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IA3a.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IA3b.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IA3c.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IB1.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IB2.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IB3.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| CATEGORY II - IMPROVE MECHANICAL COUPLING    |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| *IA1.                                        | - $\pm 5"$ (2.5 times standard lateral gathering range).                                                                                                                                                                                                                                                                                                                                                                     |
| *IA2.                                        | - $\pm 5"$ (3.3 times standard vertical gathering range).                                                                                                                                                                                                                                                                                                                                                                    |
| *IA3.                                        | - Positive locking.                                                                                                                                                                                                                                                                                                                                                                                                          |
| IB1.                                         | - 0.125" slack (0.16 times standard). Economical cast coupling face.                                                                                                                                                                                                                                                                                                                                                         |
| *IB2.                                        | - Vertical interlock.                                                                                                                                                                                                                                                                                                                                                                                                        |
| *IB3.                                        | - Absolute entrapment of broken coupler.                                                                                                                                                                                                                                                                                                                                                                                     |
| *IB4.                                        | ** Light duty design with weight ratio = 385 at draft pull = 308,000 lbs.                                                                                                                                                                                                                                                                                                                                                    |
| IC1.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IC2.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IC3.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| ID.                                          |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IIA1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IIA2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IIA3a.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IIA3b.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IIA4.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| *IIB1.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IIB2.                                        | - Always open upon uncoupling (like open knuckle).                                                                                                                                                                                                                                                                                                                                                                           |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS        |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IVA1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| IVA2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| VB1.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| VB3.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| VB4.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| VB5.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| VB6.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                              |
| *VC.                                         | Improved safety.                                                                                                                                                                                                                                                                                                                                                                                                             |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

Concept 6b: CONCEPT GRESHAM AND CRAVEN LTD. AIR CONNECTOR

Primary Bibliography Reference No.: 6

|                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                    |
| Description of Concept                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                    |
| <b>Compatibility with AAR Type "E" Coupler:</b><br>1. Can be added to Type "E" <input type="checkbox"/><br>2. Requires modification of Type "E" <input type="checkbox"/><br>3. Requires head adapter for Type "E" <input type="checkbox"/><br>4. Incompatible with Type "E" <input checked="" type="checkbox"/> | Automatic air connection (within the head of rigid coupler) located on centerline and beneath coupler head.                                                                        |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                               |                                                                                                                                                                                    |
| <b>Pertinent Functions</b><br>IA1.<br>IA2.<br>IA3a.<br>IA3b.<br>IA3c.<br>IB1.<br>IB2.<br>IB3.                                                                                                                                                                                                                   |                                                                                                                                                                                    |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                |                                                                                                                                                                                    |
| <b>Pertinent Functions</b><br>*IA1.<br>IA2.<br>IA3.<br>IB1.<br>IB2.<br>IB3.<br>IB4.<br>IC1.<br>IC2.<br>IC3.<br>ID.                                                                                                                                                                                              | ** Ball type air closure connection (spring loaded and approximately 5-1/2" O.D.) would be susceptible to clogging from foreign particles. In addition, is rather large and bulky. |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                             |                                                                                                                                                                                    |
| <b>Pertinent Functions</b><br>IIIA1.<br>IIIA2.<br>IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIB1.<br>IIB2.                                                                                                                                                                                                                |                                                                                                                                                                                    |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                    |                                                                                                                                                                                    |
| <b>Pertinent Functions</b><br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                               |                                                                                                                                                                                    |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

## Concept 8: SW COUPLER POSITIONING DEVICE

Primary Bibliography Reference No.: 8

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------|-----------------------------|-------|--------------------------------------|-------|---------------------------------------|------|-------------------------------|------|--------------------------------------------------------------------------------------------------------------------------------------------|------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 41,517                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td colspan="2" style="padding: 2px;">Compatibility with AAR Type "E" Coupler:</td> </tr> <tr> <td style="padding: 2px;">1. Can be added to Type "E"</td> <td style="text-align: center; padding: 2px;">X</td> </tr> <tr> <td style="padding: 2px;">2. Requires modification of Type "E"</td> <td style="padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">3. Requires head adapter for Type "E"</td> <td style="padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">4. Incompatible with Type "E"</td> <td style="padding: 2px;"></td> </tr> </table>                                                       | Compatibility with AAR Type "E" Coupler: |      | 1. Can be added to Type "E" | X     | 2. Requires modification of Type "E" |       | 3. Requires head adapter for Type "E" |      | 4. Incompatible with Type "E" |      | <p>Mechanical linkage-roller type (for existing cars;</p> <p>Automatic positioning through manual linkage;</p> <p>Reduced maintenance.</p> |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | X                                        |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
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| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
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| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
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| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| ID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
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| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
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| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |
| IC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |      |                             |       |                                      |       |                                       |      |                               |      |                                                                                                                                            |      |     |                                                                                                                                                                                                                                                                                                                                                                           |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

## Concept 9: SW 800 COUPLER

Primary Bibliography Reference No.: 9

|                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 517                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Description of Concept</b><br>Rigid, horn-funnel, hinged hook type with automatic air and electrical connections (symmetrical, pyramid shaped horn/funnel;<br>Uncoupling cam released pneumatically;<br>Locking hooks forced apart by cam wedge force;<br>Spring loaded locking hooks automatically engage opposite horn at coupling;<br>Automatic air connections (within the head of rigid coupler);<br>Electrical connector suspended below coupler. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Compatibility with AAR Type "E" Coupler:</b><br>1. Can be added to Type "E"<br>2. Requires modification of Type "E"<br>3. Requires head adapter for Type "E"<br>4. Incompatible with Type "E"                                                                                                                                                                                                                                                           | Environmental cover cammed aside by force of the mating coupler;<br>Final electrical contact is made by air inflation of a diaphragm which moves pins forward;<br>Automatic air connection and locking hook always open.                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Pertinent Functions</b><br>*IA1.<br>*IA2.<br>*IA3.<br>*IA4.<br>*IA5.<br>*IA6.<br>*IA7.<br>*IA8.<br>*IA9.<br>*IA10.                                                                                                                                                                                                                                                                                                                                      | - Ball type connection should have good fit and function due to tight fit of coupler spring loaded, compressed rubber air seals.<br>- Second air line system available.<br>** Air valve control (part of Walton system - see Biblio. No. 254) switching may have maintenance problems as result of plug-up of solenoid valves due to rusting of iron cores.<br>- Aligning pins free air connector of stress forces.<br>- Lack of glad-hand air seal and hose lateral movement would improve integrity and reliability and reduce maintenance.                                                                                         |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Pertinent Functions</b><br>*IA1.<br>*IA2.<br>*IA3.<br>*IA4.<br>*IA5.<br>*IA6.<br>*IA7.<br>*IA8.<br>*IA9.<br>*IA10.                                                                                                                                                                                                                                                                                                                                      | - (Larger version of proven subway coupler).<br>- Lateral = $\pm 5"$ (2.5 times standard gathering range).<br>- Vertical = $\pm 5"$ (3.0 times standard gathering range).<br>- Hinged locking hooks have positive spring loaded interlock by direct action of compression of guide pins on coupler face.<br>- Machined rigid face = "no" free slack.<br>- Aligning pins and dowels plus locked hooks gives good vertical interlock.<br>- Pin/dowel fit plus interlocking spring loaded hooks achieves absolute entrapment and gives reduced control angling.<br>- Reduced maintenance of air hoses etc. from self-contained features. |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Pertinent Functions</b><br>*IA1.<br>*IA2.<br>*IA3.<br>*IA4.<br>*IA5.<br>*IA6.<br>*IA7.<br>*IA8.<br>*IA9.<br>*IA10.                                                                                                                                                                                                                                                                                                                                      | - Allows remote uncoupling release from within train.<br>- Provides good reliability against unintentional uncoupling and provides uncoupling capability in draft.<br>- Always open at uncoupling (like open knuckle).                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Pertinent Functions</b><br>*IA1.<br>*IA2.<br>*IA3.<br>*IA4.<br>*IA5.<br>*IA6.<br>*IA7.<br>*IA8.<br>*IA9.<br>*IA10.                                                                                                                                                                                                                                                                                                                                      | ** Electrical contacts may be subject to excessive wear from environmental grime from roadbed.<br>** Cover subject to damage and malfunction due to impact forces of camming action during coupling.<br>** Potential for malfunction from a jamming and rupture of diaphragm or to stress aging and hardening of diaphragm.<br>- Improved safety.                                                                                                                                                                                                                                                                                     |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

## Concept 22: DRESSER AUTOMATIC/PNEUMATIC COUPLING SYSTEM

### Primary Bibliography Reference No.: 22

|                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
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| Related Reference Number(s) 434, 451, 605, 517                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| <b>Description of Concept</b><br>Automatic air connection (coupler mounted, spread-wing with butt line connections);<br>Automatic connection with coupling;<br>Automatic operation of air valves;<br>Improved performance.                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| <b>Compatibility with AAR Type "E" Coupler:</b> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 80%;">1. Can be added to Type "E"</td> <td style="width: 20%; text-align: center;">X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                           | X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| <b>Pertinent Functions</b><br>*IA1.<br>*IA2.<br>*IA3.<br>*IA3a.<br>*IA3b.<br>*IA3c.<br>*IB1.<br>*IB2.<br>*IB3.                                                                                                                                                                                                                                                                                                                                        | ** Careful analysis and test would be required of spread-wing design to assure adequate wear strength and wear characteristics.<br>- Coupling mechanical forces operate a push rod and pilot line which opens the air line valve at coupling (no added movements).<br>- Lifting the uncoupling lockset lever operates a valve which pressurizes a pilot line to close train air line valve (no added movements).<br>- Unintentional uncoupling (no operations of uncoupling lever) leaves train air line valves open to set brakes.<br>- Less air leakage, improved line seal, improved safety.<br>- Valve controls would add mechanical and maintenance complexity but a minimum of sensitive control circuits.<br>- System provides for "mixed" coupling without any mechanical changes. |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| <b>Pertinent Functions</b><br>IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| <b>Pertinent Functions</b><br>IIA1.<br>IIA2.<br>IIA3.<br>IIA3a.<br>IIA3b.<br>IIA3c.<br>IIB1.<br>IIB2.                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| <b>Pertinent Functions</b><br>IVA1.<br>*IVA2.<br>*VBI.<br>VB3.<br>VB4.<br>VB5.<br>*VB6.<br>*VC.                                                                                                                                                                                                                                                                                                                                                       | - Improved safety.<br>- Air connector can provide second air line <u>or</u> a small electrical connection system.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 25: S-W "L-C" COUPLER

Primary Bibliography Reference No.: 25

|                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 517                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| <p>Compatibility with AAR Type "E" Coupler:</p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                                                                                   | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                               | X                                                                                                                                                                                 |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| <p>Long car coupler (72" shank with swivel butt and vertical swivel point midway to "F" head);<br/>Interlocking head.</p>                                                                                                                                                                                                                 |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| *IA1.                                                                                                                                                                                                                                                                                                                                     | - Gathering range, locking, free slack, interlock and entrapment improvements through use of "F" coupler head.                                                                    |                             |   |                                      |  |                                       |  |                               |  |
| *IA2.                                                                                                                                                                                                                                                                                                                                     | ** Longer (72") shank and "F" (interlocking) head result in reduced contour angling.                                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| *IA3.                                                                                                                                                                                                                                                                                                                                     | - Vertical pivot allows greater head vertical movement w/o increasing jackknifing possibility.                                                                                    |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                      | Total lateral movement = $\pm 16-1/4"$ (32-1/2").                                                                                                                                 |                             |   |                                      |  |                                       |  |                               |  |
| *IB2.                                                                                                                                                                                                                                                                                                                                     | total vertical movement = $\pm 2-3/4"$ -5" (7-3.4").                                                                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| *IB3.                                                                                                                                                                                                                                                                                                                                     | ** Manual centering would not aid normal switching operations with this heavy (967 lbs.) head and shank, some mechanical aid would be needed to achieve centering where required. |                             |   |                                      |  |                                       |  |                               |  |
| *IB4.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| *IC1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| *IC2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| *IC3.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| *ID.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IIA3a.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IIA3b.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IIA4.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| VB1.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| VB3.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| VB4.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| VB5.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| VB6.                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| *VC.                                                                                                                                                                                                                                                                                                                                      | - Reduced probability of lifting trucks on curves, and therefore, reduced derailment probability.                                                                                 |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
\*\*Denotes potential operating or safety problem.

## Concept 26: CONTROLLED SWIVEL "E" COUPLER

Primary Bibliography Reference No.: 26

| Related Reference Number(s) 517                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th colspan="2">Compatibility with AAR Type "E" Coupler:</th> </tr> <tr> <td>1. Can be added to Type "E"</td> <td style="text-align: center;">X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Compatibility with AAR Type "E" Coupler: |        | 1. Can be added to Type "E" | X       | 2. Requires modification of Type "E" |         | 3. Requires head adapter for Type "E" |        | 4. Incompatible with Type "E" |        | <p>Limited centering and contour angling capability;</p> <p>Reduced contour angling.</p> |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | X                                        |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Pertinent Functions</td></tr> <tr><td>IA1.</td></tr> <tr><td>IA2.</td></tr> <tr><td>IA3a.</td></tr> <tr><td>IA3b.</td></tr> <tr><td>IA3c.</td></tr> <tr><td>IB1.</td></tr> <tr><td>IB2.</td></tr> <tr><td>IB3.</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Pertinent Functions                      | IA1.   | IA2.                        | IA3a.   | IA3b.                                | IA3c.   | IB1.                                  | IB2.   | IB3.                          |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIA1.</td></tr> <tr><td>IIA2.</td></tr> <tr><td>IIA3.</td></tr> <tr><td>IIA4.</td></tr> <tr><td>IIA5.</td></tr> <tr><td>IIA6.</td></tr> <tr><td>IIA7.</td></tr> <tr><td>IIA8.</td></tr> <tr><td>IIA9.</td></tr> <tr><td>IIA10.</td></tr> <tr><td>IIA11.</td></tr> <tr><td>IIA12.</td></tr> <tr><td>IIA13.</td></tr> <tr><td>IIA14.</td></tr> <tr><td>IIA15.</td></tr> <tr><td>IIA16.</td></tr> <tr><td>IIA17.</td></tr> <tr><td>IIA18.</td></tr> <tr><td>IIA19.</td></tr> <tr><td>IIA20.</td></tr> <tr><td>IIA21.</td></tr> <tr><td>IIA22.</td></tr> <tr><td>IIA23.</td></tr> <tr><td>IIA24.</td></tr> <tr><td>IIA25.</td></tr> <tr><td>IIA26.</td></tr> <tr><td>IIA27.</td></tr> <tr><td>IIA28.</td></tr> <tr><td>IIA29.</td></tr> <tr><td>IIA30.</td></tr> <tr><td>IIA31.</td></tr> <tr><td>IIA32.</td></tr> <tr><td>IIA33.</td></tr> <tr><td>IIA34.</td></tr> <tr><td>IIA35.</td></tr> <tr><td>IIA36.</td></tr> <tr><td>IIA37.</td></tr> <tr><td>IIA38.</td></tr> <tr><td>IIA39.</td></tr> <tr><td>IIA40.</td></tr> <tr><td>IIA41.</td></tr> <tr><td>IIA42.</td></tr> <tr><td>IIA43.</td></tr> <tr><td>IIA44.</td></tr> <tr><td>IIA45.</td></tr> <tr><td>IIA46.</td></tr> <tr><td>IIA47.</td></tr> <tr><td>IIA48.</td></tr> <tr><td>IIA49.</td></tr> <tr><td>IIA50.</td></tr> <tr><td>IIA51.</td></tr> <tr><td>IIA52.</td></tr> <tr><td>IIA53.</td></tr> <tr><td>IIA54.</td></tr> <tr><td>IIA55.</td></tr> <tr><td>IIA56.</td></tr> <tr><td>IIA57.</td></tr> <tr><td>IIA58.</td></tr> <tr><td>IIA59.</td></tr> <tr><td>IIA60.</td></tr> <tr><td>IIA61.</td></tr> <tr><td>IIA62.</td></tr> <tr><td>IIA63.</td></tr> <tr><td>IIA64.</td></tr> <tr><td>IIA65.</td></tr> <tr><td>IIA66.</td></tr> <tr><td>IIA67.</td></tr> <tr><td>IIA68.</td></tr> <tr><td>IIA69.</td></tr> <tr><td>IIA70.</td></tr> <tr><td>IIA71.</td></tr> <tr><td>IIA72.</td></tr> <tr><td>IIA73.</td></tr> <tr><td>IIA74.</td></tr> <tr><td>IIA75.</td></tr> <tr><td>IIA76.</td></tr> <tr><td>IIA77.</td></tr> <tr><td>IIA78.</td></tr> <tr><td>IIA79.</td></tr> <tr><td>IIA80.</td></tr> <tr><td>IIA81.</td></tr> <tr><td>IIA82.</td></tr> <tr><td>IIA83.</td></tr> <tr><td>IIA84.</td></tr> <tr><td>IIA85.</td></tr> <tr><td>IIA86.</td></tr> <tr><td>IIA87.</td></tr> <tr><td>IIA88.</td></tr> <tr><td>IIA89.</td></tr> <tr><td>IIA90.</td></tr> <tr><td>IIA91.</td></tr> <tr><td>IIA92.</td></tr> <tr><td>IIA93.</td></tr> <tr><td>IIA94.</td></tr> <tr><td>IIA95.</td></tr> <tr><td>IIA96.</td></tr> <tr><td>IIA97.</td></tr> <tr><td>IIA98.</td></tr> <tr><td>IIA99.</td></tr> <tr><td>IIA100.</td></tr> </table>                                                                                                     | Pertinent Functions                      | IIA1.  | IIA2.                       | IIA3.   | IIA4.                                | IIA5.   | IIA6.                                 | IIA7.  | IIA8.                         | IIA9.  | IIA10.                                                                                   | IIA11.  | IIA12.  | IIA13.  | IIA14.  | IIA15.  | IIA16.  | IIA17.  | IIA18.  | IIA19.  | IIA20.  | IIA21.  | IIA22.  | IIA23.  | IIA24.  | IIA25.  | IIA26.  | IIA27.  | IIA28.  | IIA29.  | IIA30.  | IIA31.  | IIA32.  | IIA33.  | IIA34.  | IIA35.  | IIA36.  | IIA37.  | IIA38.  | IIA39.  | IIA40.  | IIA41.  | IIA42.  | IIA43.  | IIA44.  | IIA45.  | IIA46.  | IIA47.  | IIA48.  | IIA49.  | IIA50.  | IIA51.  | IIA52.  | IIA53.  | IIA54.  | IIA55.  | IIA56.  | IIA57.  | IIA58.  | IIA59.  | IIA60.  | IIA61.  | IIA62.  | IIA63.  | IIA64.  | IIA65.  | IIA66.  | IIA67.  | IIA68.  | IIA69.  | IIA70.  | IIA71.  | IIA72.  | IIA73.  | IIA74.  | IIA75.  | IIA76.  | IIA77.  | IIA78.  | IIA79.  | IIA80.  | IIA81.  | IIA82.  | IIA83.  | IIA84.  | IIA85.  | IIA86.  | IIA87.  | IIA88.  | IIA89.  | IIA90.  | IIA91.  | IIA92.  | IIA93.  | IIA94.  | IIA95.  | IIA96.  | IIA97.  | IIA98.  | IIA99.  | IIA100.  | <ul style="list-style-type: none"> <li>- Self centering achieved as follows:<br/>             Angularity above 4°, draft gear is depressed and uncoupled gear returns to center when lateral force is removed. (4° = 2.0" offset for 28.5" coupler and 4.2" for 60" coupler). Angularity above 4° expected on 10-20% of operating time.</li> <li>- Maximum angularity of 15° (for 60" coupler) as compared to standard of 7°, results in less contour angling on curves.</li> </ul> |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA7.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA8.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA9.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA10.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA11.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA12.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA13.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA14.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA15.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA16.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA17.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA18.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA19.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA20.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA21.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA22.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA23.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA24.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA25.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA26.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA27.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA28.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA29.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA30.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA31.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA32.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA33.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA34.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA35.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA36.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA37.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA38.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA39.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA40.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA41.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA42.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA43.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA44.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA45.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA46.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA47.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA48.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA49.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA50.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA51.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA52.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA53.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA54.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA55.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA56.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA57.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA58.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA59.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA60.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA61.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA62.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA63.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA64.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA65.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA66.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA67.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA68.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA69.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA70.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA71.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA72.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA73.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA74.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA75.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA76.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA77.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA78.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA79.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA80.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA81.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA82.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA83.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA84.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA85.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA86.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA87.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA88.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA89.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA90.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA91.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA92.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA93.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA94.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA95.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA96.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA97.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA98.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA99.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIA100.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIIA1.</td></tr> <tr><td>IIIA2.</td></tr> <tr><td>IIIA3a.</td></tr> <tr><td>IIIA3b.</td></tr> <tr><td>IIIA3c.</td></tr> <tr><td>IIIA4.</td></tr> <tr><td>IIIA5.</td></tr> <tr><td>IIIA6.</td></tr> <tr><td>IIIA7.</td></tr> <tr><td>IIIA8.</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Pertinent Functions                      | IIIA1. | IIIA2.                      | IIIA3a. | IIIA3b.                              | IIIA3c. | IIIA4.                                | IIIA5. | IIIA6.                        | IIIA7. | IIIA8.                                                                                   |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA7.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIA8.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIIV1.</td></tr> <tr><td>IIIV2.</td></tr> <tr><td>IIIV3.</td></tr> <tr><td>IIIV4.</td></tr> <tr><td>IIIV5.</td></tr> <tr><td>IIIV6.</td></tr> <tr><td>IIIV7.</td></tr> <tr><td>IIIV8.</td></tr> <tr><td>IIIV9.</td></tr> <tr><td>IIIV10.</td></tr> <tr><td>IIIV11.</td></tr> <tr><td>IIIV12.</td></tr> <tr><td>IIIV13.</td></tr> <tr><td>IIIV14.</td></tr> <tr><td>IIIV15.</td></tr> <tr><td>IIIV16.</td></tr> <tr><td>IIIV17.</td></tr> <tr><td>IIIV18.</td></tr> <tr><td>IIIV19.</td></tr> <tr><td>IIIV20.</td></tr> <tr><td>IIIV21.</td></tr> <tr><td>IIIV22.</td></tr> <tr><td>IIIV23.</td></tr> <tr><td>IIIV24.</td></tr> <tr><td>IIIV25.</td></tr> <tr><td>IIIV26.</td></tr> <tr><td>IIIV27.</td></tr> <tr><td>IIIV28.</td></tr> <tr><td>IIIV29.</td></tr> <tr><td>IIIV30.</td></tr> <tr><td>IIIV31.</td></tr> <tr><td>IIIV32.</td></tr> <tr><td>IIIV33.</td></tr> <tr><td>IIIV34.</td></tr> <tr><td>IIIV35.</td></tr> <tr><td>IIIV36.</td></tr> <tr><td>IIIV37.</td></tr> <tr><td>IIIV38.</td></tr> <tr><td>IIIV39.</td></tr> <tr><td>IIIV40.</td></tr> <tr><td>IIIV41.</td></tr> <tr><td>IIIV42.</td></tr> <tr><td>IIIV43.</td></tr> <tr><td>IIIV44.</td></tr> <tr><td>IIIV45.</td></tr> <tr><td>IIIV46.</td></tr> <tr><td>IIIV47.</td></tr> <tr><td>IIIV48.</td></tr> <tr><td>IIIV49.</td></tr> <tr><td>IIIV50.</td></tr> <tr><td>IIIV51.</td></tr> <tr><td>IIIV52.</td></tr> <tr><td>IIIV53.</td></tr> <tr><td>IIIV54.</td></tr> <tr><td>IIIV55.</td></tr> <tr><td>IIIV56.</td></tr> <tr><td>IIIV57.</td></tr> <tr><td>IIIV58.</td></tr> <tr><td>IIIV59.</td></tr> <tr><td>IIIV60.</td></tr> <tr><td>IIIV61.</td></tr> <tr><td>IIIV62.</td></tr> <tr><td>IIIV63.</td></tr> <tr><td>IIIV64.</td></tr> <tr><td>IIIV65.</td></tr> <tr><td>IIIV66.</td></tr> <tr><td>IIIV67.</td></tr> <tr><td>IIIV68.</td></tr> <tr><td>IIIV69.</td></tr> <tr><td>IIIV70.</td></tr> <tr><td>IIIV71.</td></tr> <tr><td>IIIV72.</td></tr> <tr><td>IIIV73.</td></tr> <tr><td>IIIV74.</td></tr> <tr><td>IIIV75.</td></tr> <tr><td>IIIV76.</td></tr> <tr><td>IIIV77.</td></tr> <tr><td>IIIV78.</td></tr> <tr><td>IIIV79.</td></tr> <tr><td>IIIV80.</td></tr> <tr><td>IIIV81.</td></tr> <tr><td>IIIV82.</td></tr> <tr><td>IIIV83.</td></tr> <tr><td>IIIV84.</td></tr> <tr><td>IIIV85.</td></tr> <tr><td>IIIV86.</td></tr> <tr><td>IIIV87.</td></tr> <tr><td>IIIV88.</td></tr> <tr><td>IIIV89.</td></tr> <tr><td>IIIV90.</td></tr> <tr><td>IIIV91.</td></tr> <tr><td>IIIV92.</td></tr> <tr><td>IIIV93.</td></tr> <tr><td>IIIV94.</td></tr> <tr><td>IIIV95.</td></tr> <tr><td>IIIV96.</td></tr> <tr><td>IIIV97.</td></tr> <tr><td>IIIV98.</td></tr> <tr><td>IIIV99.</td></tr> <tr><td>IIIV100.</td></tr> </table> | Pertinent Functions                      | IIIV1. | IIIV2.                      | IIIV3.  | IIIV4.                               | IIIV5.  | IIIV6.                                | IIIV7. | IIIV8.                        | IIIV9. | IIIV10.                                                                                  | IIIV11. | IIIV12. | IIIV13. | IIIV14. | IIIV15. | IIIV16. | IIIV17. | IIIV18. | IIIV19. | IIIV20. | IIIV21. | IIIV22. | IIIV23. | IIIV24. | IIIV25. | IIIV26. | IIIV27. | IIIV28. | IIIV29. | IIIV30. | IIIV31. | IIIV32. | IIIV33. | IIIV34. | IIIV35. | IIIV36. | IIIV37. | IIIV38. | IIIV39. | IIIV40. | IIIV41. | IIIV42. | IIIV43. | IIIV44. | IIIV45. | IIIV46. | IIIV47. | IIIV48. | IIIV49. | IIIV50. | IIIV51. | IIIV52. | IIIV53. | IIIV54. | IIIV55. | IIIV56. | IIIV57. | IIIV58. | IIIV59. | IIIV60. | IIIV61. | IIIV62. | IIIV63. | IIIV64. | IIIV65. | IIIV66. | IIIV67. | IIIV68. | IIIV69. | IIIV70. | IIIV71. | IIIV72. | IIIV73. | IIIV74. | IIIV75. | IIIV76. | IIIV77. | IIIV78. | IIIV79. | IIIV80. | IIIV81. | IIIV82. | IIIV83. | IIIV84. | IIIV85. | IIIV86. | IIIV87. | IIIV88. | IIIV89. | IIIV90. | IIIV91. | IIIV92. | IIIV93. | IIIV94. | IIIV95. | IIIV96. | IIIV97. | IIIV98. | IIIV99. | IIIV100. | <ul style="list-style-type: none"> <li>- Reduced contour angling lowers derail probability and increases safety.</li> </ul>                                                                                                                                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV7.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV8.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV9.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV10.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV11.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV12.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV13.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV14.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV15.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV16.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV17.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV18.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV19.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV20.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV21.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV22.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV23.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV24.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV25.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV26.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV27.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV28.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV29.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV30.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV31.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV32.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV33.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV34.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV35.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV36.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV37.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV38.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV39.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV40.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV41.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV42.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV43.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV44.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV45.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV46.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV47.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV48.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV49.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV50.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV51.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV52.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV53.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV54.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV55.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV56.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV57.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV58.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV59.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV60.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV61.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV62.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV63.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV64.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV65.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV66.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV67.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV68.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV69.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV70.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV71.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV72.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV73.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV74.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV75.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV76.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV77.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV78.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV79.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV80.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV81.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV82.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV83.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV84.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV85.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV86.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV87.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV88.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV89.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV90.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV91.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV92.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV93.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV94.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV95.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV96.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV97.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV98.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV99.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| IIIV100.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                          |        |                             |         |                                      |         |                                       |        |                               |        |                                                                                          |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 27: DRESSER RAPID TRANSIT COUPLER

Primary Bibliography Reference No.: 27

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-------------------------------------------|-----------------------------|----------------------------------------------------|--------------------------------------|----------------------------------------|---------------------------------------|---------------------------|-------------------------------|----------------------------------------------------|--|---|
| Related Reference Number(s) 448, 517, 606, 750                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| Description of Concept<br>Smaller version of SW 800 (see also Bibliography Reference Number 9).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| <table border="0"> <tr> <td>Compatibility with AAR Type "E" Coupler:</td> <td>Electro-pneumatic switching unit operates</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td>(1) Train air valves (at coupling and uncoupling).</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td>(2) Make/break of electrical contacts.</td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td>(3) Car uncoupling lever.</td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td>(4) Centering device (at coupling and uncoupling).</td> </tr> <tr> <td></td> <td>X</td> </tr> </table> |                                                                                                                                                                                            | Compatibility with AAR Type "E" Coupler: | Electro-pneumatic switching unit operates | 1. Can be added to Type "E" | (1) Train air valves (at coupling and uncoupling). | 2. Requires modification of Type "E" | (2) Make/break of electrical contacts. | 3. Requires head adapter for Type "E" | (3) Car uncoupling lever. | 4. Incompatible with Type "E" | (4) Centering device (at coupling and uncoupling). |  | X |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Electro-pneumatic switching unit operates                                                                                                                                                  |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | (1) Train air valves (at coupling and uncoupling).                                                                                                                                         |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | (2) Make/break of electrical contacts.                                                                                                                                                     |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | (3) Car uncoupling lever.                                                                                                                                                                  |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | (4) Centering device (at coupling and uncoupling).                                                                                                                                         |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | X                                                                                                                                                                                          |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p>Small version of SW-800.<br/>See Bibliography Reference Number 9.</p>                                                                                                                   |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| *IA1.<br>*IA2.<br>*IA3a.<br>*IA3b.<br>*IA3c.<br>*IB1.<br>*IB2.<br>*IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p>- Pneumatic actuated (at uncoupling) rubber boots on each side of shank to achieve self-centering.</p>                                                                                  |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| *IIA1.<br>*IIA2.<br>*IIA3.<br>*IIB1.<br>*IIB2.<br>*IIB3.<br>*IIB4.<br>*IIC1.<br>*IIC2.<br>*IIC3.<br>*IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p>** Achieves self-centering in uncoupled state (some question of permanent retention of air in expanded rubber boots for self-centering in extreme environments).</p>                    |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| *IIIA1.<br>*IIIA2.<br>*IIIA3a.<br>*IIIA3b.<br>*IIIA4.<br>*IIIB1.<br>*IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p>- Achieves automatic brake control at uncoupling (assuming electrical power available).<br/>- Achieves train control for air valves, electrical contacts, uncoupling and centering.</p> |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |
| *IVA1.<br>*IVA2.<br>*IVB1.<br>*IVB3.<br>*IVB4.<br>*IVB5.<br>*IVB6.<br>*IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                            |                                          |                                           |                             |                                                    |                                      |                                        |                                       |                           |                               |                                                    |  |   |

Notes: \*This concept embodies improvements in this function.  
\*\*Denotes potential operating or safety problem.

# Concept 31a: SW COUPLER POSITIONING DEVICE

Primary Bibliography Reference No.: 31

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------------------------|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 517                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td colspan="2"><b>Compatibility with AAR Type "E" Coupler:</b></td> <td rowspan="5" style="vertical-align: top; padding-left: 10px;">                     Hydraulic master-slave type (for existing cars);<br/>                     Automatic positioning through hydraulic master-slave system.                 </td> </tr> <tr> <td style="width: 40%;">1. Can be added to Type "E"</td> <td style="width: 10%; text-align: center;">X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                                                                                                                                                                                                                    | <b>Compatibility with AAR Type "E" Coupler:</b>                                                                  |  | Hydraulic master-slave type (for existing cars);<br>Automatic positioning through hydraulic master-slave system. | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| <b>Compatibility with AAR Type "E" Coupler:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                    | Hydraulic master-slave type (for existing cars);<br>Automatic positioning through hydraulic master-slave system. |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | X                                                                                                                                                                                                                                                                                                                  |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| <b>Pertinent Functions</b><br>IAI.<br>IAZ.<br>IASa.<br>IASb.<br>IASc.<br>IB1.<br>IB2.<br>IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| <b>Pertinent Functions</b><br>IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>IIC1.<br>IIC2.<br>*IICJ.<br>*IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>- Truck bolster movement transmitted to hydraulic cylinder "master" through flexible hose to a "slave" hydraulic cylinder to move coupler head.</li> <li>** May be difficult to position manually.</li> <li>- Would eliminate estimated 90% of coupler bypasses.</li> </ul> |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| <b>Pertinent Functions</b><br>IIIA1.<br>IIIA2.<br>IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIIB1.<br>IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |
| <b>Pertinent Functions</b><br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>*IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | See Bibliography Reference Number 8.                                                                                                                                                                                                                                                                               |                                                                                                                  |  |                                                                                                                  |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 31b: SW COUPLER POSITIONING DEVICE

Primary Bibliography Reference No.: 31

|                                                                                                                                                                                                                                                                                                                                           |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------|---------|--------------------------------------|--------|---------------------------------------|--------|-------------------------------|---------------------------------------------|---------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 517                                                                                                                                                                                                                                                                                                           |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Description of Concept                                                                                                                                                                                                                                                                                                                    |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p>Hydraulic direct guided 136" coupler with wide mouth swing draft sill (for new construction); Automatic positioning through hydraulic direct guiding of long coupler.</p>                                                                                                                                                              |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p>Compatibility with AAR Type "E" Coupler:</p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |        | 1. Can be added to Type "E" | X       | 2. Requires modification of Type "E" |        | 3. Requires head adapter for Type "E" |        | 4. Incompatible with Type "E" |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                               | X      |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                      |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                             |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p>Pertinent Functions</p> <table border="1"> <tr><td>IA1.</td></tr> <tr><td>IA2.</td></tr> <tr><td>IA3a.</td></tr> <tr><td>IA3b.</td></tr> <tr><td>IA3c.</td></tr> <tr><td>IB1.</td></tr> <tr><td>IB2.</td></tr> <tr><td>IB3.</td></tr> </table>                                                                                         | IA1.   | IA2.                        | IA3a.   | IA3b.                                | IA3c.  | IB1.                                  | IB2.   | IB3.                          |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IA1.                                                                                                                                                                                                                                                                                                                                      |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IA2.                                                                                                                                                                                                                                                                                                                                      |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IA3a.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IA3b.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IA3c.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IB1.                                                                                                                                                                                                                                                                                                                                      |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IB2.                                                                                                                                                                                                                                                                                                                                      |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IB3.                                                                                                                                                                                                                                                                                                                                      |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                 |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p>Pertinent Functions</p> <table border="1"> <tr><td>IIA1.</td></tr> <tr><td>IIA2.</td></tr> <tr><td>IIA3.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> <tr><td>IIB3.</td></tr> <tr><td>IIB4.</td></tr> <tr><td>IIC1.</td></tr> <tr><td>* IIC2.</td></tr> <tr><td>* IIC3.</td></tr> <tr><td>* IID.</td></tr> </table>       | IIA1.  | IIA2.                       | IIA3.   | IIB1.                                | IIB2.  | IIB3.                                 | IIB4.  | IIC1.                         | * IIC2.                                     | * IIC3. | * IID. | <ul style="list-style-type: none"> <li>- Two hydraulic cylinders at outer edge of truck bolster directly move the coupler shank, simple system should be very reliable.</li> <li>- 136" coupler length reduces contour angling (would need "F" type locking head).</li> <li>- Would eliminate approximately 90% of coupler bypasses.</li> <li>** Heavy swinging draft sill would be very difficult to position manually (if required to mate with a non-equipped car).</li> </ul> |
| IIA1.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIA2.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIA3.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIB1.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIB2.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIB3.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIB4.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIC1.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| * IIC2.                                                                                                                                                                                                                                                                                                                                   |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| * IIC3.                                                                                                                                                                                                                                                                                                                                   |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| * IID.                                                                                                                                                                                                                                                                                                                                    |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                              |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p>Pertinent Functions</p> <table border="1"> <tr><td>IIIA1.</td></tr> <tr><td>IIIA2.</td></tr> <tr><td>IIIA3a.</td></tr> <tr><td>IIIA3b.</td></tr> <tr><td>IIIA4.</td></tr> <tr><td>IIIB1.</td></tr> <tr><td>IIIB2.</td></tr> </table>                                                                                                   | IIIA1. | IIIA2.                      | IIIA3a. | IIIA3b.                              | IIIA4. | IIIB1.                                | IIIB2. |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIIA1.                                                                                                                                                                                                                                                                                                                                    |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIIA2.                                                                                                                                                                                                                                                                                                                                    |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                   |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                   |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIIA4.                                                                                                                                                                                                                                                                                                                                    |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIIB1.                                                                                                                                                                                                                                                                                                                                    |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IIIB2.                                                                                                                                                                                                                                                                                                                                    |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <p>Pertinent Functions</p> <table border="1"> <tr><td>IVA1.</td></tr> <tr><td>IVA2.</td></tr> <tr><td>IVB1.</td></tr> <tr><td>IVB3.</td></tr> <tr><td>IVB4.</td></tr> <tr><td>IVB5.</td></tr> <tr><td>IVB6.</td></tr> <tr><td>* IVC.</td></tr> </table>                                                                                   | IVA1.  | IVA2.                       | IVB1.   | IVB3.                                | IVB4.  | IVB5.                                 | IVB6.  | * IVC.                        | <p>See Bibliography Reference Number 8.</p> |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IVA1.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IVA2.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IVB1.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IVB3.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IVB4.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IVB5.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| IVB6.                                                                                                                                                                                                                                                                                                                                     |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| * IVC.                                                                                                                                                                                                                                                                                                                                    |        |                             |         |                                      |        |                                       |        |                               |                                             |         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 33: EUROCOPPLER 68

## Primary Bibliography Reference No.: 33

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--|--------------------------------------|--|---------------------------------------|--|-------------------------------|---|
| Related Reference Number(s) 46, 301, 303, 308, 309                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
| <b>Description of Concept</b><br>Integral, rigid coupler with automatic air connection and automatic operation of air valves;<br>Semi-rigid, open faced, spread wing, hinged hook type with positive locking and reduced free slack;<br>flexible pull clutch (air cylinder operated) releases wedge lock to allow hinged locking hook to be<br>forced open by slant rear edge of rating coupler;<br>Hinged environmental cover is wedged open at coupling;<br>Round electrical connector with pin/socket mating. |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
| <b>Compatibility with AAR Type "E" Coupler:</b> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td></td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td align="center">X</td> </tr> </table>                                                                                                                                                         |                                                                                                                                                                                                                                                                                     | 1. Can be added to Type "E" |  | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" | X |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | X                                                                                                                                                                                                                                                                                   |                             |  |                                      |  |                                       |  |                               |   |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
| <b>Pertinent Functions</b><br>* IA1.<br>* IA2.<br>* IA3a.<br>IA3b.<br>IA3c.<br>* IB1.<br>* IB2.<br>* IB3.                                                                                                                                                                                                                                                                                                                                                                                                        | ** Air connection depends on rubber compression held by coupler locking hook which has slack of at least 0.04" in all directions.<br><br>** Electric solenoid operation of air valve subject to possible malfunction from rust or contamination.                                    |                             |  |                                      |  |                                       |  |                               |   |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
| <b>Pertinent Functions</b><br>IA1A.<br>IA2.<br>* IA3.<br>IB1.<br>* IB2.<br>* IB3.<br>* IB4.<br>IC1.<br>* IC2.<br>IC3.<br>ID.                                                                                                                                                                                                                                                                                                                                                                                     | ** Spring loaded movable hook locks on outside of rear slant face of fixed knuckle (depending on rust or grime build-up, bounce-back may occur before final locking).<br><br>** Machined movable pieces and mating faces gives approximately 0.04" free slack (complicated system). |                             |  |                                      |  |                                       |  |                               |   |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
| <b>Pertinent Functions</b><br>IA1A.<br>IA2.<br>* IA3a.<br>IA3b.<br>IA4.<br>IB1.<br>IB2.                                                                                                                                                                                                                                                                                                                                                                                                                          | - Air cylinder offers good remote uncoupling capability.<br><br>** Electric solenoid not yet successful indicates excessive force may be required to release wedges for uncoupling.                                                                                                 |                             |  |                                      |  |                                       |  |                               |   |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                     |                             |  |                                      |  |                                       |  |                               |   |
| <b>Pertinent Functions</b><br>VA1.<br>VA2.<br>* VB1.<br>VB3.<br>* VB4.<br>VB5.<br>* VB6.<br>* VC.                                                                                                                                                                                                                                                                                                                                                                                                                | ** Cover/wedge design needs careful review for adequacy against damage and malfunction.<br><br>** Round connector limits number of circuits.<br><br>** Rigid pin/socket type contacts subject to damage and malfunction due to free slack movements of coupler.                     |                             |  |                                      |  |                                       |  |                               |   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 36: BRITISH WEDGLOCK COUPLER

Primary Bibliography Reference No.: 36

|                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Description of Concept                                                                                 | <p>Rigid, flat faced, hinged hook with locking from camshaft driven wedge;<br/>Integral automatic air connection and automatic operation of valve (international only).<br/>Electrical signal from CPB operates electro-pneumatic switch so air rotates a camshaft for unlocking coupler;<br/>Environmental cover uses nylon hinges;<br/>Butt type, spring loaded, brass contacts in electrical connector;<br/>Automatic air connection and locking hook always open.</p> |
| Compatibility with AAR Type "E" Coupler:                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 1. Can be added to Type "E"                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 2. Requires modification of Type "E"                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 3. Requires head adapter for Type "E"                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 4. Incompatible with Type "E"                                                                          | X                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Pertinent Functions                                                                                    | <p>** Air connection depends on rubber compression held only by coupler locking.<br/>- Air valves operated by air or manual camshaft (same operation as automatic coupler locking) should achieve very reliable operation.</p>                                                                                                                                                                                                                                            |
| *IA1.<br>*IA2.<br>*IA3a.<br>IA3b.<br>IA3c.<br>*IB1.<br>*IB2.<br>*IB3.                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Pertinent Functions                                                                                    | <p>** Light duty rapid transit design.<br/>** No automatic locking unless positive action from <u>both</u> air and electrical signals.<br/>- Hook wear is taken up by camlock wedge action.<br/>- Positive locking from wedge retained even with subsequent air loss.</p>                                                                                                                                                                                                 |
| *IIA1.<br>*IIA2.<br>*IIA3.<br>*IIB1.<br>*IIB2.<br>*IIB3.<br>*IIB4.<br>IIC1.<br>*IIC2.<br>IIC3.<br>IID. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Pertinent Functions                                                                                    | <p>- Camshaft unlock would give positive rotating (leveraged) control of uncoupling.</p>                                                                                                                                                                                                                                                                                                                                                                                  |
| *IIIA1.<br>*IIIA2.<br>*IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIIB1.<br>IIIB2.                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Pertinent Functions                                                                                    | <p>- Free movement (and reliability) of environmental cover as improved by non-binding hinges.<br/>** Brass contacts (not silver faced) are subject to low contact reliability with use.<br/>- Improved safety.</p>                                                                                                                                                                                                                                                       |
| *IVA1.<br>*IVA2.<br>*IVB1.<br>*IVB3.<br>*IVB4.<br>*IVB5.<br>*IVB6.<br>*IVC.                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

Notes: \*This concept embodies improvements in this function.  
\*\*Denotes potential operating or safety problem.

# Concept 41a: HOLLAND POSITIONING DEVICE

Primary Bibliography Reference No.: 41

|                                                                                                                                                                                                                                                                                                                                           |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 512                                                                                                                                                                                                                                                                                                           |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                    |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| <p>Compatibility with AAR Type "E" Coupler:</p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                         | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                               | X                                                                                                       |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                      |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                             |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| Direct positioning control from trucks through rod-lever-cable linkage.                                                                                                                                                                                                                                                                   |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                                      |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                                      |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                      |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                      |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                      |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                 |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIB1.                                                                                                                                                                                                                                                                                                                                     | - Simple, direct connected (rod-lever-cable) positioning of coupler from trucks (permanent connection). |                             |   |                                      |  |                                       |  |                               |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIB3.                                                                                                                                                                                                                                                                                                                                     | ** User report of rapid deterioration from normal wear and vibration.                                   |                             |   |                                      |  |                                       |  |                               |  |
| IIB4.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIC1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIC2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| * IIC3.                                                                                                                                                                                                                                                                                                                                   |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IID.                                                                                                                                                                                                                                                                                                                                      |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                              |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIIA1.                                                                                                                                                                                                                                                                                                                                    |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                    |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                   |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                   |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                    |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIIB1.                                                                                                                                                                                                                                                                                                                                    |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IIIB2.                                                                                                                                                                                                                                                                                                                                    |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IVB1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IVB3.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IVB4.                                                                                                                                                                                                                                                                                                                                     | - Improved safety by reducing bypass probability.                                                       |                             |   |                                      |  |                                       |  |                               |  |
| IVB5.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| IVB6.                                                                                                                                                                                                                                                                                                                                     |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |
| * IVC.                                                                                                                                                                                                                                                                                                                                    |                                                                                                         |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 41b: EVANS CENTERING DEVICE

Primary Bibliography Reference No.: 41

|                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------|-----------------------------|---------|--------------------------------------|--------|---------------------------------------|-------|-------------------------------|-------|-------------------------------------------------------------------------------------|------|----------------------------------------------------------------------|
| Related Reference Number(s) 512                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td colspan="2">Compatibility with AAR Type "E" Coupler:</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td align="center">X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td align="center">X</td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> | Compatibility with AAR Type "E" Coupler: |        | 1. Can be added to Type "E" | X       | 2. Requires modification of Type "E" | X      | 3. Requires head adapter for Type "E" |       | 4. Incompatible with Type "E" |       | <p>Direct centering by opposing horizontal spring below shank and bell housing.</p> |      |                                                                      |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                         |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                      | X                                        |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                             | X                                        |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td>Pertinent Functions</td></tr> <tr><td>IA1.</td></tr> <tr><td>IA2.</td></tr> <tr><td>IA3a.</td></tr> <tr><td>IA3b.</td></tr> <tr><td>IA3c.</td></tr> <tr><td>IB1.</td></tr> <tr><td>IB2.</td></tr> <tr><td>IB3.</td></tr> <tr><td> </td></tr> <tr><td> </td></tr> </table>                                                                                              | Pertinent Functions                      | IA1.   | IA2.                        | IA3a.   | IA3b.                                | IA3c.  | IB1.                                  | IB2.  | IB3.                          |       |                                                                                     |      |                                                                      |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                        |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIA1.</td></tr> <tr><td>IIA2.</td></tr> <tr><td>IIA3.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> <tr><td>IIB3.</td></tr> <tr><td>IIB4.</td></tr> <tr><td>*IIC1.</td></tr> <tr><td>IIC2.</td></tr> <tr><td>IIC3.</td></tr> <tr><td>IID.</td></tr> </table>                                                         | Pertinent Functions                      | IIA1.  | IIA2.                       | IIA3.   | IIB1.                                | IIB2.  | IIB3.                                 | IIB4. | *IIC1.                        | IIC2. | IIC3.                                                                               | IID. | <p>** Manual disengagement difficult unless coupler is centered.</p> |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIB3.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIB4.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| *IIC1.                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IID.                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                     |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIIA1.</td></tr> <tr><td>IIIA2.</td></tr> <tr><td>IIIA3a.</td></tr> <tr><td>IIIA3b.</td></tr> <tr><td>IIIA4.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> </table>                                                                                                                                                  | Pertinent Functions                      | IIIA1. | IIIA2.                      | IIIA3a. | IIIA3b.                              | IIIA4. | IIB1.                                 | IIB2. |                               |       |                                                                                     |      |                                                                      |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td>Pertinent Functions</td></tr> <tr><td>IVA1.</td></tr> <tr><td>IVA2.</td></tr> <tr><td>IVB1.</td></tr> <tr><td>IVB3.</td></tr> <tr><td>IVB4.</td></tr> <tr><td>IVB5.</td></tr> <tr><td>IVB6.</td></tr> <tr><td>IVC.</td></tr> </table>                                                                                                                                  | Pertinent Functions                      | IVA1.  | IVA2.                       | IVB1.   | IVB3.                                | IVB4.  | IVB5.                                 | IVB6. | IVC.                          |       |                                                                                     |      |                                                                      |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IVB1.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IVB3.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IVB4.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IVB6.                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |
| IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |        |                                       |       |                               |       |                                                                                     |      |                                                                      |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 41c: EVANS POSITIONING DEVICE

Primary Bibliography Reference No.: 41

|                                                                                                                                                                                                                                                                                                                                            |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------------|---|--------------------------------------|---|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 512                                                                                                                                                                                                                                                                                                            |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                     |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| <p>Compatibility with AAR Type "E" Coupler:</p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td>X</td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                   | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" | X | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                | X                                                                                                 |                             |   |                                      |   |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                       | X                                                                                                 |                             |   |                                      |   |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                              |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| Direct positioning control from trucks through a double-acting side spring moving a lateral spring loaded shank carrier.                                                                                                                                                                                                                   |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                 |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                        |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                  |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                        |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IB4.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IC1.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IC2.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| * IC3.                                                                                                                                                                                                                                                                                                                                     | ** Reliability suspect due to high leverage movements needed under high friction load conditions. |                             |   |                                      |   |                                       |  |                               |  |
| IC4.                                                                                                                                                                                                                                                                                                                                       |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                               |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                        |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIIA1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                    |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                    |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                     |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIIB1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IIIB2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                        |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IVB1.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IVB3.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IVB4.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IVB5.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| IVB6.                                                                                                                                                                                                                                                                                                                                      |                                                                                                   |                             |   |                                      |   |                                       |  |                               |  |
| * IVB7.                                                                                                                                                                                                                                                                                                                                    | See Bibliography Reference 41a Category IV.                                                       |                             |   |                                      |   |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

Concept 41d: STANRAY CENTERING DEVICE

Primary Bibliography Reference No.: 41

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--|-----------------------------|---|--------------------------------------|---|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 446, 507                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td colspan="2">Compatibility with AAR Type "E" Coupler:</td> </tr> <tr> <td style="width: 50%;">1. Can be added to Type "E"</td> <td style="width: 50%; text-align: center;">X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td style="text-align: center;">X</td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                                                              | Compatibility with AAR Type "E" Coupler: |  | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" | X | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | X                                                                                                                                                            |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | X                                                                                                                                                            |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Single coil spring type.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions:<br>IA1.<br>IA2.<br>IA3a.<br>IA3b.<br>IA3c.<br>IB1.<br>IB2.<br>IB3.                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions:<br>IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>* IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                                                                                                                                                                                                                                                                                                                                   | - For use on standard or high-cube cars.<br>- Low maintenance and inoperability rate.<br>** Some problem to manually disengage if coupler not on centerline. |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions:<br>IIIA1.<br>IIIA2.<br>IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIIB1.<br>IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions:<br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                              |                                          |  |                             |   |                                      |   |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 41e: STANRAY CENTERING DEVICE

Primary Bibliography Reference No.: 41

|                                                                                                                                                                                                                                                                                                                                                                    |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------------------|--------|-----------------------------|---------|--------------------------------------|--------|---------------------------------------|--------|-------------------------------|-------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 446, 507                                                                                                                                                                                                                                                                                                                               |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| Description of Concept                                                                                                                                                                                                                                                                                                                                             |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| <table border="1"> <tr> <td colspan="2">Compatibility with AA Type "E" Coupler:</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td>X</td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                     | Compatibility with AA Type "E" Coupler: |        | 1. Can be added to Type "E" | X       | 2. Requires modification of Type "E" | X      | 3. Requires head adapter for Type "E" |        | 4. Incompatible with Type "E" |       |      |                                                                                                                                                                                                            |
| Compatibility with AA Type "E" Coupler:                                                                                                                                                                                                                                                                                                                            |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                        | X                   |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                               | X                   |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                      |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| Double leaf spring type.                                                                                                                                                                                                                                                                                                                                           |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                         |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IA1.</td></tr> <tr><td>IA2.</td></tr> <tr><td>IA3a.</td></tr> <tr><td>IA3b.</td></tr> <tr><td>IA3c.</td></tr> <tr><td>IB1.</td></tr> <tr><td>IB2.</td></tr> <tr><td>IB3.</td></tr> <tr><td> </td></tr> <tr><td> </td></tr> </table>                                                               | Pertinent Functions | IA1.                                    | IA2.   | IA3a.                       | IA3b.   | IA3c.                                | IB1.   | IB2.                                  | IB3.   |                               |       |      |                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IA1.                                                                                                                                                                                                                                                                                                                                                               |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IA2.                                                                                                                                                                                                                                                                                                                                                               |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IA3a.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IA3b.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IA3c.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IB1.                                                                                                                                                                                                                                                                                                                                                               |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IB2.                                                                                                                                                                                                                                                                                                                                                               |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IB3.                                                                                                                                                                                                                                                                                                                                                               |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
|                                                                                                                                                                                                                                                                                                                                                                    |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
|                                                                                                                                                                                                                                                                                                                                                                    |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                          |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIA1.</td></tr> <tr><td>IIA2.</td></tr> <tr><td>IIA3.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> <tr><td>IIB3.</td></tr> <tr><td>IIB4.</td></tr> <tr><td>*IIC1.</td></tr> <tr><td>IIC2.</td></tr> <tr><td>IIC3.</td></tr> <tr><td>IID.</td></tr> </table>                          | Pertinent Functions | IIA1.                                   | IIA2.  | IIA3.                       | IIB1.   | IIB2.                                | IIB3.  | IIB4.                                 | *IIC1. | IIC2.                         | IIC3. | IID. | <p>** High damage susceptibility when used on high-cube cars.</p> <p>** Relatively high maintenance and inoperability rate.</p> <p>** Some problem to manually disengage if coupler not on centerline.</p> |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIA1.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIA2.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIA3.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIB1.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIB2.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIB3.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIB4.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| *IIC1.                                                                                                                                                                                                                                                                                                                                                             |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIC2.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIC3.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IID.                                                                                                                                                                                                                                                                                                                                                               |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                       |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIIA1.</td></tr> <tr><td>IIIA2.</td></tr> <tr><td>IIIA3a.</td></tr> <tr><td>IIIA3b.</td></tr> <tr><td>IIIA4.</td></tr> <tr><td>IIIB1.</td></tr> <tr><td>IIIB2.</td></tr> </table>                                                                                                                 | Pertinent Functions | IIIA1.                                  | IIIA2. | IIIA3a.                     | IIIA3b. | IIIA4.                               | IIIB1. | IIIB2.                                |        |                               |       |      |                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                             |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                             |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                            |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                            |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                             |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIIB1.                                                                                                                                                                                                                                                                                                                                                             |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IIIB2.                                                                                                                                                                                                                                                                                                                                                             |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IVAI.</td></tr> <tr><td>IVAZ.</td></tr> <tr><td>IVB1.</td></tr> <tr><td>IVB3.</td></tr> <tr><td>IVB4.</td></tr> <tr><td>IVB5.</td></tr> <tr><td>IVB6.</td></tr> <tr><td>IVC.</td></tr> </table>                                                                                                   | Pertinent Functions | IVAI.                                   | IVAZ.  | IVB1.                       | IVB3.   | IVB4.                                | IVB5.  | IVB6.                                 | IVC.   |                               |       |      |                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IVAI.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IVAZ.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IVB1.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IVB3.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IVB4.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IVB5.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IVB6.                                                                                                                                                                                                                                                                                                                                                              |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |
| IVC.                                                                                                                                                                                                                                                                                                                                                               |                     |                                         |        |                             |         |                                      |        |                                       |        |                               |       |      |                                                                                                                                                                                                            |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 41f: STANRAY CENTERING DEVICE

Primary Bibliography Reference No.: 41

|                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------|--|-------------------------|-----------------------------|---|--------------------------------------|---|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 446, 507                                                                                                                                                                                                                                                                                                                                                                             |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| <table border="1"> <tr> <td colspan="2">Compatibility with AAR Type "E" Coupler:</td> <td rowspan="5">Double coil spring type</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td>X</td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                   | Compatibility with AAR Type "E" Coupler: |  | Double coil spring type | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" | X | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                         |                                                                                   | Double coil spring type                  |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                      | X                                                                                 |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                             | X                                                                                 |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                       |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                        |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                            | ** Limited application for mid-size cars.                                         |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIB3.                                                                                                                                                                                                                                                                                                                                                                                                            | ** Damage problems and higher cost caused manufacturer to remove from production. |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIB4.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| *IIC1.                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IID.                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                     |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIIB1.                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IVB1.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IVB3.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IVB4.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IVB6.                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |
| IVC.                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                   |                                          |  |                         |                             |   |                                      |   |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

Concept 41q: STANRAY CENTERING DEVICE

Primary Bibliography Reference No.: 41

|                                            |   |
|--------------------------------------------|---|
| Related Reference Number(s) 446, 507       |   |
| Description of Concept                     |   |
| Swing type                                 |   |
| Compatibility with AAL Type "E" Coupler:   |   |
| 1. Can be added to Type "E"                | X |
| 2. Requires modification of Type "E"       | X |
| 3. Requires head adapter for Type "E"      |   |
| 4. Incompatible with Type "E"              |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM |   |
| Pertinent Functions                        |   |
| IA1.                                       |   |
| IA2.                                       |   |
| IA3.                                       |   |
| IA4.                                       |   |
| IA5.                                       |   |
| IA6.                                       |   |
| IA7.                                       |   |
| IA8.                                       |   |
| IA9.                                       |   |
| IA10.                                      |   |
| IA11.                                      |   |
| IA12.                                      |   |
| IA13.                                      |   |
| IA14.                                      |   |
| IA15.                                      |   |
| IA16.                                      |   |
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# Concept 45a: SNCF DOUBLE-LIP SEAL AIR CONNECTOR

Primary Bibliography Reference No.: 45

|                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
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| Related Reference Number(s)                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| Description of Concept                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>COMPATIBILITY WITH AAR Type "E" COUPLER:</p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td></td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td>X</td> </tr> </table> |                                                                                                                                                                                                                                                                                                                                                                          | 1. Can be added to Type "E" |  | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" | X |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                             | X                                                                                                                                                                                                                                                                                                                                                                        |                             |  |                                      |  |                                       |  |                               |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Pertinent Functions</p> <p>*IA1.</p> <p>*IA2.</p> <p>*IA3a.</p> <p>*IA3b.</p> <p>IA3c.</p> <p>*IB1.</p> <p>IB2.</p> <p>IB3.</p>                                                                                                                                                                                                        | <p>- Double-lip (concentric seals) would hold sufficient seal for both vacuum and pressure.</p> <p>** Air valves operated by vacuum differential (approximately 2 psi) applied to quick release valves in each car for simultaneous bleed of air lines for switching. (Holding the required vacuum and quick vacuum differentials doubtful for a long train system.)</p> |                             |  |                                      |  |                                       |  |                               |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Pertinent Functions</p> <p>IIA1.</p> <p>IIA2.</p> <p>IIA3.</p> <p>IIB1.</p> <p>IIB2.</p> <p>IIB3.</p> <p>IIB4.</p> <p>IIC1.</p> <p>IIC2.</p> <p>IIC3.</p> <p>IID.</p>                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Pertinent Functions</p> <p>IIIA1.</p> <p>IIIA2.</p> <p>IIIA3a.</p> <p>IIIA3b.</p> <p>IIIA4.</p> <p>IIB1.</p> <p>IIB2.</p>                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Pertinent Functions</p> <p>IVA1.</p> <p>IVA2.</p> <p>IVB1.</p> <p>IVB3.</p> <p>IVB4.</p> <p>IVB5.</p> <p>IVB6.</p> <p>IVC.</p>                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 45b: SNCF VACUUM BRAKE CONTROL SYSTEM

Primary Bibliography Reference No.: 45

|                                                                                                                                                                                                                                                                                                                                           |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                               |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                    |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| <p>Compatibility with AAR Type "E" Coupler:</p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                              | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                               | X                                                                            |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                     |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                             |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| Centrally operated brake release of all cars through quick release valves operated on approximately 2 psi vacuum.                                                                                                                                                                                                                         |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                     |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                     |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                     |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                 |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                     |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                     |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                     |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IB4.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IC1.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IC2.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IC3.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IC5.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                              |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIIA1.                                                                                                                                                                                                                                                                                                                                    |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                    |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                   |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                   |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                    |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIIB1.                                                                                                                                                                                                                                                                                                                                    |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IIIB2.                                                                                                                                                                                                                                                                                                                                    |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                     |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                       |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| * IVA1.                                                                                                                                                                                                                                                                                                                                   |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                     | - System to bleed all cars simultaneously in preparation for hump switching. |                             |   |                                      |  |                                       |  |                               |  |
| VB1.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| VB2.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| VB3.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| VB4.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| VB5.                                                                                                                                                                                                                                                                                                                                      |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| * VVB6.                                                                                                                                                                                                                                                                                                                                   |                                                                              |                             |   |                                      |  |                                       |  |                               |  |
| VC.                                                                                                                                                                                                                                                                                                                                       |                                                                              |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 450: KROFFS ELECTRICAL CONNECTOR

Primary Bibliography Reference No.: 45

Related Reference Number(s)

Description of Concept

## Compatibility with AIR Type "T" Coupler

1. Can be added to Type "T"
2. Requires modification of Type "T"
3. Requires head adapter for Type "T"
4. Incompatible with Type "T"

## CATEGORY I IMPROVE GRAIN AIR LINE SYSTEM

Pertinent Functions

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

## CATEGORY II IMPROVE MECHANICAL COUPLING

Pertinent Functions

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

## CATEGORY III IMPROVE MECHANICAL COUPLING

Pertinent Functions

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

## CATEGORY IV IMPROVE GENERAL SYSTEMS

Pertinent Functions

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

- \*\* Contact life satisfactory only when connection was made without load.
- \*\* Environmental tests over electrical contacts not totally successful.

Notes: \*This concept embodies improvements in this and the  
 \*\*Denotes potential operating or safety problem.

# Concept 47a: SIMPLIFIED U.I.C. COUPLER - FRENCH

Primary Bibliography Reference No.: 47

|                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------|--|---------------------------------------|--|-------------------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                              |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| Description of Concept                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| <p>Compatibility with AA Type "E" Coupler:</p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td></td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td>X</td> </tr> </table> | 1. Can be added to Type "E"                                                                                                       |  | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" | X | <p>Sliding rods release uncoupling mechanism;<br/>Locking bolts drop into place ready for automatic recoupling;</p> <p>Semi-free, open-face, spread claw, fixed knuckle, discontinuous coupling movement modified Willison.</p> |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                              |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                            | X                                                                                                                                 |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                               |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                      |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA1.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA2.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA3.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA4.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA5.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA6.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA7.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA8.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA9.                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IA10.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                      | (Interchange with Willison)                                                                                                       |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA1.                                                                                                                                                                                                                                                                                                                                    | - Lateral gathering = 17.4" total (4.35 x standard) - however, is not balanced around centerline.                                 |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA2.                                                                                                                                                                                                                                                                                                                                    | ** Discontinuous lateral coupling movement (0.8") would tend to create damage problems for integral air or electrical connectors. |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA3.                                                                                                                                                                                                                                                                                                                                    | ** Coupler "blocking" occurs at coupling angle over 9° (a separate buidling horn would possibly correct).                         |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA4.                                                                                                                                                                                                                                                                                                                                    | - Vertical and horizontal centering with direct attached springs (two vertical on each side, two horizontal outside of shank).    |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA5.                                                                                                                                                                                                                                                                                                                                    | ** Centering disengagement device is damage prone.                                                                                |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA6.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA7.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA8.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA9.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIA10.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                             |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                      |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA1.                                                                                                                                                                                                                                                                                                                                   | - Uncoupling in draft is possible up to approximately 8,800 lbs. draft force.                                                     |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA2.                                                                                                                                                                                                                                                                                                                                   | ** Corrosion or environmental build-up can prevent gravity drop of locking bolts.                                                 |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA3.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA4.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA5.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA6.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA7.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA8.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA9.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IIIA10.                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                      |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA1.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA2.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA3.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA4.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA5.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA6.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA7.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA8.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA9.                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |
| IVA10.                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                   |  |                                      |  |                                       |  |                               |   |                                                                                                                                                                                                                                 |

Notes: \*This concept embodies improvements in this function.  
\*\*Denotes potential operating or safety problem.

# Concept 47b: PENDULUM SELF CENTERING SYSTEM

Primary Bibliography Reference No.: 47

|                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|---|-------------------------------------------------------------|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| <p><u>Compatibility with AAR Type "E" Coupler:</u></p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> <td rowspan="4">Simplified U.I.C. coupler - pendulum self-centering system.</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                                                                                                                                                                             | 1. Can be added to Type "E"                                 | X | Simplified U.I.C. coupler - pendulum self-centering system. | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                       | X                                                                                                                                                                                                                                                                           | Simplified U.I.C. coupler - pendulum self-centering system. |   |                                                             |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| <p align="center"><b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b></p>                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| <p>Pertinent Functions</p> <p>IA1.</p> <p>IA2.</p> <p>IA3a.</p> <p>IA3b.</p> <p>IA3c.</p> <p>IB1.</p> <p>IB2.</p> <p>IB3.</p>                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| <p align="center"><b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b></p>                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| <p>Pertinent Functions</p> <p>IIA1.</p> <p>IIA2.</p> <p>IIA3.</p> <p>IIB1.</p> <p>IIB2.</p> <p>IIB3.</p> <p>IIB4.</p> <p>*IIC1.</p> <p>IIC2.</p> <p>IIC3.</p> <p>IID.</p>                                                                                                                                                                                                                                                         | <p>- Shank rides on a swinging bench supported on each side by hanging bars - gives pendulum or gravity centering.</p> <p>** Potential problem of damaging harmonic swings under lateral vibration.</p> <p>** Safety problem in hand centering cars coupled on a curve.</p> |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| <p align="center"><b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b></p>                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| <p>Pertinent Functions</p> <p>IIIA1.</p> <p>IIIA2.</p> <p>IIIA3a.</p> <p>IIIA3b.</p> <p>IIIA4.</p> <p>IIIB1.</p> <p>IIIB2.</p>                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| <p align="center"><b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b></p>                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |
| <p>Pertinent Functions</p> <p>IVA1.</p> <p>IVA2.</p> <p>IVB1.</p> <p>IVB3.</p> <p>IVB4.</p> <p>IVB5.</p> <p>IVB6.</p> <p>IVC.</p>                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                             |                                                             |   |                                                             |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 52: TYPE "F" COUPLER WITH TOP SHELF

Primary Bibliography Reference No.: 52

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
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| Related Reference Number(s) 38, 54, 405, 455                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| <p><u>Compatibility with AAR Type "E" Coupler:</u></p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |      | 1. Can be added to Type "E" | X     | 2. Requires modification of Type "E" |       | 3. Requires head adapter for Type "E" |      | 4. Incompatible with Type "E" |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | X    |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| <p>Pertinent Functions</p> <table border="1"> <tr><td>FA1.</td></tr> <tr><td>FA2.</td></tr> <tr><td>FA3a.</td></tr> <tr><td>FA3b.</td></tr> <tr><td>FA3c.</td></tr> <tr><td>FA4.</td></tr> <tr><td>FA5.</td></tr> <tr><td>FA6.</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | FA1. | FA2.                        | FA3a. | FA3b.                                | FA3c. | FA4.                                  | FA5. | FA6.                          |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| <p>Pertinent Functions</p> <table border="1"> <tr><td>FA1.</td></tr> <tr><td>FA2.</td></tr> <tr><td>FA3.</td></tr> <tr><td>FA4.</td></tr> <tr><td>FA5.</td></tr> <tr><td>FA6.</td></tr> <tr><td>FA7.</td></tr> <tr><td>FA8.</td></tr> <tr><td>FA9.</td></tr> <tr><td>FA10.</td></tr> <tr><td>FA11.</td></tr> <tr><td>FA12.</td></tr> <tr><td>FA13.</td></tr> <tr><td>FA14.</td></tr> <tr><td>FA15.</td></tr> <tr><td>FA16.</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | FA1. | FA2.                        | FA3.  | FA4.                                 | FA5.  | FA6.                                  | FA7. | FA8.                          | FA9. | FA10. | FA11. | FA12. | FA13. | FA14. | FA15. | FA16. | <p>- Gives full vertical entrapment for mated "E" or "F" couplers.</p> |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA7.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA8.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA9.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA10.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA11.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA12.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA13.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA14.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA15.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA16.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| <p>Pertinent Functions</p> <table border="1"> <tr><td>FA1.</td></tr> <tr><td>FA2.</td></tr> <tr><td>FA3a.</td></tr> <tr><td>FA3b.</td></tr> <tr><td>FA4.</td></tr> <tr><td>FA5.</td></tr> <tr><td>FA6.</td></tr> <tr><td>FA7.</td></tr> <tr><td>FA8.</td></tr> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | FA1. | FA2.                        | FA3a. | FA3b.                                | FA4.  | FA5.                                  | FA6. | FA7.                          | FA8. |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA7.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA8.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| <p>Pertinent Functions</p> <table border="1"> <tr><td>FA1.</td></tr> <tr><td>FA2.</td></tr> <tr><td>FA3.</td></tr> <tr><td>FA4.</td></tr> <tr><td>FA5.</td></tr> <tr><td>FA6.</td></tr> <tr><td>FA7.</td></tr> <tr><td>FA8.</td></tr> <tr><td>FA9.</td></tr> <tr><td>FA10.</td></tr> <tr><td>FA11.</td></tr> <tr><td>FA12.</td></tr> <tr><td>FA13.</td></tr> <tr><td>FA14.</td></tr> <tr><td>FA15.</td></tr> <tr><td>FA16.</td></tr> <tr><td>FA17.</td></tr> <tr><td>FA18.</td></tr> <tr><td>FA19.</td></tr> <tr><td>FA20.</td></tr> <tr><td>FA21.</td></tr> <tr><td>FA22.</td></tr> <tr><td>FA23.</td></tr> <tr><td>FA24.</td></tr> <tr><td>FA25.</td></tr> <tr><td>FA26.</td></tr> <tr><td>FA27.</td></tr> <tr><td>FA28.</td></tr> <tr><td>FA29.</td></tr> <tr><td>FA30.</td></tr> <tr><td>FA31.</td></tr> <tr><td>FA32.</td></tr> <tr><td>FA33.</td></tr> <tr><td>FA34.</td></tr> <tr><td>FA35.</td></tr> <tr><td>FA36.</td></tr> <tr><td>FA37.</td></tr> <tr><td>FA38.</td></tr> <tr><td>FA39.</td></tr> <tr><td>FA40.</td></tr> <tr><td>FA41.</td></tr> <tr><td>FA42.</td></tr> <tr><td>FA43.</td></tr> <tr><td>FA44.</td></tr> <tr><td>FA45.</td></tr> <tr><td>FA46.</td></tr> <tr><td>FA47.</td></tr> <tr><td>FA48.</td></tr> <tr><td>FA49.</td></tr> <tr><td>FA50.</td></tr> <tr><td>FA51.</td></tr> <tr><td>FA52.</td></tr> <tr><td>FA53.</td></tr> <tr><td>FA54.</td></tr> <tr><td>FA55.</td></tr> <tr><td>FA56.</td></tr> <tr><td>FA57.</td></tr> <tr><td>FA58.</td></tr> <tr><td>FA59.</td></tr> <tr><td>FA60.</td></tr> <tr><td>FA61.</td></tr> <tr><td>FA62.</td></tr> <tr><td>FA63.</td></tr> <tr><td>FA64.</td></tr> <tr><td>FA65.</td></tr> <tr><td>FA66.</td></tr> <tr><td>FA67.</td></tr> <tr><td>FA68.</td></tr> <tr><td>FA69.</td></tr> <tr><td>FA70.</td></tr> <tr><td>FA71.</td></tr> <tr><td>FA72.</td></tr> <tr><td>FA73.</td></tr> <tr><td>FA74.</td></tr> <tr><td>FA75.</td></tr> <tr><td>FA76.</td></tr> <tr><td>FA77.</td></tr> <tr><td>FA78.</td></tr> <tr><td>FA79.</td></tr> <tr><td>FA80.</td></tr> <tr><td>FA81.</td></tr> <tr><td>FA82.</td></tr> <tr><td>FA83.</td></tr> <tr><td>FA84.</td></tr> <tr><td>FA85.</td></tr> <tr><td>FA86.</td></tr> <tr><td>FA87.</td></tr> <tr><td>FA88.</td></tr> <tr><td>FA89.</td></tr> <tr><td>FA90.</td></tr> <tr><td>FA91.</td></tr> <tr><td>FA92.</td></tr> <tr><td>FA93.</td></tr> <tr><td>FA94.</td></tr> <tr><td>FA95.</td></tr> <tr><td>FA96.</td></tr> <tr><td>FA97.</td></tr> <tr><td>FA98.</td></tr> <tr><td>FA99.</td></tr> <tr><td>FA100.</td></tr> </table> | FA1. | FA2.                        | FA3.  | FA4.                                 | FA5.  | FA6.                                  | FA7. | FA8.                          | FA9. | FA10. | FA11. | FA12. | FA13. | FA14. | FA15. | FA16. | FA17.                                                                  | FA18. | FA19. | FA20. | FA21. | FA22. | FA23. | FA24. | FA25. | FA26. | FA27. | FA28. | FA29. | FA30. | FA31. | FA32. | FA33. | FA34. | FA35. | FA36. | FA37. | FA38. | FA39. | FA40. | FA41. | FA42. | FA43. | FA44. | FA45. | FA46. | FA47. | FA48. | FA49. | FA50. | FA51. | FA52. | FA53. | FA54. | FA55. | FA56. | FA57. | FA58. | FA59. | FA60. | FA61. | FA62. | FA63. | FA64. | FA65. | FA66. | FA67. | FA68. | FA69. | FA70. | FA71. | FA72. | FA73. | FA74. | FA75. | FA76. | FA77. | FA78. | FA79. | FA80. | FA81. | FA82. | FA83. | FA84. | FA85. | FA86. | FA87. | FA88. | FA89. | FA90. | FA91. | FA92. | FA93. | FA94. | FA95. | FA96. | FA97. | FA98. | FA99. | FA100. | <p>- Would reduce tank car punctures an estimated 60%.</p> <p>- Prevent vertical separation.</p> <p>** Still has possibility for high rupture probability (if subject to tank car impact) due to sharp interlocking lug.</p> |
| FA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA7.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA8.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA9.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA10.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA11.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA12.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA13.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA14.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA15.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA16.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA17.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA18.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA19.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA20.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA21.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA22.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA23.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA24.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA25.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA26.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA27.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA28.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA29.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA30.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA31.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA32.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA33.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA34.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA35.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA36.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA37.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA38.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA39.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA40.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA41.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA42.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA43.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA44.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA45.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA46.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA47.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA48.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA49.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA50.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA51.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA52.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA53.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA54.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA55.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA56.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA57.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA58.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA59.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA60.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA61.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA62.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA63.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA64.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA65.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA66.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA67.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA68.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA69.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA70.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA71.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA72.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA73.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA74.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA75.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA76.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA77.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA78.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA79.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA80.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA81.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA82.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA83.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA84.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA85.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA86.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA87.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA88.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA89.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA90.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA91.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA92.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA93.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA94.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA95.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA96.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA97.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA98.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA99.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |
| FA100.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |                             |       |                                      |       |                                       |      |                               |      |       |       |       |       |       |       |       |                                                                        |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |        |                                                                                                                                                                                                                              |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes notential operating or safety problem.

# Concept 54: TYPE "E" COUPLER WITH TOP AND BOTTOM SHELF

Primary Bibliography Reference No.: 54

|                                                                                                                                                                                                                                                                                                                                                                    |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------------|--------|-----------------------------|---------|--------------------------------------|--------|---------------------------------------|-------|------------------------------------------------------------------------|-------|------|-----------------------------------------------------------------|
| Related Reference Number(s) 38, 52, 405, 455                                                                                                                                                                                                                                                                                                                       |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| Description of Concept                                                                                                                                                                                                                                                                                                                                             |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| <table border="1"> <tr> <td colspan="2">Compatibility with AAR Type "E" Coupler:</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                     | Compatibility with AAR Type "E" Coupler: |        | 1. Can be added to Type "E" | X       | 2. Requires modification of Type "E" |        | 3. Requires head adapter for Type "E" |       | 4. Incompatible with Type "E"                                          |       |      |                                                                 |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                           |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                        | X                   |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                               |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                      |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                         |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IA1.</td></tr> <tr><td>IA2.</td></tr> <tr><td>IA3a.</td></tr> <tr><td>IA3b.</td></tr> <tr><td>IA3c.</td></tr> <tr><td>IB1.</td></tr> <tr><td>IB2.</td></tr> <tr><td>IB3.</td></tr> </table>                                                                                                       | Pertinent Functions | IA1.                                     | IA2.   | IA3a.                       | IA3b.   | IA3c.                                | IB1.   | IB2.                                  | IB3.  |                                                                        |       |      |                                                                 |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IA1.                                                                                                                                                                                                                                                                                                                                                               |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IA2.                                                                                                                                                                                                                                                                                                                                                               |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IA3a.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IA3b.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IA3c.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IB1.                                                                                                                                                                                                                                                                                                                                                               |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IB2.                                                                                                                                                                                                                                                                                                                                                               |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IB3.                                                                                                                                                                                                                                                                                                                                                               |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                          |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIA1.</td></tr> <tr><td>IIA2.</td></tr> <tr><td>IIA3.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> <tr><td>*IIB3.</td></tr> <tr><td>*IIB4.</td></tr> <tr><td>IIC1.</td></tr> <tr><td>IIC2.</td></tr> <tr><td>IIC3.</td></tr> <tr><td>IID.</td></tr> </table>                         | Pertinent Functions | IIA1.                                    | IIA2.  | IIA3.                       | IIB1.   | IIB2.                                | *IIB3. | *IIB4.                                | IIC1. | IIC2.                                                                  | IIC3. | IID. | - Gives full vertical entrapment for mated "E" or "F" couplers. |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIA1.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIA2.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIA3.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIB1.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIB2.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| *IIB3.                                                                                                                                                                                                                                                                                                                                                             |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| *IIB4.                                                                                                                                                                                                                                                                                                                                                             |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIC1.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIC2.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIC3.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IID.                                                                                                                                                                                                                                                                                                                                                               |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                       |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIIA1.</td></tr> <tr><td>IIIA2.</td></tr> <tr><td>IIIA3a.</td></tr> <tr><td>IIIA3b.</td></tr> <tr><td>IIIA4.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> </table>                                                                                                                   | Pertinent Functions | IIIA1.                                   | IIIA2. | IIIA3a.                     | IIIA3b. | IIIA4.                               | IIB1.  | IIB2.                                 |       |                                                                        |       |      |                                                                 |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                             |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                             |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                            |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                            |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                             |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIB1.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IIB2.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IVA1.</td></tr> <tr><td>IVA2.</td></tr> <tr><td>IVB1.</td></tr> <tr><td>IVB3.</td></tr> <tr><td>IVB4.</td></tr> <tr><td>IVB5.</td></tr> <tr><td>IVB6.</td></tr> <tr><td>*IVC.</td></tr> </table>                                                                                                  | Pertinent Functions | IVA1.                                    | IVA2.  | IVB1.                       | IVB3.   | IVB4.                                | IVB5.  | IVB6.                                 | *IVC. | - Same advantages as type "F" (Biblio 5.2) without sharp lug problems. |       |      |                                                                 |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IVA1.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IVA2.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IVB1.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IVB3.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IVB4.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IVB5.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| IVB6.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |
| *IVC.                                                                                                                                                                                                                                                                                                                                                              |                     |                                          |        |                             |         |                                      |        |                                       |       |                                                                        |       |      |                                                                 |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 254: WALTON "ELECTRO-PNEUMATIC" CONTROL SYSTEM

Primary Bibliography Reference No.: 254

|                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 516              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Description of Concept                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Also see data sheets following.              | <p>Operation of air valves is sequenced automatically as part of electro-pneumatic control system started by (1) coupling process (2) pushing uncoupling button or (3) manual, air valve operation;</p> <p>Uncoupling initiated by (2) electric signal from control car (2) electric switch at growth level or (3) manual lever on top of coupler;</p> <p>Train brakes set automatically (on cars being set-off) and electrical connections completed automatically. Remote uncoupling and train air valve control. (See next page for full system description.)</p> |
| Compatibility with AAL Type "E" Coupler:     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 1. Can be added to Type "E"                  | X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 2. Requires modification of Type "E"         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 3. Requires head adapter for Type "E"        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 4. Incompatible with Type "E"                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Pertinent Functions                          | - Provides automatic operation of air valves for both coupling and uncoupling sequences.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| IA1.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IA2.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IA3a.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IA3b.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IA3c.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IB1.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IB2.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IB3.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CATEGORY II - IMPROVE MECHANICAL COUPLING    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIA1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIA2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIA3.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIB1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIB2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIB3.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIC1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIC2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIC3.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IID.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Pertinent Functions                          | - Provides automatic uncoupling release from within train (cab of switching car), external (outside of switching car) or manual backup at coupler head.                                                                                                                                                                                                                                                                                                                                                                                                              |
| IIIA1.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IIIA2.                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IIIA3a.                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IIIA3b.                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIIA5.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIB1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IIB2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Pertinent Functions                          | <p>- Full automatic electrical and brake control.</p> <p>** System requires a fixed minimum residual car air pressure to operate without delays.</p> <p>** System requires definite maintenance at frequent intervals.</p> <p>- Improved safety (remote uncoupling and valve control).</p>                                                                                                                                                                                                                                                                           |
| IVA1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IVA2.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IVB1.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IVB3.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IVC4.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IVD5.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IVE6.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IVF.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

SUPPLEMENTAL SYSTEM DESCRIPTION  
FOR BIBLIOGRAPHY REFERENCE NO. 254

The basic operating sequence for the Walton "Electric-Pneumatic" control system (as affecting the cars being coupled/uncoupled) is:

Coupling Sequence

- 1) Electrical box covers are levered open to expose contacts.
- 2) Permanently extended circuit pins make contact.
- 3) Coupling switch is closed by complete insertion of the coupling locking hook.
- 4) Coupling solenoid is actuated and instigates the following functions (some with time delay).
  - (a) Open pilot air line valves.
  - (b) Open train air line valves.
  - (c) Open valve to provide air to electric coupler box piston (which moves the contact block forward to project the retracted contact pins to extended position in full contact).
  - (d) Exhaust air from centering device cylinders to disengage automatic centering.
- 5) Appropriate system indicators display in control cab.

Uncoupling Sequence

- 1) Uncoupling signal (electric switch from control cab or ground level of switching car) is started.
- 2) Uncoupling solenoid is actuated and instigates the following functions (some with time delay).
  - (a) Apply air to centering device cylinders.
  - (b) Close train air line valves.
  - (c) Exhaust air to electric coupler box piston (which

allows a spring loaded retraction of contact block and disconnection of all contact pins except permanently extended contact pins).

(d) Energize the uncoupling cylinder to mechanically disengage the coupler locking hooks.

3) Cars pull apart.

4) Permanently extended circuit pins break contact which instigates the following functions.

(a) Exhaust air from uncoupling cylinder to allow a spring closure of hinged locking hook ready for next coupling.

(b) Emergency brake set on the set-off car(s).

(c) Reset of all control valves.

5) Electrical box cover is closed by spring pressure when boxes are fully parted.

# Concept 301a: WILLISON TYPE II (UIC) COUPLER

Primary Bibliography Reference No.: 301

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--|--------------------------------------|--|---------------------------------------|--|-------------------------------|---|
| Related Reference Number(s) 301, 305, 308, 309, 449, 502                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Description of Concept</p> <p>Semi-free, open face, spread claw, fixed knuckle, discontinuous movement;</p> <p>Gravity type lock (no springs) using five cast unmachined parts;</p> <p>A preliminary stop in locking mechanism reduces recoil possibility;</p> <p>Coupler lock, interlocking arms and wedges behind rigid knuckles;</p> <p>Lateral movement of approximately 0.6" during final coupling;</p> <p>Lock set can be actuated or released from either side of coupler;</p> <p>Locking pieces have a rolling action (as compared to the usual sliding action);</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Compatibility with AAR Type "E" Coupler:</p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td></td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td>X</td> </tr> </table>                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1. Can be added to Type "E" |  | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" | X |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                             |  |                                      |  |                                       |  |                               |   |
| <p>Gravity lock is held open at uncoupling, "knuckle" is a solid cast piece;</p> <p>Visual indication of coupler locked condition, "knuckle open" capability.</p>                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Pertinent Functions</p> <p>IA1.</p> <p>IA2.</p> <p>IA3a.</p> <p>IA3b.</p> <p>IA3c.</p> <p>IB1.</p> <p>IB2.</p> <p>IB3.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>CATEGORY II - IMPROVE MECHANICAL COUPLING</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Pertinent Functions</p> <p>*IA1.</p> <p>*IA2.</p> <p>*IA3.</p> <p>*IB1.</p> <p>*IB2.</p> <p>*IB3.</p> <p>*IB4.</p> <p>IC1.</p> <p>IC2.</p> <p>IC3.</p> <p>*ID.</p>                                                                                                                                                                                                                                                                                                                                                                                                           | <p>- Increased gathering</p> <p>Lateral + 3.95" (2.0 x standard).</p> <p>Vertical + 2.35" (1.6 x standard).</p> <p>- Reduced free slack of 0.28" (0.36 x standard).</p> <p>** Positive locking might not be obtained with excess rust or grime build-up since gravity is sole locking force.</p> <p>- Should increase coupling speed range.</p> <p>- Good vertical interlock and entrapment of broken coupler.</p> <p>** Discontinuous lateral coupling movement would tend to create potential for damage to integral air or electrical connectors.</p> |                             |  |                                      |  |                                       |  |                               |   |
| <p>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Pertinent Functions</p> <p>IIIA1.</p> <p>IIIA2.</p> <p>IIIA3a.</p> <p>IIIA3b.</p> <p>IIIA4.</p> <p>IIIB1.</p> <p>IIIB2.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <p>- Allows possibility for an alternate side lever for manual uncoupling.</p> <p>- Allows uncoupling in draft (up to approximately 100 lbs. tension).</p> <p>- Accomplishes the "knuckle open" concept.</p>                                                                                                                                                                                                                                                                                                                                             |                             |  |                                      |  |                                       |  |                               |   |
| <p>CATEGORY IV - IMPROVE GENERAL SYSTEMS</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |   |
| <p>Pertinent Functions</p> <p>IVA1.</p> <p>IVA2.</p> <p>IVB1.</p> <p>IVB3.</p> <p>IVB4.</p> <p>IVB5.</p> <p>IVB6.</p> <p>IVC.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                               | <p>- Improved safety due to reduction of coupler bypass.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |  |                                      |  |                                       |  |                               |   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# **Concept 301b: SCHARFENBERG KUPPLUNG**

**Primary Bibliography Reference No.: 301**

|                                                                                                                                                                                                            |                                                                                                                                                                                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 46, 305, 308, 309, 510                                                                                                                                                         |                                                                                                                                                                                                                                         |
| Description of Concept                                                                                                                                                                                     |                                                                                                                                                                                                                                         |
| Rigid, flat-faced, matching horn/funnel, symmetrical horizontal disc-shaped "oscillating hooks"; Locking plates are rotated at uncoupling and secured in ready position in a spring loaded recessed catch; |                                                                                                                                                                                                                                         |
| Manual or pneumatic or electro-mechanical uncoupling;                                                                                                                                                      |                                                                                                                                                                                                                                         |
| Integral air connection system;                                                                                                                                                                            |                                                                                                                                                                                                                                         |
| Automatic electric connection at side or top of coupler;                                                                                                                                                   |                                                                                                                                                                                                                                         |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                   |                                                                                                                                                                                                                                         |
| 1. Can be added to Type "E"                                                                                                                                                                                |                                                                                                                                                                                                                                         |
| 2. Requires modification of Type "E"                                                                                                                                                                       |                                                                                                                                                                                                                                         |
| 3. Requires head adapter for Type "E"                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| 4. Incompatible with Type "E"                                                                                                                                                                              | X                                                                                                                                                                                                                                       |
| Environmental cover moved aside manually or pneumatically (with electrical contacts also made pneumatically); Automatic air connection and air valve operation.                                            |                                                                                                                                                                                                                                         |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                 |                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                                        |                                                                                                                                                                                                                                         |
| *IA1.                                                                                                                                                                                                      | - Air connection integral with rigid coupler head.                                                                                                                                                                                      |
| *IA2.                                                                                                                                                                                                      | - Up to three air lines (including one needed for uncoupling).                                                                                                                                                                          |
| *IA3a.                                                                                                                                                                                                     | - Air valves are automatically operated by final mechanical operating of coupling.                                                                                                                                                      |
| *IA3b.                                                                                                                                                                                                     | ** Air connection depends on fixed compression of rubber seals.                                                                                                                                                                         |
| *IA3c.                                                                                                                                                                                                     |                                                                                                                                                                                                                                         |
| *IB1.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| *IB2.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| *IB3.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                  |                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                                        |                                                                                                                                                                                                                                         |
| *IA1.                                                                                                                                                                                                      | - Basic gathering range                                                                                                                                                                                                                 |
| *IA2.                                                                                                                                                                                                      | Lateral: $\pm 7.7"$ (3.85 x standard).                                                                                                                                                                                                  |
| *IA3a.                                                                                                                                                                                                     | Vertical: $\pm 5.45"$ (3.63 x standard).                                                                                                                                                                                                |
| *IA3b.                                                                                                                                                                                                     | ** Extended gathering range with use of external horn up to 26.7" lateral - marginal addition due to damage potential of horn with high length/diameter ratio                                                                           |
| *IA3c.                                                                                                                                                                                                     | - Positive locking from spring loaded locking cam.                                                                                                                                                                                      |
| *IB1.                                                                                                                                                                                                      | - Positive locking, vertical interlock and entrapment from horn/funnel tolerances plus locking cam hooks.                                                                                                                               |
| *IB2.                                                                                                                                                                                                      | ** Reduced free slack (0.04") from machined faces (complicated system from cost and maintainability viewpoint).                                                                                                                         |
| *IB3.                                                                                                                                                                                                      | - Vertical centering from multiple leaf spring.                                                                                                                                                                                         |
| *IB4.                                                                                                                                                                                                      | ** Lateral centering from side hydraulic cylinder may have low reliability due to damage susceptibility.                                                                                                                                |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                               |                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                                        |                                                                                                                                                                                                                                         |
| *IA1.                                                                                                                                                                                                      | - Locking plate held in spring loaded ready position (knuckle open condition).                                                                                                                                                          |
| *IA2.                                                                                                                                                                                                      | - Second air system used to transmit pressure to operate uncoupling cylinder (alternate system uses electric solenoids). Good remote uncoupling if a means is available to select cars for uncoupling.                                  |
| *IA3a.                                                                                                                                                                                                     | ** Uncoupling subject to marginal reliability after use and environmental grime contamination due to high force required to rotate both locking plates (against coupling draft force friction) and to compress both recoupling springs. |
| *IA3b.                                                                                                                                                                                                     |                                                                                                                                                                                                                                         |
| *IA3c.                                                                                                                                                                                                     |                                                                                                                                                                                                                                         |
| *IB1.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| *IB2.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                                        |                                                                                                                                                                                                                                         |
| *IA1.                                                                                                                                                                                                      | - Electrical contacts are held away from environment.                                                                                                                                                                                   |
| *IA2.                                                                                                                                                                                                      | ** Manual cover removal system subject to damage possibility.                                                                                                                                                                           |
| *IB1.                                                                                                                                                                                                      | - Combination of pneumatic removal of cover and pneumatic engagement of contacts (after coupling forces are complete) has good reliability potential.                                                                                   |
| *IB2.                                                                                                                                                                                                      | - Improved reliability.                                                                                                                                                                                                                 |
| *IB3.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| *IB4.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| *IB5.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| *IB6.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |
| *IB7.                                                                                                                                                                                                      |                                                                                                                                                                                                                                         |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 306: FREIGHT MASTER POSITIONING DEVICE

Primary Bibliography Reference No.: 306

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|-----------------------------------------------------------------------------|
| Related Reference Number(s) 515                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;"> <b>Compatibility with AAR Type "E" Coupler:</b> </div> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 80%; padding: 2px;">1. Can be added to Type "E"</td> <td style="width: 20%; text-align: center; padding: 2px;">x</td> </tr> <tr> <td style="padding: 2px;">2. Requires modification of Type "E"</td> <td style="text-align: center; padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">3. Requires head adapter for Type "E"</td> <td style="text-align: center; padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">4. Incompatible with Type "E"</td> <td style="text-align: center; padding: 2px;"></td> </tr> </table> | 1. Can be added to Type "E"                                                                                                                                             | x | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  | Direct linkage from trucks through rod and chain with spring slack take-up. |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | x                                                                                                                                                                       |   |                                      |  |                                       |  |                               |  |                                                                             |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| Pertinent Functions<br>IA1.<br>IA2.<br>IA3a.<br>IA3b.<br>IA3c.<br>IB1.<br>IB2.<br>IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| Pertinent Functions<br>IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>IIC1.<br>IIC2.<br>* IIC3.<br>IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | - Simple device which should be economical in cost and maintenance (assuming adequate design stresses).<br><br>** User reports of maintainability after extended usage. |   |                                      |  |                                       |  |                               |  |                                                                             |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| Pertinent Functions<br>IIIA1.<br>IIIA2.<br>IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIIB1.<br>IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                         |   |                                      |  |                                       |  |                               |  |                                                                             |
| Pertinent Functions<br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>* IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | - Improved safety by reducing bypass probability.                                                                                                                       |   |                                      |  |                                       |  |                               |  |                                                                             |

Notes:    \*This concept embodies improvements in this function.  
           \*\*Denote potential operating or safety problem.

# Concept 309: UNICUPLER (U.I.G.) COUPLER

Primary Bibliography Reference No.: 309

|                                                                                                                                                                                                                                                                                                     |                                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 33, 47, 49, 301, 308, 309, 502                                                                                                                                                                                                                                          |                                                                                                                     |
| Description of Concept                                                                                                                                                                                                                                                                              |                                                                                                                     |
| <p>Semi-rigid, open face, spread claw, internal hinged hook (ridigized Willison with hinged hook);</p> <p>Uses ORE II - cross beam centering device Biblio. No. 318);</p> <p>Hinged environmental cover is wedged opened at coupling;</p> <p>Round electrical connector with pin/socket mating.</p> |                                                                                                                     |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                            |                                                                                                                     |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                         |                                                                                                                     |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                |                                                                                                                     |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                               |                                                                                                                     |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                       | X                                                                                                                   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                          |                                                                                                                     |
| Pertinent Functions                                                                                                                                                                                                                                                                                 | Air connection integral with non-compatible rigid coupler head.                                                     |
| *IA1.                                                                                                                                                                                                                                                                                               | - Final sealing pressure is attained by forward movement of connectors from cam actuated by coupler closure.        |
| *IA2.                                                                                                                                                                                                                                                                                               |                                                                                                                     |
| IA3a.                                                                                                                                                                                                                                                                                               | - Air lines can be opened from rear of <u>connected coupler</u> for maintenance (pivoted opening).                  |
| IA3b.                                                                                                                                                                                                                                                                                               |                                                                                                                     |
| IA3c.                                                                                                                                                                                                                                                                                               |                                                                                                                     |
| *IB1.                                                                                                                                                                                                                                                                                               | - Air connectors are well protected by recess in coupler head.                                                      |
| *IB2.                                                                                                                                                                                                                                                                                               |                                                                                                                     |
| *IB3.                                                                                                                                                                                                                                                                                               |                                                                                                                     |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                           |                                                                                                                     |
| Pertinent Functions                                                                                                                                                                                                                                                                                 | - Basic gathering range.                                                                                            |
| *IIA1.                                                                                                                                                                                                                                                                                              | Lateral: + 8.7" (4.35 x standard).                                                                                  |
| *IIA2.                                                                                                                                                                                                                                                                                              | Vertical: ± 5.5" (3.67 x standard).                                                                                 |
| *IIA3.                                                                                                                                                                                                                                                                                              | - Simple, internal, spring loaded hinged hook for locking, interlock and entrapment.                                |
| *IIB1.                                                                                                                                                                                                                                                                                              | - Most simple of hinged-hook Willison types.                                                                        |
| *IIB2.                                                                                                                                                                                                                                                                                              | - Basic cast/forged head and shank is extremely rugged with minimum of machining to obtain 0.31" free slack.        |
| *IIB3.                                                                                                                                                                                                                                                                                              | - Locking mechanism composed of approximately six unmachined steel castings plus one spring.                        |
| *IIB4.                                                                                                                                                                                                                                                                                              |                                                                                                                     |
| *IIC1.                                                                                                                                                                                                                                                                                              |                                                                                                                     |
| *IIC2.                                                                                                                                                                                                                                                                                              |                                                                                                                     |
| *IIC3.                                                                                                                                                                                                                                                                                              |                                                                                                                     |
| *IID.                                                                                                                                                                                                                                                                                               |                                                                                                                     |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                        |                                                                                                                     |
| Pertinent Functions                                                                                                                                                                                                                                                                                 | - Alternate (2nd side) uncoupling lever using a cable connection or rigid joint and shaft.                          |
| *IIIA1.                                                                                                                                                                                                                                                                                             | - Alternate uncoupling release by air valve located at side of car.                                                 |
| *IIIA2.                                                                                                                                                                                                                                                                                             | - Locking pawls (knuckles) are spring loaded in ready position at uncoupling.                                       |
| *IIIA3a.                                                                                                                                                                                                                                                                                            | - Locking pawls can be manually locked open to prevent automatic recoupling during switching operations.            |
| *IIIA3b.                                                                                                                                                                                                                                                                                            |                                                                                                                     |
| *IIIA4.                                                                                                                                                                                                                                                                                             |                                                                                                                     |
| *IIIB1.                                                                                                                                                                                                                                                                                             |                                                                                                                     |
| *IIIB2.                                                                                                                                                                                                                                                                                             |                                                                                                                     |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                               |                                                                                                                     |
| Pertinent Functions                                                                                                                                                                                                                                                                                 | - Electrical connections integral to coupler.                                                                       |
| *IVA1.                                                                                                                                                                                                                                                                                              | - Electrical pin/socket connections are clustered around an air connector (protected area).                         |
| *IVA2.                                                                                                                                                                                                                                                                                              | - Final electrical contact made by air pressure after coupling closure.                                             |
| *IVB1.                                                                                                                                                                                                                                                                                              | ** Environmental protection covers are manually cammed aside at coupling (damage susceptible).                      |
| *IVB3.                                                                                                                                                                                                                                                                                              |                                                                                                                     |
| *IVB4.                                                                                                                                                                                                                                                                                              | - Electrical contacts can be opened (hinged aside) from rear of coupled unit.                                       |
| *IVB5.                                                                                                                                                                                                                                                                                              | ** Round connector limits number of circuits.                                                                       |
| *IVB6.                                                                                                                                                                                                                                                                                              | ** Rigid pin/socket type contacts subject to damage and malfunction due to free slack (0.31") movements of coupler. |
| *IVC.                                                                                                                                                                                                                                                                                               |                                                                                                                     |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 318: ORE II CROSS-BEAM SUPPORT CENTERING DEVICE

Primary Bibliography Reference No.: 318

|                                              |                                                                           |
|----------------------------------------------|---------------------------------------------------------------------------|
| Related Reference Number(s) 459              |                                                                           |
| Description of Concept                       |                                                                           |
| Cross beam support.                          |                                                                           |
| Compatibility with AAR Type "E" Coupler:     |                                                                           |
| 1. Can be added to Type "E"                  | X                                                                         |
| 2. Requires modification of Type "E"         |                                                                           |
| 3. Requires head adapter for Type "E"        |                                                                           |
| 4. Incompatible with Type "E"                |                                                                           |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM   |                                                                           |
| Pertinent Functions                          |                                                                           |
| IA1.                                         |                                                                           |
| IA2.                                         |                                                                           |
| IA3a.                                        |                                                                           |
| IA3b.                                        |                                                                           |
| IA3c.                                        |                                                                           |
| IB1.                                         |                                                                           |
| IB2.                                         |                                                                           |
| IB3.                                         |                                                                           |
| CATEGORY II - IMPROVE MECHANICAL COUPLING    |                                                                           |
| Pertinent Functions                          |                                                                           |
| IIA1.                                        | - Spring actuated centering device ( $\pm 1.2$ " from centerline of car). |
| IIA2.                                        | - Simple rugged, reliable.                                                |
| IIA3.                                        | - Manual disengagement and automatic reengagement.                        |
| IIB1.                                        | - Nominal initial cost and minimal maintenance.                           |
| IIB2.                                        |                                                                           |
| IIB3.                                        |                                                                           |
| IIB4.                                        |                                                                           |
| *IIC1.                                       |                                                                           |
| IIC2.                                        |                                                                           |
| IIC3.                                        |                                                                           |
| *IID.                                        |                                                                           |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING |                                                                           |
| Pertinent Functions                          |                                                                           |
| IIIA1.                                       |                                                                           |
| IIIA2.                                       |                                                                           |
| IIIA3a.                                      |                                                                           |
| IIIA3b.                                      |                                                                           |
| IIIA4.                                       |                                                                           |
| IIB1.                                        |                                                                           |
| IIB2.                                        |                                                                           |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS        |                                                                           |
| Pertinent Functions                          |                                                                           |
| IVA1.                                        |                                                                           |
| IVA2.                                        |                                                                           |
| IVB1.                                        |                                                                           |
| IVB3.                                        |                                                                           |
| IVB4.                                        |                                                                           |
| IVB5.                                        |                                                                           |
| IVB6.                                        |                                                                           |
| IVC.                                         |                                                                           |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 387: GERMAN UIC ELECTRICAL CONTROL

Primary Bibliography Reference No.: 387

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|-------|-----------------------------|--------|--------------------------------------|-------|---------------------------------------|--------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|------|--|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td colspan="2" style="padding: 2px;">Compatibility with AAR Type "E" Coupler:</td> </tr> <tr> <td style="width:80%; padding: 2px;">1. Can be added to Type "E"</td> <td style="width:20%; padding: 2px; text-align: center;">X</td> </tr> <tr> <td style="padding: 2px;">2. Requires modification of Type "E"</td> <td style="padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">3. Requires head adapter for Type "E"</td> <td style="padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">4. Incompatible with Type "E"</td> <td style="padding: 2px;"></td> </tr> </table> | Compatibility with AAR Type "E" Coupler: |       | 1. Can be added to Type "E" | X      | 2. Requires modification of Type "E" |       | 3. Requires head adapter for Type "E" |        | 4. Incompatible with Type "E" |                                                                                                                                                             | <p>Electrical control signaling using multiplexing principal (simultaneous transmission of multiple signals on one line).</p> |      |  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | X                                        |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td style="padding: 2px;">Pertinent Functions</td></tr> <tr><td style="padding: 2px;">FA1.</td></tr> <tr><td style="padding: 2px;">FA2.</td></tr> <tr><td style="padding: 2px;">FA3a.</td></tr> <tr><td style="padding: 2px;">FA3b.</td></tr> <tr><td style="padding: 2px;">FA3c.</td></tr> <tr><td style="padding: 2px;">FB1.</td></tr> <tr><td style="padding: 2px;">FB2.</td></tr> <tr><td style="padding: 2px;">FB3.</td></tr> </table>                                                                                                                                                 | Pertinent Functions                      | FA1.  | FA2.                        | FA3a.  | FA3b.                                | FA3c. | FB1.                                  | FB2.   | FB3.                          |                                                                                                                                                             |                                                                                                                               |      |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td style="padding: 2px;">Pertinent Functions</td></tr> <tr><td style="padding: 2px;">FAA1.</td></tr> <tr><td style="padding: 2px;">FAA2.</td></tr> <tr><td style="padding: 2px;">FAA3.</td></tr> <tr><td style="padding: 2px;">FBB1.</td></tr> <tr><td style="padding: 2px;">FBB2.</td></tr> <tr><td style="padding: 2px;">FBB3.</td></tr> <tr><td style="padding: 2px;">FBB4.</td></tr> <tr><td style="padding: 2px;">FCC1.</td></tr> <tr><td style="padding: 2px;">FCC2.</td></tr> <tr><td style="padding: 2px;">FCC3.</td></tr> <tr><td style="padding: 2px;">FDD.</td></tr> </table>   | Pertinent Functions                      | FAA1. | FAA2.                       | FAA3.  | FBB1.                                | FBB2. | FBB3.                                 | FBB4.  | FCC1.                         | FCC2.                                                                                                                                                       | FCC3.                                                                                                                         | FDD. |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FAA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FAA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FAA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FBB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FBB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FBB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FBB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FCC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FCC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FCC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FDD.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
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| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FAA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FAA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FAA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FAA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FAA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FBB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FBB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
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| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FAA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| *FAA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| *FBB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FBB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FBB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| *FBB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| *FBB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |
| FCC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |       |                             |        |                                      |       |                                       |        |                               |                                                                                                                                                             |                                                                                                                               |      |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 391: OSAKA COUPLER SYSTEM

Primary Bibliography Reference No.: 391

|                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                           |
| <p align="right">Hinged locking hook (spring-loaded) automatically engage opposite horn at coupling;<br/>Provisions for mounting a lower suspended electrical connector system;<br/>Automatic air connection, "knuckle" always open and remote (air actuated) uncoupling.<br/>Butt type seals;<br/>Rigid type, flat face, horn-funnel;<br/>Rotary locking block can be opened by operation of air cylinder or manual.</p> |                                                                                                                                           |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                           |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                             | X                                                                                                                                         |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                           |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                           |
| *IA1.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| *IA2.                                                                                                                                                                                                                                                                                                                                                                                                                     | - Two air lines automatically connected at coupling.                                                                                      |
| IA3.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                           |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                           |
| *IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                    | - Improved gathering range.<br>Lateral = $\pm 3.9"$ (1.95 x standard).<br>Vertical = $\pm 3.9"$ (2.6 x standard).                         |
| *IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                    | - Positive locking from spring loaded hinged hook and rotary block locking.                                                               |
| *IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                    | - Machined rigid face = "no" free slack.                                                                                                  |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                      | - Vertical interlock and entrapment from horn-funnel interlock plus rotary block lock.                                                    |
| *IB2.                                                                                                                                                                                                                                                                                                                                                                                                                     | - Simple construction and slack free design should reduce maintenance.                                                                    |
| *IB3.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| *IB4.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| IC1.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| *IC2.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| IC3.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| *ID.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                           |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                           |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                    | - Offers remote uncoupling from within train.                                                                                             |
| *IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                   | - Capability of uncoupling and draft (28 psi line pressure needed for up to 2,000 lb. draft force and 100 psi at 8,800 lbs. draft force). |
| *IIIA3.                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                           |
| *IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                           |
| *IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                   | - "Knuckle" always open at uncoupling.                                                                                                    |
| *IB1.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                           |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                     | - Offers easy potential for automatic electrical system.                                                                                  |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| *VB1.                                                                                                                                                                                                                                                                                                                                                                                                                     | - Improved safety due to automatic air connection and reduced probability of coupler by-pass.                                             |
| VB3.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| VB4.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| VB5.                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                           |
| *VB6.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
| *VVC.                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |

Notes: \*This concept embodies improvements in this function.  
\*\*Denotes potential operating or safety problem.

# Concept 428a: STANDARD AAR "H" TIGHTLOCK

Primary Bibliography Reference No.: 428

|                                                                                                                                                                                                                                                                                                                              |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 446                                                                                                                                                                                                                                                                                              |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                       |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| <div>Compatibility with AAR Type "E" Coupler:</div> <table border="1"><tr><td>1. Can be added to Type "E"</td><td>X</td></tr><tr><td>2. Requires modification of Type "E"</td><td></td></tr><tr><td>3. Requires head adapter for Type "E"</td><td></td></tr><tr><td>4. Incompatible with Type "E"</td><td></td></tr></table> |                                                                                                     | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                  | X                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                        |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Passenger car application;<br>Optional double lock-lift assembly;<br>Interlocking feature;<br>Reduced free slack.                                                                                                                                                                                                            |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                   |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                          |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                        |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                        |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA3c.                                                                                                                                                                                                                                                                                                                        |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                    |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                          |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| *IA1.                                                                                                                                                                                                                                                                                                                        | - Increased lateral gathering: $\pm 2\text{-}3/8"$ (1.19 x standard).                               |                             |   |                                      |  |                                       |  |                               |  |
| *IA2.                                                                                                                                                                                                                                                                                                                        | - Increased vertical gathering: 4-1/2" total (1.5 x standard).                                      |                             |   |                                      |  |                                       |  |                               |  |
| IA3.                                                                                                                                                                                                                                                                                                                         | - Reduced free slack: 0.25" (0.32 x standard).                                                      |                             |   |                                      |  |                                       |  |                               |  |
| *IB1.                                                                                                                                                                                                                                                                                                                        | - More positive coupler engagement at low speeds.                                                   |                             |   |                                      |  |                                       |  |                               |  |
| *IB2.                                                                                                                                                                                                                                                                                                                        | ** Tight machined tolerances on all mating surfaces causes a significant increase in original cost. |                             |   |                                      |  |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB4.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IC1.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IC2.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IC3.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| *ID.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                 |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                          |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| *IA1.                                                                                                                                                                                                                                                                                                                        |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                        |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                        |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA4.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| - Allows use of two side uncoupling levers.                                                                                                                                                                                                                                                                                  |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                        |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                          |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB4.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB5.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| IB6.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| *IC.                                                                                                                                                                                                                                                                                                                         |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| - Same basic features as type "F" coupler (ref. No. 428b) except in a higher grade steel with greater machining to reduce free slack.                                                                                                                                                                                        |                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
\*\*Denotes potential operating or safety problem.

# Concept 428b: STANDARD AAR "F" INTERLOCKING COUPLER

Primary Bibliography Reference No.: 428

|                                                             |                                                                                                                          |
|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 9, 38, 52, 405, 502 (N.C.), 553 |                                                                                                                          |
| Description of Concept                                      |                                                                                                                          |
| Tank car, long car, or dangerous car application            |                                                                                                                          |
| Compatibility with AAR Type "E" Coupler:                    |                                                                                                                          |
| 1. Can be added to Type "E"                                 | X                                                                                                                        |
| 2. Requires modification of Type "E"                        |                                                                                                                          |
| 3. Requires head adapter for Type "E"                       |                                                                                                                          |
| 4. Incompatible with Type "E"                               |                                                                                                                          |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                  |                                                                                                                          |
| Pertinent Functions                                         |                                                                                                                          |
| IA1.                                                        |                                                                                                                          |
| IA2.                                                        |                                                                                                                          |
| IA3a.                                                       |                                                                                                                          |
| IA3b.                                                       |                                                                                                                          |
| IA3c.                                                       |                                                                                                                          |
| IB1.                                                        |                                                                                                                          |
| IB2.                                                        |                                                                                                                          |
| IB3.                                                        |                                                                                                                          |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                   |                                                                                                                          |
| Pertinent Functions                                         |                                                                                                                          |
| *IIA1.                                                      | - Increased lateral gathering: $\pm 1-3/8"$ (1.19 x standard).                                                           |
| *IIA2.                                                      | - Increased vertical gathering: $\pm 1-1/2"$ total (1.5 x standard).                                                     |
| IIA3.                                                       | - Reduced tree slack: 3-8" (0.48 x standard).                                                                            |
| IIB1.                                                       | - Six way interlock and entrapment (when mated with another "F"). * When mated with "E" will allow "E" to ride over top. |
| *IIB2.                                                      | ** Requires vertical spring carrier due to coupler head interlock.                                                       |
| *IIB3.                                                      | ** Problem of knocking ears off in misaligned couplings.                                                                 |
| *IIB4.                                                      | ** Excess failures at shank pin hole.                                                                                    |
| IIIC1.                                                      |                                                                                                                          |
| *IIC2.                                                      |                                                                                                                          |
| IIIC3.                                                      |                                                                                                                          |
| IID.                                                        |                                                                                                                          |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                |                                                                                                                          |
| Pertinent Functions                                         |                                                                                                                          |
| IIIA1.                                                      |                                                                                                                          |
| IIIA2.                                                      |                                                                                                                          |
| IIIA3a.                                                     |                                                                                                                          |
| IIIA3b.                                                     |                                                                                                                          |
| IIIA...                                                     |                                                                                                                          |
| IIIB1.                                                      |                                                                                                                          |
| IIIB2.                                                      |                                                                                                                          |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                       |                                                                                                                          |
| Pertinent Functions                                         |                                                                                                                          |
| IVA1.                                                       |                                                                                                                          |
| IVA2.                                                       |                                                                                                                          |
| IVB1.                                                       | - Interlocking feature helps reduce derail probability under the condition of broken coupler head or shank.              |
| IVB3.                                                       | ** Protects other car but not always "F" car from override damage.                                                       |
| IVB4.                                                       | ** Sharp edges of interlocking ears may promote puncture in derailments.                                                 |
| IVB5.                                                       |                                                                                                                          |
| *IVC.                                                       |                                                                                                                          |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 434a: COBB AIR CONNECTOR SYSTEM

Primary Bibliography Reference No.: 434

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|--------|-----------------------------|---------|--------------------------------------|--------|---------------------------------------|--------|-------------------------------|------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td colspan="2" style="padding: 2px;"><u>Compatibility with AAR Type "E" Coupler:</u></td> </tr> <tr> <td style="width: 80%; padding: 2px;">1. Can be added to Type "E"</td> <td style="width: 20%; padding: 2px; text-align: center;">X</td> </tr> <tr> <td style="padding: 2px;">2. Requires modification of Type "E"</td> <td style="padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">3. Requires head adapter for Type "E"</td> <td style="padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">4. Incompatible with Type "E"</td> <td style="padding: 2px;"></td> </tr> </table> | <u>Compatibility with AAR Type "E" Coupler:</u> |        | 1. Can be added to Type "E" | X       | 2. Requires modification of Type "E" |        | 3. Requires head adapter for Type "E" |        | 4. Incompatible with Type "E" |                                                                                                      | <p>Car mounted, twin unit, horn-funnel type with angled line connections (spring loaded); Automatic air connection.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <u>Compatibility with AAR Type "E" Coupler:</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | X                                               |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">Pertinent Functions</td> </tr> <tr><td style="padding: 2px;">*IA1.</td></tr> <tr><td style="padding: 2px;">*IA2.</td></tr> <tr><td style="padding: 2px;">IA3a.</td></tr> <tr><td style="padding: 2px;">IA3b.</td></tr> <tr><td style="padding: 2px;">IA3c.</td></tr> <tr><td style="padding: 2px;">*IB1.</td></tr> <tr><td style="padding: 2px;">*IB2.</td></tr> <tr><td style="padding: 2px;">*IB3.</td></tr> <tr><td style="padding: 2px;"></td></tr> <tr><td style="padding: 2px;"></td></tr> </table>                                                                 | Pertinent Functions                             | *IA1.  | *IA2.                       | IA3a.   | IA3b.                                | IA3c.  | *IB1.                                 | *IB2.  | *IB3.                         |                                                                                                      |                                                                                                                         | <ul style="list-style-type: none"> <li>- Add-on unit (compatible with built-in gathering).</li> <li>** Angled air connections subject to coupling damage.</li> <li>** Long cantilever design subject to potential vibration problems and shock damage to mounting.</li> <li>** Sliding spring tubes subject to binding.</li> <li>** Connector units do not swing with coupler and subject to by-pass due to limited gathering.</li> </ul> |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| *IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| *IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| *IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| *IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| *IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">Pertinent Functions</td> </tr> <tr><td style="padding: 2px;">IIA1.</td></tr> <tr><td style="padding: 2px;">IIA2.</td></tr> <tr><td style="padding: 2px;">IIA3.</td></tr> <tr><td style="padding: 2px;">IIB1.</td></tr> <tr><td style="padding: 2px;">IIB2.</td></tr> <tr><td style="padding: 2px;">IIB3.</td></tr> <tr><td style="padding: 2px;">IIB4.</td></tr> <tr><td style="padding: 2px;">IIC1.</td></tr> <tr><td style="padding: 2px;">IIC2.</td></tr> <tr><td style="padding: 2px;">IIC3.</td></tr> <tr><td style="padding: 2px;">IID.</td></tr> </table>          | Pertinent Functions                             | IIA1.  | IIA2.                       | IIA3.   | IIB1.                                | IIB2.  | IIB3.                                 | IIB4.  | IIC1.                         | IIC2.                                                                                                | IIC3.                                                                                                                   | IID.                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">Pertinent Functions</td> </tr> <tr><td style="padding: 2px;">IIIA1.</td></tr> <tr><td style="padding: 2px;">IIIA2.</td></tr> <tr><td style="padding: 2px;">IIIA3a.</td></tr> <tr><td style="padding: 2px;">IIIA3b.</td></tr> <tr><td style="padding: 2px;">IIIA4.</td></tr> <tr><td style="padding: 2px;">IIIB1.</td></tr> <tr><td style="padding: 2px;">IIIB2.</td></tr> </table>                                                                                                                                                                                        | Pertinent Functions                             | IIIA1. | IIIA2.                      | IIIA3a. | IIIA3b.                              | IIIA4. | IIIB1.                                | IIIB2. |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">Pertinent Functions</td> </tr> <tr><td style="padding: 2px;">IVAI.</td></tr> <tr><td style="padding: 2px;">IVAZ.</td></tr> <tr><td style="padding: 2px;">IVB1.</td></tr> <tr><td style="padding: 2px;">IVB3.</td></tr> <tr><td style="padding: 2px;">IVB4.</td></tr> <tr><td style="padding: 2px;">IVB5.</td></tr> <tr><td style="padding: 2px;">IVB6.</td></tr> <tr><td style="padding: 2px;">*IVC.</td></tr> </table>                                                                                                                                                   | Pertinent Functions                             | IVAI.  | IVAZ.                       | IVB1.   | IVB3.                                | IVB4.  | IVB5.                                 | IVB6.  | *IVC.                         | <ul style="list-style-type: none"> <li>- Improved safety due to automatic air connection.</li> </ul> |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IVAI.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IVAZ.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IVB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IVB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IVB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| IVB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| *IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 |        |                             |         |                                      |        |                                       |        |                               |                                                                                                      |                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |

Notes:   \*This concept embodies improvements in this function.  
           \*\*Denotes potential operating or safety problem.

# Concept 434b: FRANCIS AIR CONNECTOR SYSTEM

Primary Bibliography Reference No.: 434

|                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| <p><b>COMPATIBILITY WITH AAX TYPE "E" COUPLER:</b></p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                                                                                                                                                                                                                        | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                      | X                                                                                                                                                                                                                                                                                                                      |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| Automatic air connection;<br>Car mounted (with coupler guide), cone-ring type with butt line connections (spring loaded).                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                              | <p>- Add-on unit (compatible with built-in gathering.</p> <p>** Air seal subject to permanent damage from point of opposite gathering cone.</p> <p>** Recesses in front face allow solid stop before seating.</p> <p>** Wide seating face requires critical alignment to achieve proper sealing before solid stop.</p> |                             |   |                                      |  |                                       |  |                               |  |
| <p>* IAI.</p> <p>* IAZ.</p> <p>IA3a.</p> <p>IA3b.</p> <p>IA3c.</p> <p>* IB1.</p> <p>* IB2.</p> <p>* IB3.</p>                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| <p>IIA1.</p> <p>IIA2.</p> <p>IIA3.</p> <p>IIB1.</p> <p>IIB2.</p> <p>IIB3.</p> <p>IIB4.</p> <p>IIC1.</p> <p>IIC2.</p> <p>IIC3.</p> <p>IID.</p>                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| <p>IIIA1.</p> <p>IIIA2.</p> <p>IIIA3a.</p> <p>IIIA3b.</p> <p>IIIA4.</p> <p>IIB1.</p> <p>IIB2.</p>                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                        |                             |   |                                      |  |                                       |  |                               |  |
| <p>IVA1.</p> <p>IVA2.</p> <p>IVB1.</p> <p>IVB3.</p> <p>IVB4.</p> <p>IVB5.</p> <p>IVB6.</p> <p>* IVC.</p>                                                                                                                                                                                                                                         | <p>- Improved safety due to automatic air connection.</p>                                                                                                                                                                                                                                                              |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

Concept 448a: OHIO BRASS FORM 8 COUPLER

Primary Bibliography Reference No.: 448

|                                                                                                                                          |   |
|------------------------------------------------------------------------------------------------------------------------------------------|---|
| Related Reference Number(s) 503                                                                                                          |   |
| Description of Concept                                                                                                                   |   |
| Rigid, non-reversible, male/female coupler (mine car application); spring actuated locking cam <u>in female coupler</u> is always ready. |   |
| Compatibility with AAR Type "E" Coupler:                                                                                                 |   |
| 1. Can be added to Type "E"                                                                                                              |   |
| 2. Requires modification of Type "E"                                                                                                     |   |
| 3. Requires head adapter for Type "E"                                                                                                    |   |
| 4. Incompatible with Type "E"                                                                                                            | X |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                               |   |
| Pertinent Functions                                                                                                                      |   |
| IA1.                                                                                                                                     |   |
| IA2.                                                                                                                                     |   |
| IA3a.                                                                                                                                    |   |
| IA3b.                                                                                                                                    |   |
| IA3c.                                                                                                                                    |   |
| IB1.                                                                                                                                     |   |
| IB2.                                                                                                                                     |   |
| IB3.                                                                                                                                     |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                |   |
| Pertinent Functions                                                                                                                      |   |
| *IA1.                                                                                                                                    |   |
| *IA2.                                                                                                                                    |   |
| *IA3.                                                                                                                                    |   |
| IB1.                                                                                                                                     |   |
| *IB2.                                                                                                                                    |   |
| IB3.                                                                                                                                     |   |
| IB4.                                                                                                                                     |   |
| *IC1.                                                                                                                                    |   |
| *IC2.                                                                                                                                    |   |
| IC3.                                                                                                                                     |   |
| IC4.                                                                                                                                     |   |
| * Concept not adaptable to general railroad operations due to the requirement for specific car orientation to achieve coupling.          |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                             |   |
| Pertinent Functions                                                                                                                      |   |
| *IA1.                                                                                                                                    |   |
| IA2.                                                                                                                                     |   |
| IA3a.                                                                                                                                    |   |
| IA3b.                                                                                                                                    |   |
| IA4.                                                                                                                                     |   |
| IB1.                                                                                                                                     |   |
| IB2.                                                                                                                                     |   |
| - "Open knuckle" capability.                                                                                                             |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                    |   |
| Pertinent Functions                                                                                                                      |   |
| IA1.                                                                                                                                     |   |
| IA2.                                                                                                                                     |   |
| IB1.                                                                                                                                     |   |
| IB3.                                                                                                                                     |   |
| IB4.                                                                                                                                     |   |
| IB5.                                                                                                                                     |   |
| IB6.                                                                                                                                     |   |
| IC.                                                                                                                                      |   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

**Concept 448b: OHIO BRASS FORM 9 COUPLER**

**Primary Bibliography Reference No.: 448**

|                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--|--------------------------------------|--|---------------------------------------|--|-------------------------------|---|
| Related Reference Number(s) 503                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| Rigid, non-reversible, male/female coupler with integral air connector;                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| Compare 503 with AA Type "E" Coupler: <table border="1" style="float: right; margin-top: 10px;"> <tr><td>1. Can be added to Type "E"</td><td></td></tr> <tr><td>2. Requires modification of Type "E"</td><td></td></tr> <tr><td>3. Requires head adapter for Type "E"</td><td></td></tr> <tr><td>4. Incompatible with Type "E"</td><td style="text-align: center;">X</td></tr> </table> |                                                                                                                                                                                                                                                                           | 1. Can be added to Type "E" |  | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" | X |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                           | X                                                                                                                                                                                                                                                                         |                             |  |                                      |  |                                       |  |                               |   |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| Pertinent Functions<br>IA1.<br>IA2.<br>IA3a.<br>IA3b.<br>IA3c.<br>IB1.<br>IB2.<br>IB3.                                                                                                                                                                                                                                                                                                  | - Same non-compatible system as O.B. form 8 (biblio. 448) except:<br>- Air connection integral with non-compatible rigid coupler head;<br>- Spring loaded air seal should be reliable to retain seal within coupler movements.<br>- Rotary air union for rotating dumper. |                             |  |                                      |  |                                       |  |                               |   |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| Pertinent Functions<br>IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| Pertinent Functions<br>IIIA1.<br>IIIA2.<br>IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIIB1.<br>IIIB2.                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |
| Pertinent Functions<br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                           |                             |  |                                      |  |                                       |  |                               |   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 449: ALTERNATOR-BATTERY SYSTEM FOR SUPPLYING POWER

Primary Bibliography Reference No.: 449

|                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 503                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <table border="1"> <tr> <td colspan="2">Compatibility with AAR Type "E" Coupler:</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                                 | Compatibility with AAR Type "E" Coupler: |  | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                           |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                        | X                                                                                                                               |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                               |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| Alternator-battery electrical power system (power source within each car).                                                                                                                                                                                                                                                                                         |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                         |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                          |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIB1.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIB3.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIB4.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIC1.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIC2.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIC3.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IID.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                       |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIIB1.                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IIIB2.                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| * IVB1.                                                                                                                                                                                                                                                                                                                                                            | A viable alternate concept for supplying power for control functions in each car without requiring inter-car power connections. |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IVB3.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IVB4.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IVB5.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IVB6.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| IVC.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                 |                                          |  |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 450a: OHIO BRASS FORM 8A COUPLER

Primary Bibliography Reference No.: 450

|                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                   |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                   |
| <p>- Same capabilities as O.B. form 8 (Biblio. No. 448) plus:</p> <p>Automatic electric braking;</p> <p>Automatic electric connector system with spring loaded rotating contact mating mercury relay contact switching;</p> <p>Electrical logic and control system;</p> <p>Automatic remote coupling and uncoupling;</p> <p>Automatic uncoupling release through electric solenoid (liner actuator).</p> |                                                                                                                   |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                   |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                              | X                                                                                                                 |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                   |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                   |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                   |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                   |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                   |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                   |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIB3.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIB4.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIC1.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IID.                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                   |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                   | - Potential application for systems with electric power and control circuits.                                     |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                   | ** Electric solenoid must be environmentally protected to preclude rust of plunger or core.                       |
| ** IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                   |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                  | ** Electric solenoid must have overload protection to preclude burnout if unable to complete uncoupling movement. |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                   |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                   |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                    | ** Electrical brakes are not practical for freight cars due to the extreme braking energy required.               |
| * IVA2.                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                   |
| * IVB1.                                                                                                                                                                                                                                                                                                                                                                                                  | - Rotating spring electrical contact system should be reliable and resistant to contact problems from grime, etc. |
| * IVB3.                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                   |
| * IVB4.                                                                                                                                                                                                                                                                                                                                                                                                  | ** Mercury contacts may be subject to extraneous malfunction from vibration and shock.                            |
| * IVB5.                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                   |
| * IVB6.                                                                                                                                                                                                                                                                                                                                                                                                  | - Logic system is electronically sound and requires a minimum of circuits for adequate control.                   |
| * IVC.                                                                                                                                                                                                                                                                                                                                                                                                   | - Remote coupling and uncoupling improves safety.                                                                 |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 450b: MICROWAVE TRANSMISSION CONTROL SYSTEM

Primary Bibliography Reference No.: 450

|                                                                                                                                                                                                                                                                                                                                                  |   |                             |   |                                      |  |                                       |  |                               |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 503                                                                                                                                                                                                                                                                                                                  |   |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                           |   |                             |   |                                      |  |                                       |  |                               |  |
| <p><u>Compatibility with AAR Type "E" Coupler:</u></p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>x</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |   | 1. Can be added to Type "E" | x | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                      | x |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                    |   |                             |   |                                      |  |                                       |  |                               |  |
| Automatic uncoupling release from either internal or external microwave signal.                                                                                                                                                                                                                                                                  |   |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                       |   |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                        |   |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIB1.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIB3.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIB4.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIC1.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIC2.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIC3.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IID.                                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                     |   |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| IIIA1.                                                                                                                                                                                                                                                                                                                                           |   |                             |   |                                      |  |                                       |  |                               |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                           |   |                             |   |                                      |  |                                       |  |                               |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                          |   |                             |   |                                      |  |                                       |  |                               |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                          |   |                             |   |                                      |  |                                       |  |                               |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                           |   |                             |   |                                      |  |                                       |  |                               |  |
| IIB1.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| - Viable alternate concept for control and sensing transmission (not power) without inter-car control electrical connections.                                                                                                                                                                                                                    |   |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IVB1.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IVB3.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IVB4.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IVB5.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IVB6.                                                                                                                                                                                                                                                                                                                                            |   |                             |   |                                      |  |                                       |  |                               |  |
| IVC.                                                                                                                                                                                                                                                                                                                                             |   |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 451a: NATIONAL AIR CONNECTOR

Primary Bibliography Reference No.: 451

|                                                                                                                                                                                        |                                                                                                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 434                                                                                                                                                        |                                                                                                               |
| Description of Concept                                                                                                                                                                 |                                                                                                               |
| <div style="text-align: right;">           - Coupler mounted, ball-funnel type with angled line connections (spring loaded);<br/>           - Automatic air connection.         </div> |                                                                                                               |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                               |                                                                                                               |
| 1. Can be added to Type "E"                                                                                                                                                            | X                                                                                                             |
| 2. Requires modification of Type "E"                                                                                                                                                   |                                                                                                               |
| 3. Requires head adapter for Type "E"                                                                                                                                                  |                                                                                                               |
| 4. Incompatible with Type "E"                                                                                                                                                          |                                                                                                               |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                      |                                                                                                               |
| Pertinent Functions                                                                                                                                                                    | ** Built-in gathering angle air connections subject to coupling damage.<br>- Weight of approximately 166 lbs. |
| * IAI.                                                                                                                                                                                 |                                                                                                               |
| * IAT.                                                                                                                                                                                 |                                                                                                               |
| IA3a.                                                                                                                                                                                  |                                                                                                               |
| IA3b.                                                                                                                                                                                  |                                                                                                               |
| IA3c.                                                                                                                                                                                  |                                                                                                               |
| * IB1.                                                                                                                                                                                 |                                                                                                               |
| * IB2.                                                                                                                                                                                 |                                                                                                               |
| * IB3.                                                                                                                                                                                 |                                                                                                               |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                       |                                                                                                               |
| Pertinent Functions                                                                                                                                                                    |                                                                                                               |
| * IAI.                                                                                                                                                                                 |                                                                                                               |
| * IAT.                                                                                                                                                                                 |                                                                                                               |
| IA3a.                                                                                                                                                                                  |                                                                                                               |
| IA3b.                                                                                                                                                                                  |                                                                                                               |
| IA3c.                                                                                                                                                                                  |                                                                                                               |
| IB1.                                                                                                                                                                                   |                                                                                                               |
| IB2.                                                                                                                                                                                   |                                                                                                               |
| IB3.                                                                                                                                                                                   |                                                                                                               |
| IB4.                                                                                                                                                                                   |                                                                                                               |
| IC1.                                                                                                                                                                                   |                                                                                                               |
| IC2.                                                                                                                                                                                   |                                                                                                               |
| IC3.                                                                                                                                                                                   |                                                                                                               |
| IC4.                                                                                                                                                                                   |                                                                                                               |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                    |                                                                                                               |
| Pertinent Functions                                                                                                                                                                    |                                                                                                               |
| IIIA1.                                                                                                                                                                                 |                                                                                                               |
| IIIA2.                                                                                                                                                                                 |                                                                                                               |
| IIIA3a.                                                                                                                                                                                |                                                                                                               |
| IIIA3b.                                                                                                                                                                                |                                                                                                               |
| IIIA4.                                                                                                                                                                                 |                                                                                                               |
| IIIB1.                                                                                                                                                                                 |                                                                                                               |
| IIIB2.                                                                                                                                                                                 |                                                                                                               |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                           |                                                                                                               |
| Pertinent Functions                                                                                                                                                                    |                                                                                                               |
| IVA1.                                                                                                                                                                                  |                                                                                                               |
| IVA2.                                                                                                                                                                                  |                                                                                                               |
| IVB1.                                                                                                                                                                                  |                                                                                                               |
| IVB3.                                                                                                                                                                                  |                                                                                                               |
| IVB4.                                                                                                                                                                                  |                                                                                                               |
| IVB5.                                                                                                                                                                                  |                                                                                                               |
| IVB6.                                                                                                                                                                                  |                                                                                                               |
| * IVC.                                                                                                                                                                                 | - Improved safety due to automatic air connection.                                                            |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 451b: ROBINSON AIR CONNECTOR

Primary Bibliography Reference No.: 451

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------|-----------------------------|---------|--------------------------------------|--------|---------------------------------------|--------|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------|--|
| Related Reference Number(s) 434                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td colspan="2" style="padding: 2px;">Compatibility with AAL Type "E" Coupler:</td> </tr> <tr> <td style="width: 80%; padding: 2px;">1. Can be added to Type "E"</td> <td style="width: 20%; padding: 2px; text-align: center;">X</td> </tr> <tr> <td style="padding: 2px;">2. Requires modification of Type "E"</td> <td style="padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">3. Requires head adapter for Type "E"</td> <td style="padding: 2px;"></td> </tr> <tr> <td style="padding: 2px;">4. Incompatible with Type "E"</td> <td style="padding: 2px;"></td> </tr> </table> | Compatibility with AAL Type "E" Coupler: |        | 1. Can be added to Type "E" | X       | 2. Requires modification of Type "E" |        | 3. Requires head adapter for Type "E" |        | 4. Incompatible with Type "E" |                                                                                                                                                                                                                                                                                                                                                      | <p>Pin-funnel type automatic air connection;<br/>Butt line connections (spring loaded).</p> |      |  |
| Compatibility with AAL Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | X                                        |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="padding: 2px;">Pertinent Functions</td></tr> <tr><td style="padding: 2px;">*IA1.</td></tr> <tr><td style="padding: 2px;">*IA2.</td></tr> <tr><td style="padding: 2px;">IA3a.</td></tr> <tr><td style="padding: 2px;">IA3b.</td></tr> <tr><td style="padding: 2px;">IA3c.</td></tr> <tr><td style="padding: 2px;">*IB1.</td></tr> <tr><td style="padding: 2px;">*IB2.</td></tr> <tr><td style="padding: 2px;">*IB3.</td></tr> </table>                                                                                                                                              | Pertinent Functions                      | *IA1.  | *IA2.                       | IA3a.   | IA3b.                                | IA3c.  | *IB1.                                 | *IB2.  | *IB3.                         | <p>Built-in gathering</p> <p>- Weight of approximately 129 lbs.</p> <p>** Tendency to bind before sealing due to scraping and wear scoring near bottom of funnel (corrected with change to ball type gathering horn).</p> <p>** Some interference between air lines and mounting brackets.</p> <p>** Some wear from coupling-uncoupling cycling.</p> |                                                                                             |      |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| *IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| *IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| *IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| *IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| *IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="padding: 2px;">Pertinent Functions</td></tr> <tr><td style="padding: 2px;">IIA1.</td></tr> <tr><td style="padding: 2px;">IIA2.</td></tr> <tr><td style="padding: 2px;">IIA3.</td></tr> <tr><td style="padding: 2px;">IIB1.</td></tr> <tr><td style="padding: 2px;">IIB2.</td></tr> <tr><td style="padding: 2px;">IIB3.</td></tr> <tr><td style="padding: 2px;">IIB4.</td></tr> <tr><td style="padding: 2px;">IIC1.</td></tr> <tr><td style="padding: 2px;">IIC2.</td></tr> <tr><td style="padding: 2px;">IIC3.</td></tr> <tr><td style="padding: 2px;">IID.</td></tr> </table>     | Pertinent Functions                      | IIA1.  | IIA2.                       | IIA3.   | IIB1.                                | IIB2.  | IIB3.                                 | IIB4.  | IIC1.                         | IIC2.                                                                                                                                                                                                                                                                                                                                                | IIC3.                                                                                       | IID. |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
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| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="padding: 2px;">Pertinent Functions</td></tr> <tr><td style="padding: 2px;">IVA1.</td></tr> <tr><td style="padding: 2px;">IVA2.</td></tr> <tr><td style="padding: 2px;">VBI.</td></tr> <tr><td style="padding: 2px;">VB3.</td></tr> <tr><td style="padding: 2px;">VB4.</td></tr> <tr><td style="padding: 2px;">VB5.</td></tr> <tr><td style="padding: 2px;">VB6.</td></tr> <tr><td style="padding: 2px;">*VC.</td></tr> </table>                                                                                                                                                    | Pertinent Functions                      | IVA1.  | IVA2.                       | VBI.    | VB3.                                 | VB4.   | VB5.                                  | VB6.   | *VC.                          | <p>- Improved safety due to automatic air connection.</p>                                                                                                                                                                                                                                                                                            |                                                                                             |      |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| VBI.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| VB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| VB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| VB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| VB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |
| *VC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |        |                             |         |                                      |        |                                       |        |                               |                                                                                                                                                                                                                                                                                                                                                      |                                                                                             |      |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 451c: ROBERTS AIR CONNECTOR

Primary Bibliography Reference No.: 451

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------|-----------------------------|---|---------------------------|--------------------------------------|--|--|---------------------------------------|--|--|-------------------------------|--|--|
| Related Reference Number(s) 434                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| <table border="1"> <tr> <td>Compatibility with AA Type "E" Coupler:</td> <td></td> <td>Coupler mounted, spread-wing type with butt line connections (spring loaded);</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td align="center">X</td> <td>Automatic air connection.</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> <td></td> </tr> </table> |                                                                                                                                                                                                                                                                                                                                               | Compatibility with AA Type "E" Coupler:                                       |  | Coupler mounted, spread-wing type with butt line connections (spring loaded); | 1. Can be added to Type "E" | X | Automatic air connection. | 2. Requires modification of Type "E" |  |  | 3. Requires head adapter for Type "E" |  |  | 4. Incompatible with Type "E" |  |  |
| Compatibility with AA Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                               | Coupler mounted, spread-wing type with butt line connections (spring loaded); |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | X                                                                                                                                                                                                                                                                                                                                             | Automatic air connection.                                                     |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| <p align="center"><b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p>Built-in gathering</p> <p>** Excessive weight of approximately 227 lbs.</p> <p>*A1. ** Unstable spread-wing design (high engagement angle) results in binding and twisting of wings.</p> <p>*A2. ** Unacceptable high wear rate from cycling.</p> <p>*A3. ** Tendency to bind and seize with wear.</p> <p>*B1.</p> <p>*B2.</p> <p>*B3.</p> |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| <p align="center"><b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p>*A1.</p> <p>*A2.</p> <p>*A3.</p> <p>*B1.</p> <p>*B2.</p> <p>*B3.</p> <p>*B4.</p> <p>*C1.</p> <p>*C2.</p> <p>*C3.</p> <p>*D.</p>                                                                                                                                                                                                            |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| <p align="center"><b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p>*A1.</p> <p>*A2.</p> <p>*A3a.</p> <p>*A3b.</p> <p>*A4.</p> <p>*B1.</p> <p>*B2.</p>                                                                                                                                                                                                                                                         |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| <p align="center"><b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                               |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p>*A1.</p> <p>*A2.</p> <p>*B1.</p> <p>*B3.</p> <p>*B4.</p> <p>*B5.</p> <p>*B6.</p> <p>*VC.</p> <p>- Improved safety due to automatic air connection.</p>                                                                                                                                                                                     |                                                                               |  |                                                                               |                             |   |                           |                                      |  |  |                                       |  |  |                               |  |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 451d: JOHNSON AIR CONNECTOR

Primary Bibliography Reference No.: 451

|                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 434                                                                                                                                                                |                                                                                                                                                                                                                                                                                         |
| Description of Concept                                                                                                                                                                         |                                                                                                                                                                                                                                                                                         |
| <div style="float: right; text-align: right;"> Car mounted (with coupler guide), scoop-knob<br/> type with angled line connections (spring<br/> loaded);<br/> Automatic air connection. </div> |                                                                                                                                                                                                                                                                                         |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                       |                                                                                                                                                                                                                                                                                         |
| 1. Can be added to Type "E"                                                                                                                                                                    | X                                                                                                                                                                                                                                                                                       |
| 2. Requires modification of Type "E"                                                                                                                                                           |                                                                                                                                                                                                                                                                                         |
| 3. Requires head adapter for Type "E"                                                                                                                                                          |                                                                                                                                                                                                                                                                                         |
| 4. Incompatible with Type "E"                                                                                                                                                                  |                                                                                                                                                                                                                                                                                         |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                     |                                                                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                            | Built-in gathering<br>** Excessively heavy (approximately 440 lbs.) and complicated (80 parts)<br>** Angled air connections subject to coupling damage.<br>** Steel buffer spring tubes subject to binding.<br>** Long cantilever effect caused excess vibration damage when uncoupled. |
| *IA1.<br>*IA2.<br>IA3.<br>IA3b.<br>IA3c.<br>*IB1.<br>*IB2.<br>*IB3.                                                                                                                            |                                                                                                                                                                                                                                                                                         |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                      |                                                                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                            |                                                                                                                                                                                                                                                                                         |
| IA1.<br>IA2.<br>IA3.<br>IB1.<br>IB2.<br>IB3.<br>IB4.<br>IC1.<br>IC2.<br>IC3.<br>ID.                                                                                                            |                                                                                                                                                                                                                                                                                         |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                   |                                                                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                            |                                                                                                                                                                                                                                                                                         |
| IA1.<br>IA2.<br>IA3a.<br>IA3b.<br>IA4.<br>IB1.<br>IB2.                                                                                                                                         |                                                                                                                                                                                                                                                                                         |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                          |                                                                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                            | Improved safety due to automatic air connection.                                                                                                                                                                                                                                        |
| IA1.<br>IA2.<br>IB1.<br>IB3.<br>IB4.<br>IB5.<br>IB6.<br>*IC.                                                                                                                                   |                                                                                                                                                                                                                                                                                         |

Notes: \*This concept embodies improvements in this function.  
\*\*Denotes potential operating or safety problem.

# Concept 451e: "COMPATIMATIC" AIR CONNECTOR

Primary Bibliography Reference No.: 451

|                                                                         |   |
|-------------------------------------------------------------------------|---|
| Related Reference Number(s) 434, 451e, 511b                             |   |
| Description of Concept                                                  |   |
| - Same unit as WABCO train air connector described in Biblio. No. 511b. |   |
| Compatibility with AAR Type "E" Coupler:                                |   |
| 1. Can be added to Type "E"                                             | X |
| 2. Requires modification of Type "E"                                    |   |
| 3. Requires head adapter for Type "E"                                   |   |
| 4. Incompatible with Type "E"                                           |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                              |   |
| Pertinent Functions:                                                    |   |
| IA1.                                                                    |   |
| IA2.                                                                    |   |
| IA3a.                                                                   |   |
| IA3b.                                                                   |   |
| IA3c.                                                                   |   |
| IB1.                                                                    |   |
| IB2.                                                                    |   |
| IB3.                                                                    |   |
| IC1.                                                                    |   |
| IC2.                                                                    |   |
| IC3.                                                                    |   |
| IC4.                                                                    |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                               |   |
| Pertinent Functions:                                                    |   |
| IIA1.                                                                   |   |
| IIA2.                                                                   |   |
| IIA3.                                                                   |   |
| IIA4.                                                                   |   |
| IIB1.                                                                   |   |
| IIB2.                                                                   |   |
| IIB3.                                                                   |   |
| IIB4.                                                                   |   |
| IIC1.                                                                   |   |
| IIC2.                                                                   |   |
| IIC3.                                                                   |   |
| IIC4.                                                                   |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                            |   |
| Pertinent Functions:                                                    |   |
| IIIA1.                                                                  |   |
| IIIA2.                                                                  |   |
| IIIA3a.                                                                 |   |
| IIIA3b.                                                                 |   |
| IIIA4.                                                                  |   |
| IIIB1.                                                                  |   |
| IIIB2.                                                                  |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                   |   |
| Pertinent Functions:                                                    |   |
| IVA1.                                                                   |   |
| IVA2.                                                                   |   |
| IVB1.                                                                   |   |
| IVB3.                                                                   |   |
| IVB4.                                                                   |   |
| IVB5.                                                                   |   |
| IVB6.                                                                   |   |
| IVC.                                                                    |   |
| - Ref. Biblio. No. 511b - WABCO train air connector.                    |   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 451f: AMERICAN AIR CONNECTOR

Primary Bibliography Reference No.: 451

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------------------------------------------|--------|-----------------------------|-------------------------------------|--------------------------------------|--------------------------|---------------------------------------|--------------------------|------------------------------------------------------------------------------------------------------|--------------------------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 434                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| <table border="1"> <tr> <td colspan="2">Compatibility with AAR Type "E" Coupler:</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td><input type="checkbox"/></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td><input type="checkbox"/></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td><input type="checkbox"/></td> </tr> </table> |                                     | Compatibility with AAR Type "E" Coupler: |        | 1. Can be added to Type "E" | <input checked="" type="checkbox"/> | 2. Requires modification of Type "E" | <input type="checkbox"/> | 3. Requires head adapter for Type "E" | <input type="checkbox"/> | 4. Incompatible with Type "E"                                                                        | <input type="checkbox"/> |      |                                                                                                                                                                                                                                                            |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <input checked="" type="checkbox"/> |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                         | <input type="checkbox"/>            |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                        | <input type="checkbox"/>            |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                | <input type="checkbox"/>            |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| Coupler mounted, horn-funnel type with angled line connections (spring loaded); automatic air connection.                                                                                                                                                                                                                                                                                                                                                                    |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| <p align="center"><b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b></p>                                                                                                                                                                                                                                                                                                                                                                                                      |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>* IAI.</td></tr> <tr><td>* IAZ.</td></tr> <tr><td>IA3a.</td></tr> <tr><td>IA3b.</td></tr> <tr><td>IA3c.</td></tr> <tr><td>IB1.</td></tr> <tr><td>IB2.</td></tr> <tr><td>IB3.</td></tr> <tr><td> </td></tr> <tr><td> </td></tr> <tr><td> </td></tr> </table>                                                                                                                                                 | Pertinent Functions                 | * IAI.                                   | * IAZ. | IA3a.                       | IA3b.                               | IA3c.                                | IB1.                     | IB2.                                  | IB3.                     |                                                                                                      |                          |      | <ul style="list-style-type: none"> <li>* Built-in gathering angle air connections subject to coupling damage</li> <li>* Tendency to score and scrape at sharp corners of gathering horn and funnel.</li> <li>- Weight of approximately 182 lbs.</li> </ul> |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| * IAI.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| * IAZ.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| <p align="center"><b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b></p>                                                                                                                                                                                                                                                                                                                                                                                                       |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIA1.</td></tr> <tr><td>IIA2.</td></tr> <tr><td>IIA3.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> <tr><td>IIB3.</td></tr> <tr><td>IIB4.</td></tr> <tr><td>IIC1.</td></tr> <tr><td>IIC2.</td></tr> <tr><td>IIC3.</td></tr> <tr><td>IID.</td></tr> </table>                                                                                                                                     | Pertinent Functions                 | IIA1.                                    | IIA2.  | IIA3.                       | IIB1.                               | IIB2.                                | IIB3.                    | IIB4.                                 | IIC1.                    | IIC2.                                                                                                | IIC3.                    | IID. |                                                                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| <p align="center"><b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b></p>                                                                                                                                                                                                                                                                                                                                                                                                    |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IIIA1.</td></tr> <tr><td>IIIA2.</td></tr> <tr><td>IIIA3a.</td></tr> <tr><td>IIIA3b.</td></tr> <tr><td>IIIA4.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> </table>                                                                                                                                                                                                                             | Pertinent Functions                 | IIIA1.                                   | IIIA2. | IIIA3a.                     | IIIA3b.                             | IIIA4.                               | IIB1.                    | IIB2.                                 |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| <p align="center"><b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b></p>                                                                                                                                                                                                                                                                                                                                                                                                           |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| <table border="1"> <tr><td>Pertinent Functions</td></tr> <tr><td>IVA1.</td></tr> <tr><td>IVA2.</td></tr> <tr><td>IVB1.</td></tr> <tr><td>IVB3.</td></tr> <tr><td>IVB4.</td></tr> <tr><td>IVB5.</td></tr> <tr><td>IVB6.</td></tr> <tr><td>* IVC.</td></tr> </table>                                                                                                                                                                                                           | Pertinent Functions                 | IVA1.                                    | IVA2.  | IVB1.                       | IVB3.                               | IVB4.                                | IVB5.                    | IVB6.                                 | * IVC.                   | <ul style="list-style-type: none"> <li>- Improved safety due to automatic air connection.</li> </ul> |                          |      |                                                                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IVB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IVB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IVB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| IVB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |
| * IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                     |                                          |        |                             |                                     |                                      |                          |                                       |                          |                                                                                                      |                          |      |                                                                                                                                                                                                                                                            |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 452: DRESSER ESACS CONTROL SYSTEM

Primary Bibliography Reference No.: 452

|                                                                |                                                                                                                    |
|----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 448, 517, 1042                     |                                                                                                                    |
| Description of Concept                                         |                                                                                                                    |
| <p align="center">Multiplexing sensory and control system.</p> |                                                                                                                    |
| Compatibility with AAB Type "E" Coupler:                       |                                                                                                                    |
| 1. Can be added to Type "E"                                    | X                                                                                                                  |
| 2. Requires modification of Type "E"                           |                                                                                                                    |
| 3. Requires head adapter for Type "E"                          |                                                                                                                    |
| 4. Incompatible with Type "E"                                  |                                                                                                                    |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                     |                                                                                                                    |
| Pertinent Functions                                            |                                                                                                                    |
| IA1.                                                           |                                                                                                                    |
| IA2.                                                           |                                                                                                                    |
| IA3a.                                                          |                                                                                                                    |
| IA3b.                                                          |                                                                                                                    |
| IA3c.                                                          |                                                                                                                    |
| IB1.                                                           |                                                                                                                    |
| IB2.                                                           |                                                                                                                    |
| IB3.                                                           |                                                                                                                    |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                      |                                                                                                                    |
| Pertinent Functions                                            |                                                                                                                    |
| IIA1.                                                          |                                                                                                                    |
| IIA2.                                                          |                                                                                                                    |
| IIA3.                                                          |                                                                                                                    |
| IIB1.                                                          |                                                                                                                    |
| IIB2.                                                          |                                                                                                                    |
| IIB3.                                                          |                                                                                                                    |
| IIB4.                                                          |                                                                                                                    |
| IIC1.                                                          |                                                                                                                    |
| IIC2.                                                          |                                                                                                                    |
| IIC3.                                                          |                                                                                                                    |
| IID.                                                           |                                                                                                                    |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                   |                                                                                                                    |
| Pertinent Functions                                            |                                                                                                                    |
| IIIA1.                                                         |                                                                                                                    |
| IIIA2.                                                         |                                                                                                                    |
| IIIA3a.                                                        |                                                                                                                    |
| IIIA3b.                                                        |                                                                                                                    |
| IIIA4.                                                         |                                                                                                                    |
| IIB1.                                                          |                                                                                                                    |
| IIB2.                                                          |                                                                                                                    |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                          |                                                                                                                    |
| Pertinent Functions                                            |                                                                                                                    |
| IVA1.                                                          | - Train sensing and control using a minimum (approximately 5) electrical inter-connection lines.                   |
| * IVA2.                                                        |                                                                                                                    |
| IVB1.                                                          | ** Require electrical connection system and "black box" electronic logic package in each car in order to function. |
| IVB3.                                                          |                                                                                                                    |
| IVB4.                                                          |                                                                                                                    |
| * IVB5.                                                        |                                                                                                                    |
| * IVB6.                                                        |                                                                                                                    |
| * IVC.                                                         |                                                                                                                    |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 457: DOWTY AUTOMATIC CENTRAL COUPLER

Primary Bibliography Reference No.: 457

|                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Description of Concept                       | <p>Semi-rigid, discontinuous movement, "V" shaped gathering horns (on 45° slant), spring loaded latch and lock;<br/>         Uncoupling lever rotates out lock and pushes the mating latch out of lock position;<br/>         Latches and locks are spring loaded in ready position;<br/>         Uncoupling lever can be locked in open position (requires manual disengage);<br/>         "Knuckle" always open and automatic air connection.<br/>         Automatic air connector-supported below semi-rigid coupler head with automatic connection and improved performance.</p> |
| Compatibility with AAR Type "E" Coupler:     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 1. Can be added to Type "E"                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 2. Requires modification of Type "E"         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 3. Requires head adapter for Type "E"        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 4. Incompatible with Type "E"                | X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IA1.                                        | ** Rigid support of air connector depends on coupler for gathering and holding.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IA2.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IA3a.                                        | ** Butt type rubber seal with closure force maintained by a backing of compressed rubber blocks (possibly subject to less of sealing force due to aging of rubber).                                                                                                                                                                                                                                                                                                                                                                                                                  |
| IA3b.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IA3c.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IB1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IB2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IB3.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CATEGORY II - IMPROVE MECHANICAL COUPLING    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IA1.                                        | - Large gathering range<br>Lateral = ± 7" (3.5 times standard gathering range).<br>Vertical = ± 7" (4.7 times standard gathering range).                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| *IA2.                                        | - Hinged locks and latches slide together and interlock.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| *IA3.                                        | ** Discontinuous coupling movement at 90° force angles may create excessive shear forces on hinge pins.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| *IB1.                                        | - Coupling possible up to 15 mph (3.75 times standard maximum speed).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| *IB2.                                        | - Vertical interlock and entrapment achieved by wedging action of 45° offset (90° total) "V" shaped gathering horns plus locks and latches.                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| *IB3.                                        | ** Coupler shank supported by spring attached to a spherical rubber joint for centering - possibly subject to malfunction from rubber fatigue from draft movements and continuous vibration under stress of coupler weight.                                                                                                                                                                                                                                                                                                                                                          |
| *IC1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IC2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IC3.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| ID.                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IA1.                                        | - Achieves positive uncoupling release in draft                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IA2.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IA3a.                                        | - Locking latches (knuckle) are spring loaded in open position at uncoupling.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| IA3b.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IA4.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IB1.                                        | - Allows yard switching where coupling will not automatically take place.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| *IB2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IVA1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IVA2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IVB1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IVB3.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IVB4.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IVB5.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IVB6.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| *IVC.                                        | - Improved safety due to automatic air connection and reduced by-pass probability.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 458: ROBINSON AIR CONNECTOR

Primary Bibliography Reference No.: 458

|                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 434, 451                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td colspan="2">Compatibility with AAR Type "E" Coupler:</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td align="center">X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Compatibility with AAR Type "E" Coupler: |  | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                      | X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <div style="float: right; width: 40%;"> <p>Automatic air connection;</p> <p>Coupler mounted, spread-wing type with butt line connections (spring loaded compressible rubber seals).</p> </div>                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <p align="center"><b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b></p>                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <p>Pertinent Functions</p> <p>*IA1.</p> <p>*IA2.</p> <p>IA3a.</p> <p>IA3b.</p> <p>IA3c.</p> <p>IB1.</p> <p>IB2.</p> <p>IB3.</p>                                                                                                                                                                                                                                                                                                  | <p>Built-in gathering</p> <p>** Tendency to bind and seize with wear.</p> <p>- Detachable air passage and seal system allows use of a cheaper base casting.</p> <p>** High wear rate from cycling (can apparently be reduced or alleviated by wing design changes to higher strength and rigidity).</p> <p>- Spread-wing design includes a potential for later design changes for greater gathering range while retaining interchangeability.</p> <p>- Individual spring loaded rubber seals should enhance cold weather sealing.</p> |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <p align="center"><b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b></p>                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <p>Pertinent Functions</p> <p>IIA1.</p> <p>IIA2.</p> <p>IIA3.</p> <p>IIB1.</p> <p>IIB2.</p> <p>IIB3.</p> <p>IIB4.</p> <p>IIC1.</p> <p>IIC2.</p> <p>IIC3.</p> <p>IID.</p>                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <p align="center"><b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b></p>                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <p>Pertinent Functions</p> <p>IIIA1.</p> <p>IIIA2.</p> <p>IIIA3a.</p> <p>IIIA3b.</p> <p>IIIA4.</p> <p>IIB1.</p> <p>IIB2.</p>                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <p align="center"><b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b></p>                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                          |  |                             |   |                                      |  |                                       |  |                               |  |
| <p>Pertinent Functions</p> <p>IVA1.</p> <p>IVA2.</p> <p>IVB1.</p> <p>IVB3.</p> <p>IVB4.</p> <p>IVB5.</p> <p>IVB6.</p> <p>*IVC.</p>                                                                                                                                                                                                                                                                                               | <p>- Improved safety due to automatic air connection.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                          |  |                             |   |                                      |  |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 501: ASF COUPLER KNUCKLE CONTOUR CHANGE

Primary Bibliography Reference No.: 501

|                                                                                                                                                 |                                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                     |                                                                                             |
| Description of Concept                                                                                                                          |                                                                                             |
| <p>Revise front shape of knuckle and add 5/64 in. to front of knuckle;<br/>         Reduced free slack and greater lateral gathering range.</p> |                                                                                             |
| Comp. Compatibility with AAF Type "E" Coupler:                                                                                                  |                                                                                             |
| 1. Can be added to Type "E"                                                                                                                     | X                                                                                           |
| 2. Requires modification of Type "E"                                                                                                            | X                                                                                           |
| 3. Requires head adapter for Type "E"                                                                                                           |                                                                                             |
| 4. Incompatible with Type "E"                                                                                                                   |                                                                                             |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                      |                                                                                             |
| Pertinent Functions                                                                                                                             |                                                                                             |
| IA1.                                                                                                                                            |                                                                                             |
| IA2.                                                                                                                                            |                                                                                             |
| IA3a.                                                                                                                                           |                                                                                             |
| IA3b.                                                                                                                                           |                                                                                             |
| IA3c.                                                                                                                                           |                                                                                             |
| IB1.                                                                                                                                            |                                                                                             |
| IB2.                                                                                                                                            |                                                                                             |
| IB3.                                                                                                                                            |                                                                                             |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                       |                                                                                             |
| Pertinent Functions                                                                                                                             |                                                                                             |
| *IA1.                                                                                                                                           | - Increased lateral gathering: 6-7/8" total (1.7 x standard).                               |
| IA2.                                                                                                                                            | - Decreased free slack: 5/8" total for two mated "E" couplers so modified (0.8 x standard). |
| IA3.                                                                                                                                            |                                                                                             |
| IB1.                                                                                                                                            |                                                                                             |
| *IB2.                                                                                                                                           |                                                                                             |
| IB3.                                                                                                                                            |                                                                                             |
| IB4.                                                                                                                                            |                                                                                             |
| IC1.                                                                                                                                            |                                                                                             |
| IC2.                                                                                                                                            |                                                                                             |
| IC3.                                                                                                                                            |                                                                                             |
| ID.                                                                                                                                             |                                                                                             |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                    |                                                                                             |
| Pertinent Functions                                                                                                                             |                                                                                             |
| IIA1.                                                                                                                                           |                                                                                             |
| IIA2.                                                                                                                                           |                                                                                             |
| IIA3a.                                                                                                                                          |                                                                                             |
| IIA3b.                                                                                                                                          |                                                                                             |
| IIA4.                                                                                                                                           |                                                                                             |
| IIIB1.                                                                                                                                          |                                                                                             |
| IIIB2.                                                                                                                                          |                                                                                             |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                           |                                                                                             |
| Pertinent Functions                                                                                                                             |                                                                                             |
| IVA1.                                                                                                                                           |                                                                                             |
| IVA2.                                                                                                                                           |                                                                                             |
| IVB1.                                                                                                                                           |                                                                                             |
| IVB3.                                                                                                                                           | - Improved safety due to reduced bypass probability.                                        |
| IVB4.                                                                                                                                           |                                                                                             |
| IVB5.                                                                                                                                           |                                                                                             |
| IVB6.                                                                                                                                           |                                                                                             |
| *IVC.                                                                                                                                           |                                                                                             |

Note: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

Concept 502a: NATIONAL CASTINGS I.G.R. COUPLER KNUCKLE

Primary Bibliography Reference No.: 502

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------------|--|----------------------------------------------------------------------|-----------------------------|---|--------------------------------------|---|---------------------------------------|--|-------------------------------|--|--|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| <table border="1"> <tr> <td colspan="2">Compatibility with AAR Type "E" Coupler:</td> <td rowspan="4">Revise front shape of knuckle;<br/>Increased lateral gathering range.</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "F"</td> <td>X</td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> <td></td> </tr> </table> |                                                                | Compatibility with AAR Type "E" Coupler:                             |  | Revise front shape of knuckle;<br>Increased lateral gathering range. | 1. Can be added to Type "E" | X | 2. Requires modification of Type "F" | X | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                | Revise front shape of knuckle;<br>Increased lateral gathering range. |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                              | X                                                              |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| 2. Requires modification of Type "F"                                                                                                                                                                                                                                                                                                                                                                                                                                     | X                                                              |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| *IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | - Increased lateral gathering: 5/7/8" total (1.47 x standard). |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| VB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| VB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| VB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| VB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| VB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |
| *VC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | - Improved safety due to reduced bypass probability.           |                                                                      |  |                                                                      |                             |   |                                      |   |                                       |  |                               |  |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 502b: NATIONAL CASTINGS "COMPATIMATIC" COUPLER

Primary Bibliography Reference No.: 502

|                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|------------------------------------------|--|-----------------------------|---|--------------------------------------|---|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                         |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Description of Concept                                                                                                                                                                                                                                                                                                                                              |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| <table border="1"> <tr> <td colspan="2">Compatibility with AAR Type "E" Coupler:</td> </tr> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td>X</td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                    | Compatibility with AAR Type "E" Coupler: |  | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" | X | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                            |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                         | X                                                                                                                  |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                | X                                                                                                                  |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                       |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| <p>Knuckle is always open;</p> <p>Rotary bottom lockset is alternate;</p> <p>Knuckle is automatically spring loaded in open position at uncoupling;</p>                                                                                                                                                                                                             |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                          |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IA1.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IA2.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                           |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| *IIA1.                                                                                                                                                                                                                                                                                                                                                              | - Assured maximum lateral gathering range of:                                                                      |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                                               | "E" system: 4" total (1.0 x standard).                                                                             |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IIA3.                                                                                                                                                                                                                                                                                                                                                               | "F" system: 4-3/4" total (1.19 x standard).                                                                        |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IB1.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IB2.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IB3.                                                                                                                                                                                                                                                                                                                                                                | - Positive locking at coupling by the compatimatic device rotating the lockset and allowing lock to drop in place. |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IB4.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IC1.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IC2.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IC3.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IID.                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                        |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| *IIIA1.                                                                                                                                                                                                                                                                                                                                                             | - Allows use of alternate side uncoupling lever.                                                                   |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                             | - Knuckle always open and cannot vibrate or shock closed without coupling action.                                  |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| *IIIB1.                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IIIB2.                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                                                |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IVB1.                                                                                                                                                                                                                                                                                                                                                               | - Improved safety due to decreased probability of bypass.                                                          |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IVB3.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IVB4.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IVB5.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| IVB6.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |
| *IVC.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                    |                                          |  |                             |   |                                      |   |                                       |  |                               |  |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 502c: NATIONAL CASTINGS AIR/ELECTRICAL CONNECTOR

Primary Bibliography Reference No.: 502

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                           |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                           |
| <p>Coupler mounted, modified spread-wing type with butt line seal (spring loaded);<br/>         Modified spread-wing design depends on coupler for primary gathering (three gathering lugs with approximately 3/4" depth);<br/>         Mounting flexibility is limited to longitudinal spring travel;<br/>         Spring loaded compression of rubber butt type seal;<br/>         Backing spring provides closure force for both air/electrical connections;</p> |                                                                                                                                           |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                            | Gathering range and vertical movement range is limited;                                                                                   |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                         | Electrical control of air valves;                                                                                                         |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                | Automatic air connection and remote uncoupling;                                                                                           |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                               | Uncoupling release from within train by operation of the uncoupling lever from an electric solenoid operated through train electric line. |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                       | X                                                                                                                                         |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                           |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Designed for use with an "F" type interlocking coupler.                                                                                   |
| *IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                               | - Desirable weight of approximately 60 lbs.                                                                                               |
| *IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ** Limited for use with gathering provided by "F" coupler and interlocking protection.                                                    |
| *IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ** No provision for "mixed" coupling connection.                                                                                          |
| *IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                              | - Good basic sealing design.                                                                                                              |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| *IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| *IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| *IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| *IB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| *IC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| *IC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| *IC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| *ID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                           |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                           |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                           |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                           |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                           |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                           |
| IB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                           |
| IC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                           |
| IC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                           |
| IC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                           |
| ID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                           |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                           |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                           |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ** Electric solenoid could require an excessive power load to "break loose" uncoupling rods in a bind or rusty or frozen in place.        |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                           |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                             | ** System only good for the one car immediately behind locomotive.                                                                        |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                           |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                           |
| IIIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                           |
| IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                           |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                 | - Compatible with "F" system (add-on unit).                                                                                               |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ** Primary connector spring design must be strong enough to maintain forward force required for both air/electrical connections.          |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                               | - Each electrical contact has a separate loading spring.                                                                                  |
| *IVB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ** Designed for use with an "F" type interlocking coupler system.                                                                         |
| IVB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ** Valve control limited to first car behind locomotive.                                                                                  |
| IVB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                               | - Improve safety due to automatic air connector.                                                                                          |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |
| *IVB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                           |
| *IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                           |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 502d: WILLISON MINE CAR COUPLER

Primary Bibliography Reference No.: 502

|                                                                                                                                                                                                                                                                                                                                        |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--------|--------------------------------------|---------|---------------------------------------|-------|-------------------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 448                                                                                                                                                                                                                                                                                                        |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| Description of Concept                                                                                                                                                                                                                                                                                                                 |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| <p>Comparison with AAR Type "E" Coupler:</p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td></td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td>X</td> </tr> </table> | 1. Can be added to Type "E" |        | 2. Requires modification of Type "E" |         | 3. Requires head adapter for Type "E" |       | 4. Incompatible with Type "E" | X      | <p>Same design concepts as Willison Type II; Biblio. No. 301a except on a smaller scale;</p> <p>Rubber cushioning units on both sides of shank to achieve self centering.</p> |       |      |                                                                                                                                                        |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                   |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                          | X                           |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| <p>Pertinent Functions:</p> <table border="1"> <tr><td>IA1.</td></tr> <tr><td>IA2.</td></tr> <tr><td>IA3a.</td></tr> <tr><td>IA3b.</td></tr> <tr><td>IA3c.</td></tr> <tr><td>IB1.</td></tr> <tr><td>IB2.</td></tr> <tr><td>IB3.</td></tr> </table>                                                                                     | IA1.                        | IA2.   | IA3a.                                | IA3b.   | IA3c.                                 | IB1.  | IB2.                          | IB3.   |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IA1.                                                                                                                                                                                                                                                                                                                                   |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IA2.                                                                                                                                                                                                                                                                                                                                   |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IA3a.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IA3b.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IA3c.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IB1.                                                                                                                                                                                                                                                                                                                                   |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IB2.                                                                                                                                                                                                                                                                                                                                   |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IB3.                                                                                                                                                                                                                                                                                                                                   |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                              |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| <p>Pertinent Functions:</p> <table border="1"> <tr><td>IIA1.</td></tr> <tr><td>IIA2.</td></tr> <tr><td>IIA3.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> <tr><td>IIB3.</td></tr> <tr><td>IIB4.</td></tr> <tr><td>*IIC1.</td></tr> <tr><td>IIC2.</td></tr> <tr><td>IIC3.</td></tr> <tr><td>IID.</td></tr> </table>        | IIA1.                       | IIA2.  | IIA3.                                | IIB1.   | IIB2.                                 | IIB3. | IIB4.                         | *IIC1. | IIC2.                                                                                                                                                                         | IIC3. | IID. | <p>** Potential for loss of restraining and centering capabilities due to loss of resiliency of rubber due to environmental and temperature aging.</p> |
| IIA1.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIA2.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIA3.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIB1.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIB2.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIB3.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIB4.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| *IIC1.                                                                                                                                                                                                                                                                                                                                 |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIC2.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIC3.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IID.                                                                                                                                                                                                                                                                                                                                   |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                           |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| <p>Pertinent Functions:</p> <table border="1"> <tr><td>IIIA1.</td></tr> <tr><td>IIIA2.</td></tr> <tr><td>IIIA3a.</td></tr> <tr><td>IIIA3b.</td></tr> <tr><td>IIIA4.</td></tr> <tr><td>IIB1.</td></tr> <tr><td>IIB2.</td></tr> </table>                                                                                                 | IIIA1.                      | IIIA2. | IIIA3a.                              | IIIA3b. | IIIA4.                                | IIB1. | IIB2.                         |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIIA1.                                                                                                                                                                                                                                                                                                                                 |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIIA2.                                                                                                                                                                                                                                                                                                                                 |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIIA4.                                                                                                                                                                                                                                                                                                                                 |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIB1.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IIB2.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| <p>Pertinent Functions:</p> <table border="1"> <tr><td>IVA1.</td></tr> <tr><td>IVA2.</td></tr> <tr><td>IVB1.</td></tr> <tr><td>IVB3.</td></tr> <tr><td>IVB4.</td></tr> <tr><td>IVB5.</td></tr> <tr><td>IVB6.</td></tr> <tr><td>IVC.</td></tr> </table>                                                                                 | IVA1.                       | IVA2.  | IVB1.                                | IVB3.   | IVB4.                                 | IVB5. | IVB6.                         | IVC.   |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IVA1.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IVA2.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IVB1.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IVB3.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IVB4.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IVB5.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IVB6.                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |
| IVC.                                                                                                                                                                                                                                                                                                                                   |                             |        |                                      |         |                                       |       |                               |        |                                                                                                                                                                               |       |      |                                                                                                                                                        |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

Concept 503: OHIO BRASS RAPID TRANSIT COUPLER

Primary Bibliography Reference No.: 503

|                                                                                              |                                     |
|----------------------------------------------------------------------------------------------|-------------------------------------|
| Related Reference Number(s) 254, 448                                                         |                                     |
| Description of Concept                                                                       |                                     |
| <p>Form 15</p> <p>Form 21 Are all similar to bibliography reference 503a.</p> <p>Form 26</p> |                                     |
| Compatibility with AAR Type "E" Coupler:                                                     |                                     |
| 1. Can be added to Type "E"                                                                  | <input type="checkbox"/>            |
| 2. Requires modification of Type "E"                                                         | <input type="checkbox"/>            |
| 3. Requires head adapter for Type "E"                                                        | <input type="checkbox"/>            |
| 4. Incompatible with Type "E"                                                                | <input checked="" type="checkbox"/> |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                   |                                     |
| Pertinent Functions                                                                          |                                     |
| IA1.                                                                                         |                                     |
| IA2.                                                                                         |                                     |
| IA3a.                                                                                        |                                     |
| IA3b.                                                                                        |                                     |
| IA3c.                                                                                        |                                     |
| IB1.                                                                                         |                                     |
| IB2.                                                                                         |                                     |
| IB3.                                                                                         |                                     |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                    |                                     |
| Pertinent Functions                                                                          |                                     |
| IIA1.                                                                                        |                                     |
| IIA2.                                                                                        |                                     |
| IIA3.                                                                                        |                                     |
| IIB1.                                                                                        |                                     |
| IIB2.                                                                                        |                                     |
| IIB3.                                                                                        |                                     |
| IIB4.                                                                                        |                                     |
| IIC1.                                                                                        |                                     |
| IIC2.                                                                                        |                                     |
| IIC3.                                                                                        |                                     |
| IID.                                                                                         |                                     |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                 |                                     |
| Pertinent Functions                                                                          |                                     |
| IIIA1.                                                                                       |                                     |
| IIIA2.                                                                                       |                                     |
| IIIA3a.                                                                                      |                                     |
| IIIA3b.                                                                                      |                                     |
| IIIA4.                                                                                       |                                     |
| IIB1.                                                                                        |                                     |
| IIB2.                                                                                        |                                     |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                        |                                     |
| Pertinent Functions                                                                          |                                     |
| IVA1.                                                                                        |                                     |
| IVA2.                                                                                        |                                     |
| IVB1.                                                                                        |                                     |
| IVB3.                                                                                        |                                     |
| IVB4.                                                                                        |                                     |
| IVB5.                                                                                        |                                     |
| IVB6.                                                                                        |                                     |
| IVC.                                                                                         |                                     |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 503a: OHIO BRASS FORM 70 (SOAC RAPID TRANSIT) COUPLER

Primary Bibliography Reference No.: 503

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                       |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                       |
| <p>Rigid, flat face, automatic, tightlock, horn-pocket type; 4" symmetrical horn fits opposite recessed pocket; mechanical interlocking of spring-loaded hinges hooks; flat machined coupler faces; interlocking hocks and aligning pins/dowels; side air cylinders working against shank; tightlock coupler with mating flat faces; lubrication fittings in coupler head and at drawbar joints and replaceable nylon and manganese steel wear plates; rigid coupler with integral automatic air connections and automatic operation of air valves improved performance; uncoupling by electrical signal to air cylinder; air cylinder forces cam to wedge open locking hook (no actuate opposite cam); spring loaded hook always ready to couple; Walton electro pneumatic system with: automatic electrical system actuated by completion of mechanical coupling through time delay solenoid contact closure; environmental cover automatically operated by coupling forces; uncoupling and slack free design; electrical control of air valves and uncoupling; automatic air connection, valve control.</p> |                                                                                                       |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                       |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                       |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                       |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                       |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | X                                                                                                     |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                       |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                       |
| *IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                       |
| *IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | - Two spring loaded air connections with compressed rubber gaskets provide good sealing.              |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                       |
| *IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                       |
| *IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Air valve control from Walton electric pneumatic switching system.                                  |
| *IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                       |
| *IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | - Less air leakage, reduced maintenance.                                                              |
| *IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                       |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                       |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                       |
| *IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - State of the art (SOAC) rapid transit coupler.                                                      |
| *IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | ** Design is proven in rapid transit applications, but size, gathering range and strength is limited. |
| *IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Not compatible with "E" system.                                                                     |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | - Lateral $\pm 3-3/8"$ (1.7 times standard), vertical $\pm 3"$ (2.0 times standard).                  |
| *IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Positive locking at coupling.                                                                       |
| *IIB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Free slack 0.14" (0.18 times standard).                                                             |
| *IIB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Good vertical interlock and broken coupler entrapment.                                              |
| *IIC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Positive self centering with automatic disengagement at a coupling.                                 |
| *IIC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Minimum of contour angling - requires vertical articulation.                                        |
| *IIC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Good concepts for reducing long range maintenance and replacement costs.                            |
| *IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                       |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                       |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                       |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Automatic uncoupling release from within train.                                                     |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                       |
| *IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                       |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | - Gives a limited capability for uncoupling in draft (estimate up to 1,000 lb. draft force).          |
| *IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                       |
| *IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                       |
| IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Equivalent to automatically opened knuckle.                                                         |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                       |
| Pertinent Functions:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                       |
| *IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Electric connection system is adaptable to rigid couplers.                                          |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | - Automatic brake control and electric contact system same as Walton control system (Ref. No. 25).    |
| *IVB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Acceptable electrical contact unless excess contact contamination.                                  |
| *IVB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Up to 59 circuits at 30A - 32V capacity.                                                            |
| *IVB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Protection from environment for electrical contacts.                                                |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | ** Cover has probability for maintenance problems from coupling damage.                               |
| *IVB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | - Positive hands off control.                                                                         |
| *IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | - Improved safety.                                                                                    |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 503b: OHIO BRASS FORM 29 (RAPID TRANSIT) COUPLER SYSTEM

Primary Bibliography Reference No.: 503

|                                                                                                                                                                                                                                                                                                                   |        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                       |        |
| Description of Concept                                                                                                                                                                                                                                                                                            |        |
| <p>"C-O-B" coupler centering device using side spring carriers;</p> <p>"C-O-B" drum switch for completing electrical connections.</p>                                                                                                                                                                             |        |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                          |        |
| 1. Can be added to Type "E" electrical                                                                                                                                                                                                                                                                            | only X |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                              |        |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                             |        |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                     |        |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                        |        |
| Pertinent Functions                                                                                                                                                                                                                                                                                               |        |
| IA1.                                                                                                                                                                                                                                                                                                              |        |
| IA2.                                                                                                                                                                                                                                                                                                              |        |
| IA3a.                                                                                                                                                                                                                                                                                                             |        |
| IA3b.                                                                                                                                                                                                                                                                                                             |        |
| IA3c.                                                                                                                                                                                                                                                                                                             |        |
| IB1.                                                                                                                                                                                                                                                                                                              |        |
| IB2.                                                                                                                                                                                                                                                                                                              |        |
| IB3.                                                                                                                                                                                                                                                                                                              |        |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                         |        |
| Pertinent Functions                                                                                                                                                                                                                                                                                               |        |
| IIA1.                                                                                                                                                                                                                                                                                                             |        |
| IIA2.                                                                                                                                                                                                                                                                                                             |        |
| IIA3.                                                                                                                                                                                                                                                                                                             |        |
| IIB1.                                                                                                                                                                                                                                                                                                             |        |
| IIB2.                                                                                                                                                                                                                                                                                                             |        |
| IIB3.                                                                                                                                                                                                                                                                                                             |        |
| IIB4.                                                                                                                                                                                                                                                                                                             |        |
| *IIC1.                                                                                                                                                                                                                                                                                                            |        |
| IIC2.                                                                                                                                                                                                                                                                                                             |        |
| IIC3.                                                                                                                                                                                                                                                                                                             |        |
| IID.                                                                                                                                                                                                                                                                                                              |        |
| <p>- Same basic system as O.B. form 70 (biblio. No. 503a) in smaller size plus:</p> <p>- Positive spring self-centering (for uncoupled car) which is automatically released upon coupling by an air operated switch.</p>                                                                                          |        |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                      |        |
| Pertinent Functions                                                                                                                                                                                                                                                                                               |        |
| IIIA1.                                                                                                                                                                                                                                                                                                            |        |
| IIIA2.                                                                                                                                                                                                                                                                                                            |        |
| IIIA3a.                                                                                                                                                                                                                                                                                                           |        |
| IIIA3b.                                                                                                                                                                                                                                                                                                           |        |
| IIIA4.                                                                                                                                                                                                                                                                                                            |        |
| IIIB1.                                                                                                                                                                                                                                                                                                            |        |
| IIIB2.                                                                                                                                                                                                                                                                                                            |        |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                             |        |
| Pertinent Functions                                                                                                                                                                                                                                                                                               |        |
| IVA1.                                                                                                                                                                                                                                                                                                             |        |
| IVA2.                                                                                                                                                                                                                                                                                                             |        |
| *IVB1.                                                                                                                                                                                                                                                                                                            |        |
| *IVB3.                                                                                                                                                                                                                                                                                                            |        |
| IVB4.                                                                                                                                                                                                                                                                                                             |        |
| IVB5.                                                                                                                                                                                                                                                                                                             |        |
| IVB6.                                                                                                                                                                                                                                                                                                             |        |
| IVC.                                                                                                                                                                                                                                                                                                              |        |
| <p>- Compatible with "E" system only as part of a new control system.</p> <p>- Rotating sliding-finger contacts have demonstrated a long life and high reliability and should not be subject to extraneous action from environmental forces assuming adequate protection from freezing water on the contacts.</p> |        |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

Concept 503c: OHIO BRASS FORM 73 (RAPID TRANSIT) COUPLER

Primary Bibliography Reference No.: 503

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--------|--------------------------------------|---------|---------------------------------------|-------|-------------------------------|-------|---------------------------------------------------------------------------------------------------------------------------------------|-------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| <p><u>Compatibility with AAR Type "E" Coupler:</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 80%; padding: 2px;">1. Can be added to Type "E"</td> <td style="width: 20%; border: 1px solid black; text-align: center;"> </td> </tr> <tr> <td style="padding: 2px;">2. Requires modification of Type "E"</td> <td style="border: 1px solid black; text-align: center;"> </td> </tr> <tr> <td style="padding: 2px;">3. Requires head adapter for Type "E"</td> <td style="border: 1px solid black; text-align: center;"> </td> </tr> <tr> <td style="padding: 2px;">4. Incompatible with Type "E"</td> <td style="border: 1px solid black; text-align: center;">X</td> </tr> </table>                                                                                                                                                                                     | 1. Can be added to Type "E" |        | 2. Requires modification of Type "E" |         | 3. Requires head adapter for Type "E" |       | 4. Incompatible with Type "E" | X     | <p>Increased vertical gathering range from an external horn extending out and diagonally down from the front face of the coupler.</p> |       |      |                                                                                                                                                                                                                        |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | X                           |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| <p><u>Pertinent Functions:</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="border: 1px solid black; padding: 2px;">IA1.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IA2.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IA3a</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IA3b</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIC.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IB1.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IB2.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IB3.</td></tr> </table>                                                                                                                                                                                                                              | IA1.                        | IA2.   | IA3a                                 | IA3b    | IIC.                                  | IB1.  | IB2.                          | IB3.  |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IA3a                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IA3b                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| <p><u>Pertinent Functions:</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="border: 1px solid black; padding: 2px;">IIA1.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">*IIA2.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIA3.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIB1.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIB2.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIB3.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIB4.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIC1.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIC2.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIC3.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IID.</td></tr> </table> | IIA1.                       | *IIA2. | IIA3.                                | IIB1.   | IIB2.                                 | IIB3. | IIB4.                         | IIC1. | IIC2.                                                                                                                                 | IIC3. | IID. | <p>- Same basic system as O.B. Form 70 (Biblio. No. 503a) plus:</p> <p>** extended gathering range is of doubtful reliability due to the damage susceptibility from high moment ratio of the horn length/diameter.</p> |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| *IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| <p><u>Pertinent Functions:</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="border: 1px solid black; padding: 2px;">IIIA1.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIIA2.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIIA3a.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIIA3b.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIIA4.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIB1.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IIB2.</td></tr> </table>                                                                                                                                                                                                                                                                                      | IIIA1.                      | IIIA2. | IIIA3a.                              | IIIA3b. | IIIA4.                                | IIB1. | IIB2.                         |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| <p><u>Pertinent Functions:</u></p> <table style="width: 100%; border-collapse: collapse;"> <tr><td style="border: 1px solid black; padding: 2px;">IVA1.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IVA2.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IVB1.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IVB3.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IVB4.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IVB5.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IVB6.</td></tr> <tr><td style="border: 1px solid black; padding: 2px;">IVC.</td></tr> </table>                                                                                                                                                                                                                       | IVA1.                       | IVA2.  | IVB1.                                | IVB3.   | IVB4.                                 | IVB5. | IVB6.                         | IVC.  |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IVB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IVB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IVB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IVB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |
| IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                             |        |                                      |         |                                       |       |                               |       |                                                                                                                                       |       |      |                                                                                                                                                                                                                        |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

Concept 503d: OHIO BRASS FORM 5 (RAIL PASSENGER) COUPLER

Primary Bibliography Reference No.: 503

|                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-----------------------------|--|--------------------------------------|--|---------------------------------------|--|-------------------------------|---|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| <p>Semi-free, modified knuckle type with side pin/pocket interlock;<br/>Pin/pocket interlock at sides of coupler;<br/>Semi-machined interlock surface faces;<br/>Pin/pocket interlock with horizontally hinged shank and head supported by spring;<br/>Optional electric connector suspended below coupler head;<br/>Reduced free slack and semi-locked coupler heads.</p> |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| <p><b>Compatibility with AAR Type "E" Coupler:</b></p> <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td></td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td>X</td> </tr> </table>                           |                                                                                                                  | 1. Can be added to Type "E" |  | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" | X |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                      |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                              | X                                                                                                                |                             |  |                                      |  |                                       |  |                               |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                 |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA1.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA2.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB1.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB2.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB3.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                  |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA1.                                                                                                                                                                                                                                                                                                                                                                       | - Positive locking to prevent vertical and lateral movement (if knuckle remains closed).                         |                             |  |                                      |  |                                       |  |                               |   |
| IA2.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA3.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB1.                                                                                                                                                                                                                                                                                                                                                                       | - Basic reduction of free slack from machined faces.                                                             |                             |  |                                      |  |                                       |  |                               |   |
| IB2.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB3.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB4.                                                                                                                                                                                                                                                                                                                                                                       | - Semi-locked coupler heads reduce contour angling but require vertical articulation and head support.           |                             |  |                                      |  |                                       |  |                               |   |
| IC1.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IC2.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IC3.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IC4.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                               |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA1.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA2.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA4.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB1.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB2.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                      |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IA1.                                                                                                                                                                                                                                                                                                                                                                       | - Electric connector compatible only as part of a new control system.                                            |                             |  |                                      |  |                                       |  |                               |   |
| IA2.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB1.                                                                                                                                                                                                                                                                                                                                                                       | ** Greater probability for road damage and environmental contamination than for side mounted electric connector. |                             |  |                                      |  |                                       |  |                               |   |
| IB3.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB4.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IB5.                                                                                                                                                                                                                                                                                                                                                                       | - Improved safety due to reduced bypass probability.                                                             |                             |  |                                      |  |                                       |  |                               |   |
| IB6.                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |
| IC.                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                  |                             |  |                                      |  |                                       |  |                               |   |

Notes: \*This concept embodies improvements in this function.  
\*\*Denotes potential operating or safety problem.

# Concept 511a: WABCO N-2 MASS TRANSIT COUPLER SYSTEM

## Primary Bibliography Reference No.: 511

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 551, 552, 612                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Description of Concept</b><br>With integral air connection using compressed rubber butt seals;<br>System (rigid, flat face, dish and guide pin type with integral air and electrical connectors);<br>Uncoupling initiates by pneumatic signal;<br>Manual uncoupling requires unbolting of pin and coupler;<br>Lower attached electrical connector;<br>Environmental cover rotated down (by depression of a long guide pin) through coupling contact of mating coupler. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Compatibility with AAR Type "E" Coupler:</b><br>1. Can be added to Type "E"<br>2. Requires modification of Type "E"<br>3. Requires head adapter for Type "E"<br>4. Incompatible with Type "E"                                                                                                                                                                                                                                                                          | Electrical contacts are engaged (with spring force) when coupler faces are 0.62" apart as part of final coupling;<br>Reduced slack and automatic air connection.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Pertinent Functions:</b><br>* IAI.<br>* IAJ.<br>* IAJa.<br>* IAJb.<br>* IAJc.<br>* IB1.<br>* IB2.<br>* IB3.                                                                                                                                                                                                                                                                                                                                                            | ** Locking of coupler provides force for compression of butt rubber-to-rubber seals (potential for leakage as rubber ages or locking latch wears).<br>- Pin/dish coupler is aligned to $\pm 0.012$ " when coupler faces are 5" apart, thus no shear forces on rubber seals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Pertinent Functions:</b><br>* IIA1.<br>* IIA2.<br>* IIA3.<br>* IIB1.<br>* IIB2.<br>* IIB3.<br>* IIB4.<br>* IIC1.<br>* IIC2.<br>* IIC3.<br>* IID.                                                                                                                                                                                                                                                                                                                       | - Increased gathering range<br>Lateral: $\pm 4$ " (2.0 x standard).<br>Vertical: $\pm 4$ " (2.7 x standard).<br>- Positive locking, interlock and entrapment through mating dish and guide pins and spring loaded locking latches snapped into prong slots in pins.<br>- "Zero" slack (from machined faces and locking latches).<br>** Centering from tension spring and chain links attached on either side of coupler head may be subject to malfunction from kinking of chain.<br>** Horizontal "coupler compensator" support springs reported to deteriorate with age and use.<br>** Increased slack (and resulting poor air and electrical contacts reported from elongation of secondary guide pins with usage).<br>** "Freezing" of draft gear reported due to lack of lubrication (no fittings provided) |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Pertinent Functions:</b><br>* IIIA1.<br>* IIIA2.<br>* IIIA3a.<br>* IIIA3b.<br>* IIIA4.<br>* IIIB1.<br>* IIIB2.                                                                                                                                                                                                                                                                                                                                                         | Allows remote uncoupling release from side of car or within cab of car being uncoupled.<br>** Not a feasible system for manual uncoupling.<br>** Problems reported wherein uncoupling could not be accomplished by standard pneumatic system due to the coupler guide pin hanging up in the dish locking system (reportedly caused by coupling at "improper" angle).                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Pertinent Functions:</b><br>* IVA1.<br>* IVA2.<br>* IVB1.<br>* IVB3.<br>* IVB4.<br>* IVB5.<br>* IVB6.<br>* IVB7.                                                                                                                                                                                                                                                                                                                                                       | - Electrical connector system could be compatible with "E" system as part of an add-on control system.<br>** Potential for malfunction of environmental cover from damage to door depressing pin caused by coupling forces in wide angle coupling.<br>** Potential for damage to contact insulators from misaligned couplings due to the close interlocking tolerances and depth which the plastic insulators must engage.<br>- Improved safety.                                                                                                                                                                                                                                                                                                                                                                 |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 511b: WABCO TRAIN AIR LINE CONNECTOR

Primary Bibliography Reference No.: 511

|                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Description of Concept                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p>Coupler mounted, "spread-wing" type with integral gathering capacity, angled line seals using rubber ball compression force;</p> <p>Automatic air connection.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Compatibility with AAR Type "E" Coupler:                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 1. Can be added to Type "E"                                                                                                                                          | X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 2. Requires modification of Type "E"                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 3. Requires head adapter for Type "E"                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 4. Incompatible with Type "E"                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                  | <ul style="list-style-type: none"> <li>- Desirable weight of approximately 52 lbs.</li> <li>- Uses basic gathering and centering of mechanical coupler plus integral 5" lateral and 4" vertical gathering.</li> <li>- Has flexible mounting system to compensate for vertical movements of "E" coupler system.</li> <li>** Environmental susceptibility and wear resistance cannot be identified until system is field tested.</li> <li>** Potential maintenance problem with angled seals.</li> <li>** Rubber ball compression to establish sealing force may be subject to aging deterioration.</li> <li>- "Mixed" coupling made by swiveling connector 200 and connecting glad hand at rear.</li> </ul> |
| *IA1.<br>IA2.<br>IA3a.<br>IA3b.<br>IA3c.<br>IB1.<br>IB2.<br>IB3.                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| IIIA1.<br>IIIA2.<br>IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIIB1.<br>IIIB2.                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Pertinent Functions                                                                                                                                                  | <ul style="list-style-type: none"> <li>- Improved safety due to automatic air connection.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>*IVC.                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 511c: WABCO TRAIN LINE ELECTRICAL CONNECTOR

Primary Bibliography Reference No.: 511

|                                                                                                                                                                                                             |                                                                                                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                 |                                                                                                                                                             |
| Description of Concept                                                                                                                                                                                      |                                                                                                                                                             |
| <p>Attached as part of air connector system - held in contact by compression of "rubber ball" pressure in air connector; Environmental cover "levered" out of way by coupling action of air connectors.</p> |                                                                                                                                                             |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                    |                                                                                                                                                             |
| 1. Can be added to Type "E"                                                                                                                                                                                 | X                                                                                                                                                           |
| 2. Requires modification of Type "E"                                                                                                                                                                        |                                                                                                                                                             |
| 3. Requires head adapter for Type "E"                                                                                                                                                                       |                                                                                                                                                             |
| 4. Incompatible with Type "E"                                                                                                                                                                               |                                                                                                                                                             |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                  |                                                                                                                                                             |
| Pertinent Functions                                                                                                                                                                                         |                                                                                                                                                             |
| IA1.                                                                                                                                                                                                        |                                                                                                                                                             |
| IA2.                                                                                                                                                                                                        |                                                                                                                                                             |
| IA3a.                                                                                                                                                                                                       |                                                                                                                                                             |
| IA3b.                                                                                                                                                                                                       |                                                                                                                                                             |
| IA3c.                                                                                                                                                                                                       |                                                                                                                                                             |
| IB1.                                                                                                                                                                                                        |                                                                                                                                                             |
| IB2.                                                                                                                                                                                                        |                                                                                                                                                             |
| IB3.                                                                                                                                                                                                        |                                                                                                                                                             |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                   |                                                                                                                                                             |
| Pertinent Functions                                                                                                                                                                                         |                                                                                                                                                             |
| IIA1.                                                                                                                                                                                                       |                                                                                                                                                             |
| IIA2.                                                                                                                                                                                                       |                                                                                                                                                             |
| IIA3.                                                                                                                                                                                                       |                                                                                                                                                             |
| IIIB1.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIB2.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIB3.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIB4.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIC1.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIC2.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIC3.                                                                                                                                                                                                      |                                                                                                                                                             |
| IID.                                                                                                                                                                                                        |                                                                                                                                                             |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                |                                                                                                                                                             |
| Pertinent Functions                                                                                                                                                                                         |                                                                                                                                                             |
| IIIA1.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIA2.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIA3a.                                                                                                                                                                                                     |                                                                                                                                                             |
| IIIA3b.                                                                                                                                                                                                     |                                                                                                                                                             |
| IIIA4.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIB1.                                                                                                                                                                                                      |                                                                                                                                                             |
| IIIB2.                                                                                                                                                                                                      |                                                                                                                                                             |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                       |                                                                                                                                                             |
| Pertinent Functions                                                                                                                                                                                         |                                                                                                                                                             |
| IVA1.                                                                                                                                                                                                       |                                                                                                                                                             |
| * IVA2.                                                                                                                                                                                                     | ** Reliability of electrical contacts is questioned on the basis of uniformity and consistency of contact pressure maintained by "rubber ball" compression. |
| * IVB1.                                                                                                                                                                                                     |                                                                                                                                                             |
| * IVB3.                                                                                                                                                                                                     | ** Susceptibility of door to damage is questioned for wide angle coupling wherein one side approaches contact much earlier in the coupling sequence.        |
| * IVB4.                                                                                                                                                                                                     |                                                                                                                                                             |
| * IVB5.                                                                                                                                                                                                     |                                                                                                                                                             |
| * IVB6.                                                                                                                                                                                                     |                                                                                                                                                             |
| * IVC.                                                                                                                                                                                                      |                                                                                                                                                             |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 516a: WALTON AUTOMATIC COUPLER

Primary Bibliography Reference No.: 516

|                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 700                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                          |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                          |
| <p>Automatic air connections within head of rigid coupler (using replaceable rubber compression rubber butt seals);<br/> Rigid, flat faced, matching horn-funnel, hinged hook type with integral air and electrical connectors and automatic self centering;<br/> Spring loaded locking horns are automatically "open" for coupling;<br/> Automatic air connection and "knuckle" always open.</p> |                                                                                                                                                                                                                          |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                          |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                          |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                          |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                     | X                                                                                                                                                                                                                        |
| Note: A description of the control system is included in Biblio. No. 254.                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                          |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                          |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                          |
| *IA1.                                                                                                                                                                                                                                                                                                                                                                                             | - Seals are readily replaceable (in free or coupled state) by removing the screw-in air pipe connection.                                                                                                                 |
| *IA2.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                             | ** Gaskets are subject to possible leakage after wear and aging since the seal depends solely on compression of rubber by the coupler lock. No back up device (such as spring loading) is used to take up coupler slack. |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| *IB1.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| *IB2.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| *IB3.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                          |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                          |
| *IIA1.                                                                                                                                                                                                                                                                                                                                                                                            | - Similar to S-W 800 system (Biblio. No. 9) in concept except:                                                                                                                                                           |
| *IIA2.                                                                                                                                                                                                                                                                                                                                                                                            | - Free slack: 0.05" (0.06 times standard).                                                                                                                                                                               |
| *IIA3.                                                                                                                                                                                                                                                                                                                                                                                            | ** No positive coupler lock per se; a cam type "keeper" arrangement is used to retain the coupled condition in the event of a broken spring holding the hinged hook.                                                     |
| *IIB1.                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                          |
| *IIB2.                                                                                                                                                                                                                                                                                                                                                                                            | - Self centering accomplished by horizontal air cylinder acting on the shank.                                                                                                                                            |
| *IIB3.                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                          |
| *IIB4.                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                          |
| *IIC1.                                                                                                                                                                                                                                                                                                                                                                                            | - Increased gathering range.                                                                                                                                                                                             |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                             | Lateral: $\pm 3\text{-}1/2"$ (1.75 x standard).                                                                                                                                                                          |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                             | Vertical $\pm 3\text{-}1/2"$ (2.33 x standard).                                                                                                                                                                          |
| IID.                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                          |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                          |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                          |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                            | - Effective as "knuckle" automatically open.                                                                                                                                                                             |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                          |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                          |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                          |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                          |
| *IIB1.                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                          |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                          |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                             | - Improved safety due to automatic air connection.                                                                                                                                                                       |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| IVB1.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| IVB3.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| IVB4.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| IVB6.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |
| *IVC.                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                          |

Notes: \*This concept embodies improvements in this function.  
\*\*Denotes potential operating or safety problem.

Concept 516b: WALTON ELECTRICAL CONTROL BOX SYSTEMS

Primary Bibliography Reference No.: 516

|                                              |   |
|----------------------------------------------|---|
| Related Reference Number(s) 630, 700         |   |
| Descriptor of Concept<br>See pages following |   |
| Compatibility with AAR Type "E" Coupler:     |   |
| 1. Can be added to Type "E"                  | X |
| 2. Requires modification of Type "E"         |   |
| 3. Requires head adapter for Type "E"        |   |
| 4. Incompatible with Type "E"                |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM   |   |
| Pertinent Functions                          |   |
| IA1.                                         |   |
| IA2.                                         |   |
| IA3a.                                        |   |
| IA3b.                                        |   |
| IA3c.                                        |   |
| IB1.                                         |   |
| IB2.                                         |   |
| IB3.                                         |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING    |   |
| Pertinent Functions                          |   |
| IIA1.                                        |   |
| IIA2.                                        |   |
| IIA3.                                        |   |
| IIB1.                                        |   |
| IIB2.                                        |   |
| IIB3.                                        |   |
| IIB4.                                        |   |
| IIC1.                                        |   |
| IIC2.                                        |   |
| IIC3.                                        |   |
| IID.                                         |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING |   |
| Pertinent Functions                          |   |
| IIIA1.                                       |   |
| IIIA2.                                       |   |
| IIIA3a.                                      |   |
| IIIA3b.                                      |   |
| IIIA4.                                       |   |
| IIIB1.                                       |   |
| IIIB2.                                       |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS        |   |
| Pertinent Functions                          |   |
| IVA1.                                        |   |
| IVA2.                                        |   |
| * IVB1.                                      |   |
| * IVB3.                                      |   |
| * IVB4.                                      |   |
| IVB5.                                        |   |
| IVB6.                                        |   |
| IVC.                                         |   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

WALTON ELECTRICAL CONTROL BOX SYSTEMS (CONT'D.)

| <u>General Description<br/>of Concept</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <u>Evaluation of<br/>Concept Significance</u>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Walton Electric Control Box Systems: Various systems used in rapid transit applications use the following concepts:</p> <p>Fixed extended pilot pins and regular system pins are individually spring loaded and make direct butt contact on flat front faces;</p> <p>All contacts are silver plated over a brass type conductor; Internal wiring is direct bolt/nut to rear of contact pins</p> <p>Fixed extended pilot pins make basic contact to energize the control system (at first coupling).</p> <p>Control system supplies air to piston and rubber diaphragm (in electric box) to extend the contact block (with the remaining system pins) into the forward engaged position.</p> <p>To disengage, the control system releases air from the piston and a spring system retracts the contact block.</p> | <p>** A basic design problem to be faced is that of the ability of the coupler gathering systems to absorb the impact and misalignment energies so the electrical box experiences only direct in-line movements and minimal impact forces.</p> <p>- Individual spring loading is needed to compensate for variations in contact block flatness.</p> <p>** Some amount of contact rotation would seem desirable to make the best electrical connection.</p> <p>** For long-range maintenance, replaceable silver contact tips would be desirable.</p> <p>- Good system continuity would require all supporting contacts to be bolt/nut or compression threaded type.</p> <p>** Since good electrical contact of the pilot pins is essential for the control system to operate, these circuits should be redundant.</p> |

WALTON ELECTRICAL CONTROL BOX SYSTEMS (CONT'D.)

Manual extension/retraction is possible by use of a self-contained hand crank.

(1) Side mounted (with swing type cover).

- Cover is attached to extended radius spring loaded mounting arms and has cam shaped front with a guide arm facing forward and outward.
- As the couplers come together, the contact of the opposing cam shaped covers results in a wedging action which forces the opposing covers to swing to the outside, exposing the electrical contacts.

(2) Lower mounted (with track type cover).

- The cover rides in a recessed track running beneath the electric box and is spring loaded in the closed position.
- A horizontal push bar is compressed approximately 1-1/2 inches by a similar unit on the opposing

\*\* The use of a rubber diaphragm may present some problems with leakage from cracks brought on by age embrittlement.

- Since the entire piston/diaphragm system is enclosed in the electrical box, environmental grime problems should be negligible.

- Should be reliable for efficient contact disengagement.

- Good back-up in case of a system malfunction.

\*\* The guide arm should be of massive design since it must take the initial impact and stress before the cover starts to move.

\*\* The covers are required to lever each other aside while in full contact. This would seem to place undue stress on the mounting points due to the sliding friction between covers. It would seem that easier opening would be achieved by having total opening forces applied

WALTON ELECTRICAL CONTROL BOX SYSTEMS (CONT'D.)

coupler. The rearward movement of this bar is transmitted through a rack and pinion gear to pull the cover down and under the box (following the recessed track).

(3) No cover.

- A rubber gasket is fitted around the contact block to provide a tight seal between opposing electrical boxes when coupled.

(4) Plastic covers are applied to the facing surfaces of the metal covers to protect the fixed extended pins from accidental short circuit in the event of a bent or damaged cover assembly.

to the guide arm which would have a better lateral force moment.

- \*\* The recessed track would have a high probability of clogging up with grime or ice, thus blocking the path needed for cover movement.

- \*\*The push bar runs the full width of the electric box (and coupler). There is a high probability of an impact on one edge during any wide angle coupling. The bar (and its sliding push rod mechanism) would have to be extremely strong to withstand the resulting lateral forces while still compressing equally on both sides as needed for proper opening of the door.

- The use of a sealing gasket seems most desirable for all electrical contact units with or without covers.
- Detachable plastic insulating covers would be practical and desirable for the inside surface of electrical

# Concept 601: ELECTRICAL CONNECTOR

Primary Bibliography Reference No.: 601

|                                                                                                                                                   |                                                                                                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                       |                                                                                                      |
| Description of Concept                                                                                                                            |                                                                                                      |
| <ul style="list-style-type: none"> <li>- Multiple-contact unit carried on mating heads of the couplers</li> <li>- Italian manufacturer</li> </ul> |                                                                                                      |
| Compatibility with AAK Type "E" Coupler:                                                                                                          |                                                                                                      |
| 1. Can be added to Type "E"                                                                                                                       |                                                                                                      |
| 2. Requires modification of Type "E"                                                                                                              |                                                                                                      |
| 3. Requires head adapter for Type "E"                                                                                                             |                                                                                                      |
| 4. Incompatible with Type "E"                                                                                                                     | X                                                                                                    |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                        |                                                                                                      |
| Pertinent Functions                                                                                                                               |                                                                                                      |
| IA1.                                                                                                                                              |                                                                                                      |
| IA2.                                                                                                                                              |                                                                                                      |
| IA3a.                                                                                                                                             |                                                                                                      |
| IA3b.                                                                                                                                             |                                                                                                      |
| IA3c.                                                                                                                                             |                                                                                                      |
| IB1.                                                                                                                                              |                                                                                                      |
| IB2.                                                                                                                                              |                                                                                                      |
| IB3.                                                                                                                                              |                                                                                                      |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                         |                                                                                                      |
| Pertinent Functions                                                                                                                               |                                                                                                      |
| IIA1.                                                                                                                                             |                                                                                                      |
| IIA2.                                                                                                                                             |                                                                                                      |
| IIA3.                                                                                                                                             |                                                                                                      |
| IIB1.                                                                                                                                             |                                                                                                      |
| IIB2.                                                                                                                                             |                                                                                                      |
| IIB3.                                                                                                                                             |                                                                                                      |
| IIB4.                                                                                                                                             |                                                                                                      |
| IIC1.                                                                                                                                             |                                                                                                      |
| IIC2.                                                                                                                                             |                                                                                                      |
| IIC3.                                                                                                                                             |                                                                                                      |
| IID.                                                                                                                                              |                                                                                                      |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                      |                                                                                                      |
| Pertinent Functions                                                                                                                               |                                                                                                      |
| IIIA1.                                                                                                                                            |                                                                                                      |
| IIIA2.                                                                                                                                            |                                                                                                      |
| IIIA3a.                                                                                                                                           |                                                                                                      |
| IIIA3b.                                                                                                                                           |                                                                                                      |
| IIIA4.                                                                                                                                            |                                                                                                      |
| IIIB1.                                                                                                                                            |                                                                                                      |
| IIIB2.                                                                                                                                            |                                                                                                      |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                             |                                                                                                      |
| Pertinent Functions                                                                                                                               |                                                                                                      |
| IVAI.                                                                                                                                             | - Multiple-contact unit arranged in support casing                                                   |
| IVA2.                                                                                                                                             | - Contact unit is axially slidably mounted in support casing to absorb impact forces during coupling |
| IVB1.                                                                                                                                             |                                                                                                      |
| IVB3.                                                                                                                                             |                                                                                                      |
| IVB4.                                                                                                                                             |                                                                                                      |
| IVB5.                                                                                                                                             |                                                                                                      |
| IVB6.                                                                                                                                             |                                                                                                      |
| IVC.                                                                                                                                              |                                                                                                      |

# Concept 603: AUTOMATIC SERVICE LINE CONNECTOR

Primary Bibliography Reference No.: 603

|                                                                                    |                                                                                                                               |
|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                        |                                                                                                                               |
| Description of Concept                                                             |                                                                                                                               |
| <p>Italian Design</p> <p>To connect service line conduits for Willison coupler</p> |                                                                                                                               |
| Compatibility with AAR Type "E" Coupler:                                           |                                                                                                                               |
| 1. Can be added to Type "E"                                                        |                                                                                                                               |
| 2. Requires modification of Type "E"                                               |                                                                                                                               |
| 3. Requires head adapter for Type "E"                                              |                                                                                                                               |
| 4. Incompatible with Type "E"                                                      | X                                                                                                                             |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                         |                                                                                                                               |
| Pertinent Functions:                                                               |                                                                                                                               |
| *IA1.                                                                              | Mechanical lever system provides for final inter-engagement of the connectors after the frontal impact between coupling heads |
| IA2.                                                                               |                                                                                                                               |
| *IA3a.                                                                             |                                                                                                                               |
| IA3b.                                                                              |                                                                                                                               |
| IA3c.                                                                              |                                                                                                                               |
| IB1.                                                                               |                                                                                                                               |
| IB2.                                                                               |                                                                                                                               |
| IB3.                                                                               |                                                                                                                               |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                          |                                                                                                                               |
| Pertinent Functions:                                                               |                                                                                                                               |
| IIA1.                                                                              |                                                                                                                               |
| IIA2.                                                                              |                                                                                                                               |
| IIA3.                                                                              |                                                                                                                               |
| IB1.                                                                               |                                                                                                                               |
| IB2.                                                                               |                                                                                                                               |
| IB3.                                                                               |                                                                                                                               |
| IB4.                                                                               |                                                                                                                               |
| ICI.                                                                               |                                                                                                                               |
| IC2.                                                                               |                                                                                                                               |
| IC3.                                                                               |                                                                                                                               |
| IC4.                                                                               |                                                                                                                               |
| IC5.                                                                               |                                                                                                                               |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                       |                                                                                                                               |
| Pertinent Functions:                                                               |                                                                                                                               |
| IIIA1.                                                                             |                                                                                                                               |
| IIIA2.                                                                             |                                                                                                                               |
| IIIA3a.                                                                            |                                                                                                                               |
| IIIA3b.                                                                            |                                                                                                                               |
| IIIA4.                                                                             |                                                                                                                               |
| IIIB1.                                                                             |                                                                                                                               |
| IIIB2.                                                                             |                                                                                                                               |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                              |                                                                                                                               |
| Pertinent Functions:                                                               |                                                                                                                               |
| IVA1.                                                                              | Conduits contained in coupler heads                                                                                           |
| IVA2.                                                                              |                                                                                                                               |
| *IVB1.                                                                             |                                                                                                                               |
| IVB3.                                                                              |                                                                                                                               |
| IVB4.                                                                              |                                                                                                                               |
| IVB5.                                                                              |                                                                                                                               |
| IVB6.                                                                              |                                                                                                                               |
| IVC.                                                                               |                                                                                                                               |

# Concept 605: AUTOMATIC TRAIN LINE CONNECTOR

Primary Bibliography Reference No.: 605

|                                                                                                                                                                                                          |                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                              |                                                                          |
| Description of Concept                                                                                                                                                                                   |                                                                          |
| <ul style="list-style-type: none"> <li>- Connector suspendable from coupler (hangs below coupler)</li> <li>- Carries air and has potential to carry electric lines</li> <li>- Gathering wings</li> </ul> |                                                                          |
| Compatibility with "E" Type "E" Coupler:                                                                                                                                                                 |                                                                          |
| 1. Can be added to Type "E"                                                                                                                                                                              | X                                                                        |
| 2. Requires modification of Type "E"                                                                                                                                                                     |                                                                          |
| 3. Requires head adapter for Type "E"                                                                                                                                                                    |                                                                          |
| 4. Incompatible with Type "E"                                                                                                                                                                            |                                                                          |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                               |                                                                          |
| Pertinent Functions                                                                                                                                                                                      |                                                                          |
| *IA1.                                                                                                                                                                                                    | - Spring loaded to maintain seal                                         |
| IA2.                                                                                                                                                                                                     |                                                                          |
| *IA3a.                                                                                                                                                                                                   |                                                                          |
| *IA3b.                                                                                                                                                                                                   |                                                                          |
| *IA3c.                                                                                                                                                                                                   |                                                                          |
| *IB1.                                                                                                                                                                                                    |                                                                          |
| *IB2.                                                                                                                                                                                                    |                                                                          |
| *IB3.                                                                                                                                                                                                    |                                                                          |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                |                                                                          |
| Pertinent Functions                                                                                                                                                                                      |                                                                          |
| IIA1.                                                                                                                                                                                                    |                                                                          |
| IIA2.                                                                                                                                                                                                    |                                                                          |
| IIA3.                                                                                                                                                                                                    |                                                                          |
| IB1.                                                                                                                                                                                                     |                                                                          |
| IB2.                                                                                                                                                                                                     |                                                                          |
| IB3.                                                                                                                                                                                                     |                                                                          |
| IB4.                                                                                                                                                                                                     |                                                                          |
| IC1.                                                                                                                                                                                                     |                                                                          |
| IC2.                                                                                                                                                                                                     |                                                                          |
| IC3.                                                                                                                                                                                                     |                                                                          |
| ID.                                                                                                                                                                                                      |                                                                          |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                             |                                                                          |
| Pertinent Functions                                                                                                                                                                                      |                                                                          |
| IIIA1.                                                                                                                                                                                                   |                                                                          |
| IIIA2.                                                                                                                                                                                                   |                                                                          |
| IIIA3a.                                                                                                                                                                                                  |                                                                          |
| IIIA3b.                                                                                                                                                                                                  |                                                                          |
| IIIA2.                                                                                                                                                                                                   |                                                                          |
| IB1.                                                                                                                                                                                                     |                                                                          |
| IB2.                                                                                                                                                                                                     |                                                                          |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                    |                                                                          |
| Pertinent Functions                                                                                                                                                                                      |                                                                          |
| IVA1.                                                                                                                                                                                                    |                                                                          |
| IVA2.                                                                                                                                                                                                    |                                                                          |
| *VB1.                                                                                                                                                                                                    | - Spring holds connectors together                                       |
| VB3.                                                                                                                                                                                                     |                                                                          |
| VB4.                                                                                                                                                                                                     |                                                                          |
| *VB5.                                                                                                                                                                                                    | - Electrical connections allow potential for sensing and control systems |
| *VB6.                                                                                                                                                                                                    |                                                                          |
| VC.                                                                                                                                                                                                      |                                                                          |

# Concept 606: AUTOMATIC ELECTRICAL PORTION OF SUBWAY COUPLER

Primary Bibliography Reference No.: 606

|                                                                                                                                                                                                                                                                                  |   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Related Reference Number(s) 22, 517                                                                                                                                                                                                                                              |   |
| Description of Concept                                                                                                                                                                                                                                                           |   |
| <ul style="list-style-type: none"> <li>- Electrical connector for subway coupler likely too complex for freight service, but it could be added</li> <li>- Projected contact pins for non-arcing amperage lines with hermaphrodite fixed socket</li> </ul>                        |   |
| Compatibility with AAL Type "E" Coupler:                                                                                                                                                                                                                                         |   |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                      | X |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                             |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                            |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                    |   |
| <ul style="list-style-type: none"> <li>- Retractable pin contacts for lines carrying arcing amperages</li> <li>- Spring loaded</li> </ul>                                                                                                                                        |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                       |   |
| Pertinent Functions                                                                                                                                                                                                                                                              |   |
| IA1.                                                                                                                                                                                                                                                                             |   |
| IA2.                                                                                                                                                                                                                                                                             |   |
| IA3a.                                                                                                                                                                                                                                                                            |   |
| IA3b.                                                                                                                                                                                                                                                                            |   |
| IA3c.                                                                                                                                                                                                                                                                            |   |
| IB1.                                                                                                                                                                                                                                                                             |   |
| IB2.                                                                                                                                                                                                                                                                             |   |
| IB3.                                                                                                                                                                                                                                                                             |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                        |   |
| Pertinent Functions                                                                                                                                                                                                                                                              |   |
| IIA1.                                                                                                                                                                                                                                                                            |   |
| IIA2.                                                                                                                                                                                                                                                                            |   |
| IIA3.                                                                                                                                                                                                                                                                            |   |
| IIB1.                                                                                                                                                                                                                                                                            |   |
| IIB2.                                                                                                                                                                                                                                                                            |   |
| IIB3.                                                                                                                                                                                                                                                                            |   |
| IIB4.                                                                                                                                                                                                                                                                            |   |
| IIC1.                                                                                                                                                                                                                                                                            |   |
| IIC2.                                                                                                                                                                                                                                                                            |   |
| IIC3.                                                                                                                                                                                                                                                                            |   |
| IID.                                                                                                                                                                                                                                                                             |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                     |   |
| Pertinent Functions                                                                                                                                                                                                                                                              |   |
| IIIA1.                                                                                                                                                                                                                                                                           |   |
| IIIA2.                                                                                                                                                                                                                                                                           |   |
| IIIA3a.                                                                                                                                                                                                                                                                          |   |
| IIIA3b.                                                                                                                                                                                                                                                                          |   |
| IIIA4.                                                                                                                                                                                                                                                                           |   |
| IIB1.                                                                                                                                                                                                                                                                            |   |
| IIB2.                                                                                                                                                                                                                                                                            |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                            |   |
| Pertinent Functions                                                                                                                                                                                                                                                              |   |
| IV A1.                                                                                                                                                                                                                                                                           |   |
| IV A2.                                                                                                                                                                                                                                                                           |   |
| IV B1.                                                                                                                                                                                                                                                                           |   |
| IV B3.                                                                                                                                                                                                                                                                           |   |
| IV B4.                                                                                                                                                                                                                                                                           |   |
| IV B5.                                                                                                                                                                                                                                                                           |   |
| IV B6.                                                                                                                                                                                                                                                                           |   |
| IV C.                                                                                                                                                                                                                                                                            |   |
| <ul style="list-style-type: none"> <li>- Fluid pressure advanced, spring-retracted carriage</li> <li>- Intended to couple without arcing with mating electric coupler without depending upon a drum switch for deenergizing the contacts except when they are coupled</li> </ul> |   |

# Concept 610: RETRACTABLE TRAINLINE CONNECTOR

Primary Bibliography Reference No.: 610

|                                                                                                                                                              |                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| Related Reference Number(s) 502                                                                                                                              |                                  |
| Description of Concept                                                                                                                                       |                                  |
| <ul style="list-style-type: none"> <li>- Add on device below coupler</li> <li>- Spring loaded</li> <li>- Terminal end shielded when not connected</li> </ul> |                                  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                     |                                  |
| 1. Can be added to Type "E"                                                                                                                                  | X                                |
| 2. Requires modification of Type "E"                                                                                                                         |                                  |
| 3. Requires head adapter for Type "E"                                                                                                                        |                                  |
| 4. Incompatible with Type "E"                                                                                                                                |                                  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                   |                                  |
| Pertinent Functions                                                                                                                                          |                                  |
| IA1.                                                                                                                                                         | - Retractable when couplers mate |
| IA2.                                                                                                                                                         |                                  |
| IA3a.                                                                                                                                                        |                                  |
| IA3b.                                                                                                                                                        |                                  |
| IA3c.                                                                                                                                                        |                                  |
| IB1.                                                                                                                                                         |                                  |
| IB2.                                                                                                                                                         |                                  |
| IB3.                                                                                                                                                         |                                  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                    |                                  |
| Pertinent Functions                                                                                                                                          |                                  |
| IIA1.                                                                                                                                                        |                                  |
| IIA2.                                                                                                                                                        |                                  |
| IIA3.                                                                                                                                                        |                                  |
| IIB1.                                                                                                                                                        |                                  |
| IIB2.                                                                                                                                                        |                                  |
| IIB3.                                                                                                                                                        |                                  |
| IIB4.                                                                                                                                                        |                                  |
| IIC1.                                                                                                                                                        |                                  |
| IIC2.                                                                                                                                                        |                                  |
| IIC3.                                                                                                                                                        |                                  |
| IID.                                                                                                                                                         |                                  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                 |                                  |
| Pertinent Functions                                                                                                                                          |                                  |
| IIIA1.                                                                                                                                                       |                                  |
| IIIA2.                                                                                                                                                       |                                  |
| IIIA3a.                                                                                                                                                      |                                  |
| IIIA3b.                                                                                                                                                      |                                  |
| IIIA4.                                                                                                                                                       |                                  |
| IIIB1.                                                                                                                                                       |                                  |
| IIIB2.                                                                                                                                                       |                                  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                        |                                  |
| Pertinent Functions                                                                                                                                          |                                  |
| IVA1.                                                                                                                                                        |                                  |
| IVA2.                                                                                                                                                        |                                  |
| IVB1.                                                                                                                                                        | - Retractable when couplers mate |
| IVB3.                                                                                                                                                        |                                  |
| IVB4.                                                                                                                                                        |                                  |
| IVB5.                                                                                                                                                        |                                  |
| IVB6.                                                                                                                                                        |                                  |
| IVC.                                                                                                                                                         |                                  |

# Concept 611: RETRACTABLE TRAINLINE CONNECTOR

Primary Bibliography Reference No.: 611

Related Reference Number(s) 502

## Description of Concept

- Retracted when not connected
- Cover is optional
- Lugs support the device without tilting
- Stop ring limits forward travel; compression spring to maintain connection

## Compatibility with AAR Type "E" Coupler:

|                                       |   |
|---------------------------------------|---|
| 1. Can be added to Type "E"           | X |
| 2. Requires modification of Type "E"  |   |
| 3. Requires head adapter for Type "E" |   |
| 4. Incompatible with Type "E"         |   |

## CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM

### Pertinent Functions:

|       |                                    |
|-------|------------------------------------|
| *IA1. | - Spring loaded retractable device |
| IA2.  |                                    |
| IA3a. |                                    |
| IA3b. |                                    |
| IA3c. |                                    |
| IB1.  |                                    |
| IB2.  |                                    |
| IB3.  |                                    |

## CATEGORY II - IMPROVE MECHANICAL COUPLING

### Pertinent Functions:

|       |
|-------|
| IIA1. |
| IIA2. |
| IIA3. |
| IIB1. |
| IIB2. |
| IIB3. |
| IIB4. |
| IIC1. |
| IIC2. |
| IIC3. |
| IID.  |

## CATEGORY III - IMPROVE MECHANICAL UNCOUPLING

### Pertinent Functions:

|         |
|---------|
| IIIA1.  |
| IIIA2.  |
| IIIA3a. |
| IIIA3b. |
| IIIA4.  |
| IIB1.   |
| IIB2.   |

## CATEGORY IV - IMPROVE GENERAL SYSTEMS

### Pertinent Functions:

|        |                                    |
|--------|------------------------------------|
| *IVA1. | - Spring loaded retractable device |
| IVA2.  | with optional covers               |
| VB1.   |                                    |
| VB3.   |                                    |
| *VB4.  |                                    |
| VB5.   |                                    |
| VB6.   |                                    |
| IVC.   |                                    |

# Concept 650: AUTOMATIC COCKING AND RE-COCKING COUPLING

Primary Bibliography Reference No.: 650

|                                                                                                                                                                                                                                          |   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Related Reference Number(s)                                                                                                                                                                                                              |   |
| Description of Concept - Spring loaded device<br>- Device mounted below center of car at each side<br>- Portion of device extends beyond car to be activated from the side of the car by actuating pawls at fixed points along the track |   |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                 |   |
| 1. Can be added to Type "E"                                                                                                                                                                                                              | X |
| 2. Requires modification of Type "E"                                                                                                                                                                                                     |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                    |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                            |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                               |   |
| Pertinent Functions                                                                                                                                                                                                                      |   |
| IA1.                                                                                                                                                                                                                                     |   |
| IA2.                                                                                                                                                                                                                                     |   |
| IA3a.                                                                                                                                                                                                                                    |   |
| IA3b.                                                                                                                                                                                                                                    |   |
| IA3c.                                                                                                                                                                                                                                    |   |
| IB1.                                                                                                                                                                                                                                     |   |
| IB2.                                                                                                                                                                                                                                     |   |
| IB3.                                                                                                                                                                                                                                     |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                |   |
| Pertinent Functions                                                                                                                                                                                                                      |   |
| IIA1.                                                                                                                                                                                                                                    |   |
| IIA2.                                                                                                                                                                                                                                    |   |
| IIA3.                                                                                                                                                                                                                                    |   |
| IIB1.                                                                                                                                                                                                                                    |   |
| IIB2.                                                                                                                                                                                                                                    |   |
| IIB3.                                                                                                                                                                                                                                    |   |
| IIB4.                                                                                                                                                                                                                                    |   |
| IIC1.                                                                                                                                                                                                                                    |   |
| IIC2.                                                                                                                                                                                                                                    |   |
| IIC3.                                                                                                                                                                                                                                    |   |
| IID.                                                                                                                                                                                                                                     |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                             |   |
| Pertinent Functions                                                                                                                                                                                                                      |   |
| IIIA1.                                                                                                                                                                                                                                   |   |
| IIIA2.                                                                                                                                                                                                                                   |   |
| IIIA3a.                                                                                                                                                                                                                                  |   |
| IIIA3b.                                                                                                                                                                                                                                  |   |
| +IIIA4.                                                                                                                                                                                                                                  |   |
| +IIIB1.                                                                                                                                                                                                                                  |   |
| IIIB2.                                                                                                                                                                                                                                   |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                    |   |
| Pertinent Functions                                                                                                                                                                                                                      |   |
| IVA1.                                                                                                                                                                                                                                    |   |
| IVA2.                                                                                                                                                                                                                                    |   |
| IVB1.                                                                                                                                                                                                                                    |   |
| IVB3.                                                                                                                                                                                                                                    |   |
| IVB4.                                                                                                                                                                                                                                    |   |
| IVB5.                                                                                                                                                                                                                                    |   |
| IVB6.                                                                                                                                                                                                                                    |   |
| IVC.                                                                                                                                                                                                                                     |   |

# Concept 670: AUTOMATIC HOSE CONNECTION

Primary Bibliography Reference No.: 670

|                                                                                                                                                                                   |                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Related Reference Number(s) 511                                                                                                                                                   |                                                                         |
| Description of Concept                                                                                                                                                            |                                                                         |
| <ul style="list-style-type: none"> <li>- Device to be mounted below coupler</li> <li>- Gathering funnel to guide head into engagement</li> <li>- Spring actuated lever</li> </ul> |                                                                         |
| Compatible with AAR Type "E" Coupler:                                                                                                                                             |                                                                         |
| 1. Can be added to Type "E"                                                                                                                                                       | X                                                                       |
| 2. Requires modification of Type "E"                                                                                                                                              |                                                                         |
| 3. Requires head adapter for Type "E"                                                                                                                                             |                                                                         |
| 4. Incompatible with Type "E"                                                                                                                                                     |                                                                         |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                        |                                                                         |
| Pertinent Functions                                                                                                                                                               |                                                                         |
| *IA1.                                                                                                                                                                             | - Connection broken automatically by draft forces during car uncoupling |
| IA2.                                                                                                                                                                              |                                                                         |
| IA3a.                                                                                                                                                                             |                                                                         |
| IA3b.                                                                                                                                                                             |                                                                         |
| IA3c.                                                                                                                                                                             | - Permits manual operation if desired                                   |
| *IB1.                                                                                                                                                                             |                                                                         |
| *IB2.                                                                                                                                                                             |                                                                         |
| *IB3.                                                                                                                                                                             |                                                                         |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                         |                                                                         |
| Pertinent Functions                                                                                                                                                               |                                                                         |
| IIA1.                                                                                                                                                                             |                                                                         |
| IIA2.                                                                                                                                                                             |                                                                         |
| IIA3.                                                                                                                                                                             |                                                                         |
| IIB1.                                                                                                                                                                             |                                                                         |
| IIB2.                                                                                                                                                                             |                                                                         |
| IIB3.                                                                                                                                                                             |                                                                         |
| IIB4.                                                                                                                                                                             |                                                                         |
| IIC1.                                                                                                                                                                             |                                                                         |
| IIC2.                                                                                                                                                                             |                                                                         |
| IIC3.                                                                                                                                                                             |                                                                         |
| IID.                                                                                                                                                                              |                                                                         |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                      |                                                                         |
| Pertinent Functions                                                                                                                                                               |                                                                         |
| IIIA1.                                                                                                                                                                            |                                                                         |
| IIIA2.                                                                                                                                                                            |                                                                         |
| IIIA3a.                                                                                                                                                                           |                                                                         |
| IIIA3b.                                                                                                                                                                           |                                                                         |
| IIIA4.                                                                                                                                                                            |                                                                         |
| IIB1.                                                                                                                                                                             |                                                                         |
| IIB2.                                                                                                                                                                             |                                                                         |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                             |                                                                         |
| Pertinent Functions                                                                                                                                                               |                                                                         |
| IVA1.                                                                                                                                                                             |                                                                         |
| IVA2.                                                                                                                                                                             |                                                                         |
| IVB1.                                                                                                                                                                             |                                                                         |
| IVB3.                                                                                                                                                                             |                                                                         |
| IVB4.                                                                                                                                                                             |                                                                         |
| IVB5.                                                                                                                                                                             |                                                                         |
| IVB6.                                                                                                                                                                             |                                                                         |
| IVC.                                                                                                                                                                              |                                                                         |

# Concept 671: VALVE MEANS FOR RAILWAY CAR TRAINLINE

Primary Bibliography Reference No.: 671

|                                                                                                                                                                                                                       |                                                                                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                           |                                                                                                                        |
| Description of Concept - Side of car operated telescoping rods extend for universal connections on ball valve to adjacent ends of car<br>- May be actuated from either side of car<br>- Ball valve to control airflow |                                                                                                                        |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                              |                                                                                                                        |
| 1. Can be added to Type "E"                                                                                                                                                                                           | X                                                                                                                      |
| 2. Requires modification of Type "E"                                                                                                                                                                                  |                                                                                                                        |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                 |                                                                                                                        |
| 4. Incompatible with Type "E"                                                                                                                                                                                         |                                                                                                                        |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                            |                                                                                                                        |
| Pertinent Functions                                                                                                                                                                                                   |                                                                                                                        |
| IA1.                                                                                                                                                                                                                  |                                                                                                                        |
| IA2.                                                                                                                                                                                                                  |                                                                                                                        |
| *IA3a.                                                                                                                                                                                                                | - Ball valve controls air flow                                                                                         |
| *IA3b.                                                                                                                                                                                                                |                                                                                                                        |
| IA3c.                                                                                                                                                                                                                 | - Ball valve is freely floating within the body of the valve                                                           |
| IB1.                                                                                                                                                                                                                  |                                                                                                                        |
| IB2.                                                                                                                                                                                                                  | - Stems extend through the valve body fitting loosely in slots so the valve ball member may move relative to the stems |
| IB3.                                                                                                                                                                                                                  |                                                                                                                        |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                             |                                                                                                                        |
| Pertinent Functions                                                                                                                                                                                                   |                                                                                                                        |
| IIA1.                                                                                                                                                                                                                 |                                                                                                                        |
| IIA2.                                                                                                                                                                                                                 |                                                                                                                        |
| IIA3.                                                                                                                                                                                                                 |                                                                                                                        |
| IIB1.                                                                                                                                                                                                                 |                                                                                                                        |
| IIB2.                                                                                                                                                                                                                 |                                                                                                                        |
| IIB3.                                                                                                                                                                                                                 |                                                                                                                        |
| IIB4.                                                                                                                                                                                                                 |                                                                                                                        |
| IIC1.                                                                                                                                                                                                                 |                                                                                                                        |
| IIC2.                                                                                                                                                                                                                 |                                                                                                                        |
| IIC3.                                                                                                                                                                                                                 |                                                                                                                        |
| IID.                                                                                                                                                                                                                  |                                                                                                                        |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                          |                                                                                                                        |
| Pertinent Functions                                                                                                                                                                                                   |                                                                                                                        |
| IIIA1.                                                                                                                                                                                                                |                                                                                                                        |
| IIIA2.                                                                                                                                                                                                                |                                                                                                                        |
| IIIA3a.                                                                                                                                                                                                               |                                                                                                                        |
| IIIA3b.                                                                                                                                                                                                               |                                                                                                                        |
| IIIA4.                                                                                                                                                                                                                |                                                                                                                        |
| IIB1.                                                                                                                                                                                                                 |                                                                                                                        |
| IIB2.                                                                                                                                                                                                                 |                                                                                                                        |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                 |                                                                                                                        |
| Pertinent Functions                                                                                                                                                                                                   |                                                                                                                        |
| IVA1.                                                                                                                                                                                                                 |                                                                                                                        |
| IVA2.                                                                                                                                                                                                                 |                                                                                                                        |
| IVB1.                                                                                                                                                                                                                 |                                                                                                                        |
| IVB3.                                                                                                                                                                                                                 |                                                                                                                        |
| IVB4.                                                                                                                                                                                                                 |                                                                                                                        |
| IVB5.                                                                                                                                                                                                                 |                                                                                                                        |
| IVB6.                                                                                                                                                                                                                 |                                                                                                                        |
| IVC.                                                                                                                                                                                                                  |                                                                                                                        |

# Concept 672: AUTOMATIC AIR-COUPLING STRUCTURE

Primary Bibliography Reference No.: 672

|                                                                                                                                                                                                                                                           |                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                               |                                         |
| Description of Concept - Attaches to coupler shank, below coupler knuckle                                                                                                                                                                                 |                                         |
| <ul style="list-style-type: none"> <li>- Spring-biased air compression cylinder engages aligned air lines upon completion of mechanical coupling</li> <li>- For cars equipped with conventional draft gear and or end of car cushioning device</li> </ul> |                                         |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                  |                                         |
| 1. Can be added to Type "E"                                                                                                                                                                                                                               |                                         |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                      |                                         |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                     |                                         |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                             | X                                       |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                |                                         |
| Pertinent Functions:                                                                                                                                                                                                                                      |                                         |
| IA1.                                                                                                                                                                                                                                                      |                                         |
| IA2.                                                                                                                                                                                                                                                      |                                         |
| IA3a.                                                                                                                                                                                                                                                     | - Spring loaded cylinder maintains seal |
| IA3b.                                                                                                                                                                                                                                                     |                                         |
| IA3c.                                                                                                                                                                                                                                                     | - Ball valve controls air flow          |
| IB1.                                                                                                                                                                                                                                                      |                                         |
| IB2.                                                                                                                                                                                                                                                      |                                         |
| IB3.                                                                                                                                                                                                                                                      |                                         |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                 |                                         |
| Pertinent Functions:                                                                                                                                                                                                                                      |                                         |
| IIA1.                                                                                                                                                                                                                                                     |                                         |
| IIA2.                                                                                                                                                                                                                                                     |                                         |
| IIA3.                                                                                                                                                                                                                                                     |                                         |
| IIB1.                                                                                                                                                                                                                                                     |                                         |
| IIB2.                                                                                                                                                                                                                                                     |                                         |
| IIB3.                                                                                                                                                                                                                                                     |                                         |
| IIB4.                                                                                                                                                                                                                                                     |                                         |
| IIC1.                                                                                                                                                                                                                                                     |                                         |
| IIC2.                                                                                                                                                                                                                                                     |                                         |
| IIC3.                                                                                                                                                                                                                                                     |                                         |
| IID.                                                                                                                                                                                                                                                      |                                         |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                              |                                         |
| Pertinent Functions:                                                                                                                                                                                                                                      |                                         |
| IIIA1.                                                                                                                                                                                                                                                    |                                         |
| IIIA2.                                                                                                                                                                                                                                                    |                                         |
| IIIA3a.                                                                                                                                                                                                                                                   |                                         |
| IIIA3b.                                                                                                                                                                                                                                                   |                                         |
| IIIA4.                                                                                                                                                                                                                                                    |                                         |
| IIIB1.                                                                                                                                                                                                                                                    |                                         |
| IIIB2.                                                                                                                                                                                                                                                    |                                         |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                     |                                         |
| Pertinent Functions:                                                                                                                                                                                                                                      |                                         |
| IVA1.                                                                                                                                                                                                                                                     |                                         |
| IVA2.                                                                                                                                                                                                                                                     |                                         |
| IVB1.                                                                                                                                                                                                                                                     |                                         |
| IVB3.                                                                                                                                                                                                                                                     |                                         |
| IVB4.                                                                                                                                                                                                                                                     |                                         |
| IVB5.                                                                                                                                                                                                                                                     |                                         |
| IVB6.                                                                                                                                                                                                                                                     |                                         |
| IVC.                                                                                                                                                                                                                                                      |                                         |

**Concept 674: COUPLING VALVE ACTUATOR**  
**Primary Bibliography Reference No.: 674**

|                                                                                                                                                                                                      |   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Related Reference Number(s) 517                                                                                                                                                                      |   |
| Description of Concept                                                                                                                                                                               |   |
| <ul style="list-style-type: none"> <li>- Valve actuating mechanism to operate a pilot or interface valve</li> <li>- Force transmitted by hydraulic fluid or flexible push-pull type cable</li> </ul> |   |
| Compatibility with AAE Type "E" Coupler:                                                                                                                                                             |   |
| 1. Can be added to Type "E"                                                                                                                                                                          |   |
| 2. Requires modification of Type "E"                                                                                                                                                                 |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                |   |
| 4. Incompatible with Type "E"                                                                                                                                                                        | X |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                           |   |
| Pertinent Functions                                                                                                                                                                                  |   |
| IA1.                                                                                                                                                                                                 |   |
| IA2.                                                                                                                                                                                                 |   |
| IA3a.                                                                                                                                                                                                |   |
| IA3b.                                                                                                                                                                                                |   |
| IA3c.                                                                                                                                                                                                |   |
| IB1.                                                                                                                                                                                                 |   |
| IB2.                                                                                                                                                                                                 |   |
| IB3.                                                                                                                                                                                                 |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                            |   |
| Pertinent Functions                                                                                                                                                                                  |   |
| IIA1.                                                                                                                                                                                                |   |
| IIA2.                                                                                                                                                                                                |   |
| IIA3.                                                                                                                                                                                                |   |
| IIB1.                                                                                                                                                                                                |   |
| IIB2.                                                                                                                                                                                                |   |
| IIB3.                                                                                                                                                                                                |   |
| IIB4.                                                                                                                                                                                                |   |
| IIC1.                                                                                                                                                                                                |   |
| IIC2.                                                                                                                                                                                                |   |
| IIC3.                                                                                                                                                                                                |   |
| IID.                                                                                                                                                                                                 |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                         |   |
| Pertinent Functions                                                                                                                                                                                  |   |
| IIIA1.                                                                                                                                                                                               |   |
| IIIA2.                                                                                                                                                                                               |   |
| IIIA3a.                                                                                                                                                                                              |   |
| IIIA3b.                                                                                                                                                                                              |   |
| IIIA4.                                                                                                                                                                                               |   |
| *IIIB1.                                                                                                                                                                                              |   |
| IIIB2.                                                                                                                                                                                               |   |
| <ul style="list-style-type: none"> <li>- Hydraulic fluid or push-pull cable used to actuate uncoupling mechanism</li> </ul>                                                                          |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                |   |
| Pertinent Functions                                                                                                                                                                                  |   |
| IVA1.                                                                                                                                                                                                |   |
| IVA2.                                                                                                                                                                                                |   |
| IVB1.                                                                                                                                                                                                |   |
| IVB2.                                                                                                                                                                                                |   |
| IVB3.                                                                                                                                                                                                |   |
| IVB4.                                                                                                                                                                                                |   |
| IVB5.                                                                                                                                                                                                |   |
| IVB6.                                                                                                                                                                                                |   |
| IVC.                                                                                                                                                                                                 |   |

# Concept 676: AUTOMATIC COUPLING SYSTEM

Primary Bibliography Reference No.: 676

|                                                                                                                                                                                                               |                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                   |                                                                                                                                                                                          |
| Description of Concept                                                                                                                                                                                        |                                                                                                                                                                                          |
| <p align="center">- Pair of pilot-operated check valves connected in parallel to the air conduit supplying the actuating means to prevent air flow when main air line is charged but uncoupled at one end</p> |                                                                                                                                                                                          |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                      |                                                                                                                                                                                          |
| 1. Can be added to Type "E"                                                                                                                                                                                   | X                                                                                                                                                                                        |
| 2. Requires modification of Type "E"                                                                                                                                                                          |                                                                                                                                                                                          |
| 3. Requires head adapter for Type "E"                                                                                                                                                                         |                                                                                                                                                                                          |
| 4. Incompatible with Type "E"                                                                                                                                                                                 |                                                                                                                                                                                          |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                    |                                                                                                                                                                                          |
| Pertinent Functions                                                                                                                                                                                           |                                                                                                                                                                                          |
| IA1.                                                                                                                                                                                                          |                                                                                                                                                                                          |
| IA2.                                                                                                                                                                                                          |                                                                                                                                                                                          |
| IA3a.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| *IA3b.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| *IA3c.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| IB1.                                                                                                                                                                                                          |                                                                                                                                                                                          |
| IB2.                                                                                                                                                                                                          |                                                                                                                                                                                          |
| IB3.                                                                                                                                                                                                          |                                                                                                                                                                                          |
|                                                                                                                                                                                                               | - One pilot check valve is operated by air from the means for opening the actuating means and the other is operated by air from the main air line between the main valve and the coupler |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                     |                                                                                                                                                                                          |
| Pertinent Functions                                                                                                                                                                                           |                                                                                                                                                                                          |
| IIA1.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IIA2.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IIA3.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IIB1.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IIB2.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IIB3.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IIB4.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IIIC1.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| IIIC2.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| IIIC3.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| IID.                                                                                                                                                                                                          |                                                                                                                                                                                          |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                  |                                                                                                                                                                                          |
| Pertinent Functions                                                                                                                                                                                           |                                                                                                                                                                                          |
| IIIA1.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| IIIA2.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| IIIA3a.                                                                                                                                                                                                       |                                                                                                                                                                                          |
| IIIA3b.                                                                                                                                                                                                       |                                                                                                                                                                                          |
| IIIA4.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| IIIB1.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| IIIB2.                                                                                                                                                                                                        |                                                                                                                                                                                          |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                         |                                                                                                                                                                                          |
| Pertinent Functions                                                                                                                                                                                           |                                                                                                                                                                                          |
| IVA1.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IVA2.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IVB1.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IVB3.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IVB4.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IVB5.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IVB6.                                                                                                                                                                                                         |                                                                                                                                                                                          |
| IVC.                                                                                                                                                                                                          |                                                                                                                                                                                          |

**Concept 678: AUTOMATIC PNEUMATIC COUPLING SYSTEM**

**Primary Bibliography Reference No.: 678**

|                                                                                                                                                                                                                                                                                                                                     |                                                                                                                              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 517                                                                                                                                                                                                                                                                                                     |                                                                                                                              |
| Description of Concept - Extensible pneumatic piston and cylinder assembly, one part is attached to the main body of the coupler; the other part is operally connected to the operating mechanism of the coupler knuckle.<br><br>- Bleeding of the cylinder and piston assembly is effected through a pneumatic time delay circuit. |                                                                                                                              |
| Compatibility with AAX Type "E" Coupler:                                                                                                                                                                                                                                                                                            |                                                                                                                              |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                         | X                                                                                                                            |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                |                                                                                                                              |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                               |                                                                                                                              |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                       |                                                                                                                              |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                          |                                                                                                                              |
| Pertinent Functions<br>IAI.<br>IAZ.<br>IAJa.<br>IAJb.<br>IAJc.<br>IB1.<br>IB2.<br>IB3.                                                                                                                                                                                                                                              |                                                                                                                              |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                           |                                                                                                                              |
| Pertinent Functions<br>IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                                                                                                                                                               |                                                                                                                              |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                        |                                                                                                                              |
| Pertinent Functions<br>IIA1.<br>IIA2.<br>IIA3a.<br>IIA3b.<br>IIA4.<br>IIB1.<br>IIB2.                                                                                                                                                                                                                                                | - Pneumatically - actuated device with control line connected to main air line whereby car uncoupling opens coupler knuckle. |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                               |                                                                                                                              |
| Pertinent Functions<br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                                                          |                                                                                                                              |

# Concept 680: TRAINLINE CONNECTOR APPARATUS

Primary Bibliography Reference No.: 680

|                                                                                                                                                                                                                                                                                                                                    |                                           |                             |   |                                      |  |                                       |  |                               |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 502                                                                                                                                                                                                                                                                                                    |                                           |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept - To be carried by railway vehicle coupler <ul style="list-style-type: none"> <li>- Arm carrying the connector head can be moved and held in connecting position.</li> <li>- Can have substantially universal angling movements during trace of the vehicles when the connector is connected.</li> </ul>    |                                           |                             |   |                                      |  |                                       |  |                               |  |
| Compatibility with AAR Type "E" Coupler: <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                           | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                        | X                                         |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                               |                                           |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                              |                                           |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                      |                                           |                             |   |                                      |  |                                       |  |                               |  |
| - Can be held in storage position<br>- Gathering wings to facilitate connection.                                                                                                                                                                                                                                                   |                                           |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                         |                                           |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>* IAI.<br>IA2.<br>IA3a.<br>IA3b.<br>IA3c.<br>IB1.<br>IB2.<br>IB3.                                                                                                                                                                                                                                           | - Compression spring maintains connection |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                          |                                           |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                                                                                                                                                              |                                           |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                       |                                           |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IIIA1.<br>IIIA2.<br>IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIIB1.<br>IIIB2.                                                                                                                                                                                                                                        |                                           |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                              |                                           |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                                                         |                                           |                             |   |                                      |  |                                       |  |                               |  |

# Concept 682: AUTOMATIC COUPLING SYSTEM FOR TRAIN BRAKE LINES

Primary Bibliography Reference No.: 682

Related Reference Number(s) 517

Description of Concept - Attached to coupler below coupler head

- Air coupler on rubber grommet which couples and uncouples simultaneously with mechanical coupling or uncoupling - pilot valves control air.
- Gathering wings facilitate connection.

Compatibility with AA Type "E" Coupler:

|                                       |   |
|---------------------------------------|---|
| 1. Can be added to Type "E"           | X |
| 2. Requires modification of Type "E"  |   |
| 3. Requires head adapter for Type "E" |   |
| 4. Incompatible with Type "E"         |   |

## CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM

Pertinent Functions

- \* IA1.
  - \* IA2.
  - \* IA3a.
  - \* IA3b.
  - \* IA3c.
  - IB1.
  - IB2.
  - IB3.
- Automatic connection eliminates need for present glad hand system.

## CATEGORY II - IMPROVE MECHANICAL COUPLING

Pertinent Functions

- IIA1.
- IIA2.
- IIA3.
- IIB1.
- IIB2.
- IIB3.
- IIB4.
- IIC1.
- IIC2.
- IIC3.
- IID.

## CATEGORY III - IMPROVE MECHANICAL UNCOUPLING

Pertinent Functions

- IIIA1.
- IIIA2.
- IIIA3a.
- IIIA3b.
- IIIA4.
- IIB1.
- IIB2.

## CATEGORY IV - IMPROVE GENERAL SYSTEMS

Pertinent Functions

- IVA1.
- IVA2.
- IVB1.
- IVB2.
- IVB3.
- IVB4.
- IVB5.
- IVB6.
- IVC.

# Concept 686: ARMSTED AUTOMATIC AIR LINE CONNECTION SYSTEM

Primary Bibliography Reference No.: 686

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <p>Description of Concept Consisting of a dual probe/funnel air connection system mounted side-by-side above the coupler head such that the probe "floats" in a "U" shaped mounting and the mating funnel is solidly mounted to the coupler head. The system operates as follows:</p> <ol style="list-style-type: none"> <li>1. Coupler guides the probe into basic alignment and the funnel completes the gathering.</li> <li>2. The probe operates a quick disconnect valve to open its air line with interconnecting air pilot lines.</li> <li>3. Unintentional uncoupling results in operating of the valves through a spring bias system to set the emergency brake system.</li> </ol> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <ol style="list-style-type: none"> <li>1. Can be added to Type "E"</li> <li>2. Requires modification of Type "E"</li> <li>3. Requires head adapter for Type "E"</li> <li>4. Incompatible with Type "E"</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <ol style="list-style-type: none"> <li>4. With intentional uncoupling, an operating lever (at the valve system) is manually operated or push rod operated to retain air pressure in either or both cars to be uncoupled. Automatic air connection and brake valve control.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p>** There is reason to question the gathering ability of the twin probe/funnel system when coupling on tight curves due to the necessity of the probes to traverse tightly defined parallel paths.</p> <p>** Ability to maintain the parallel seats under conditions of relative coupler movement (vertical, lateral or rotational) seems doubtful within the travel limits of the "U" shaped mount.</p> <p>** To operate reliably, the system requires proper operation of both halves of a dual valve control system.</p> <p>- System does allow an easy use of "mixed" air connection systems since all original angle cocks and hoses remain.</p> <p>** Complicated uncoupling valve control.</p> |
| IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| IVA1.<br>IVA2.<br>IVA3.<br>IVB1.<br>IVB2.<br>IVB3.<br>IVB4.<br>IVC1.<br>IVC2.<br>IVC3.<br>IVD.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| IVA1.<br>IVA2.<br>IVA3a.<br>IVA3b.<br>IVA4.<br>IVB1.<br>IVB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

# Concept 702: ARMSTED MODIFIED DOUBLE SHELF "E" COUPLER

Primary Bibliography Reference No.: 702

|                                                                                                                                                                     |                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                         |                                                                                                                                                                                       |
| Description of Concept                                                                                                                                              |                                                                                                                                                                                       |
| Adaptation of "E" double-shelf coupler (Ref. No. 54) by adding guard arm extension faces at top and bottom of side shelf supports to achieve fixed gathering wings. |                                                                                                                                                                                       |
| Compatibility with ARM Type "E" Coupler:                                                                                                                            |                                                                                                                                                                                       |
| 1. Can be added to Type "E"                                                                                                                                         | X                                                                                                                                                                                     |
| 2. Requires modification of Type "E"                                                                                                                                |                                                                                                                                                                                       |
| 3. Requires head adapter for Type "E"                                                                                                                               |                                                                                                                                                                                       |
| 4. Incompatible with Type "E"                                                                                                                                       |                                                                                                                                                                                       |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                          |                                                                                                                                                                                       |
| Pertinent Functions                                                                                                                                                 |                                                                                                                                                                                       |
| IA1.                                                                                                                                                                |                                                                                                                                                                                       |
| IA2.                                                                                                                                                                |                                                                                                                                                                                       |
| IA3a.                                                                                                                                                               |                                                                                                                                                                                       |
| IA3b.                                                                                                                                                               |                                                                                                                                                                                       |
| IA3c.                                                                                                                                                               |                                                                                                                                                                                       |
| IB1.                                                                                                                                                                |                                                                                                                                                                                       |
| IB2.                                                                                                                                                                |                                                                                                                                                                                       |
| IB3.                                                                                                                                                                |                                                                                                                                                                                       |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                           |                                                                                                                                                                                       |
| Pertinent Functions                                                                                                                                                 |                                                                                                                                                                                       |
| *IA1.                                                                                                                                                               |                                                                                                                                                                                       |
| *IA2.                                                                                                                                                               | - Length of front face is extended.                                                                                                                                                   |
| IA3.                                                                                                                                                                | - Horizontal shelf projects at a distance from longitudinal center line greater than the height of a knuckle.                                                                         |
| IB1.                                                                                                                                                                |                                                                                                                                                                                       |
| IB2.                                                                                                                                                                |                                                                                                                                                                                       |
| IB3.                                                                                                                                                                |                                                                                                                                                                                       |
| IB4.                                                                                                                                                                |                                                                                                                                                                                       |
| IC1.                                                                                                                                                                |                                                                                                                                                                                       |
| IC2.                                                                                                                                                                |                                                                                                                                                                                       |
| IC3.                                                                                                                                                                |                                                                                                                                                                                       |
| ID.                                                                                                                                                                 |                                                                                                                                                                                       |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                        |                                                                                                                                                                                       |
| Pertinent Functions                                                                                                                                                 |                                                                                                                                                                                       |
| IIIA1.                                                                                                                                                              |                                                                                                                                                                                       |
| IIIA2.                                                                                                                                                              |                                                                                                                                                                                       |
| IIIA3a.                                                                                                                                                             |                                                                                                                                                                                       |
| IIIA3b.                                                                                                                                                             |                                                                                                                                                                                       |
| IIIA4.                                                                                                                                                              |                                                                                                                                                                                       |
| IIIB1.                                                                                                                                                              |                                                                                                                                                                                       |
| IIIB2.                                                                                                                                                              |                                                                                                                                                                                       |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                               |                                                                                                                                                                                       |
| Pertinent Functions                                                                                                                                                 |                                                                                                                                                                                       |
| IVA1.                                                                                                                                                               |                                                                                                                                                                                       |
| IVA2.                                                                                                                                                               | - Achieves a significant increase in lateral gatherings range (exact amount not quantitatively identified) without sacrifice of interlocking capabilities of "E" double shelf design. |
| VB1.                                                                                                                                                                |                                                                                                                                                                                       |
| VB3.                                                                                                                                                                |                                                                                                                                                                                       |
| VB4.                                                                                                                                                                | - Achieves a nominal increase in vertical gathering.                                                                                                                                  |
| VB5.                                                                                                                                                                |                                                                                                                                                                                       |
| VB6.                                                                                                                                                                |                                                                                                                                                                                       |
| *IVC.                                                                                                                                                               | - Increased gathering range would result in a reduced probability for bypasses and, therefore, increased safety.                                                                      |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 703: UNIVERSAL AUTOMATIC COUPLER

Primary Bibliography Reference No.: 703

|                                                                                  |  |
|----------------------------------------------------------------------------------|--|
| Related Reference Number(s)                                                      |  |
| Description of Concept                                                           |  |
| <p>- One member is a guide member, the other is a locking and guiding member</p> |  |
| Compatibility with AAR Type "E" Coupler:                                         |  |
| 1. Can be added to Type "E"                                                      |  |
| 2. Requires modification of Type "E"                                             |  |
| 3. Requires head adapter for Type "E"                                            |  |
| 4. Incompatible with Type "E"                                                    |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                       |  |
| Pertinent Functions                                                              |  |
| IA1.                                                                             |  |
| IA2.                                                                             |  |
| IA3a.                                                                            |  |
| IA3b.                                                                            |  |
| IA3c.                                                                            |  |
| IB1.                                                                             |  |
| IB2.                                                                             |  |
| IB3.                                                                             |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                        |  |
| Pertinent Functions                                                              |  |
| IIA1.                                                                            |  |
| IIA2.                                                                            |  |
| IIA3.                                                                            |  |
| IIB1.                                                                            |  |
| IIB2.                                                                            |  |
| IIB3.                                                                            |  |
| IIB4.                                                                            |  |
| IIC1.                                                                            |  |
| IIC2.                                                                            |  |
| IIC3.                                                                            |  |
| IID.                                                                             |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                     |  |
| Pertinent Functions                                                              |  |
| IIIA1.                                                                           |  |
| IIIA2.                                                                           |  |
| IIIA3a.                                                                          |  |
| IIIA3b.                                                                          |  |
| IIIA4.                                                                           |  |
| IIIB1.                                                                           |  |
| IIIB2.                                                                           |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                            |  |
| Pertinent Functions                                                              |  |
| IVA1.                                                                            |  |
| IVA2.                                                                            |  |
| IVB1.                                                                            |  |
| IVB3.                                                                            |  |
| IVB4.                                                                            |  |
| IVB5.                                                                            |  |
| IVB6.                                                                            |  |
| IVC.                                                                             |  |

# Concept 705: HOOK COUPLER

Primary Bibliography Reference No.: 705

Related Reference Number(s) 502

Description of Concept - Spring based coupling hook

- Adapted for interlocking engagement
- Inboard projections and tapered hook facilitate gathering

Compatibility with AAR Type "E" Coupler:

- |                                       |   |
|---------------------------------------|---|
| 1. Can be added to Type "E"           |   |
| 2. Requires modification of Type "E"  |   |
| 3. Requires head adapter for Type "E" |   |
| 4. Incompatible with Type "E"         | X |

## **CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM**

Pertinent Functions

- IA1.
- IA2.
- IA3a.
- IA3b.
- IA3c.
- IB1.
- IB2.
- IB3.

## **CATEGORY II - IMPROVE MECHANICAL COUPLING**

Pertinent Functions

- \*IIA1.
- IIA2.
- IIA3.
- IIB1.
- IIB2.
- IIB3.
- IIB4.
- IIC1.
- IIC2.
- IIC3.
- IID.

- Tapered hook and inboard projections effects a gathering range of approximately 6"

## **CATEGORY III - IMPROVE MECHANICAL UNCOPPLING**

Pertinent Functions

- IIIA1.
- IIIA2.
- IIIA3a.
- IIIA3b.
- IIIA4.
- IIIB1.
- IIIB2.

## **CATEGORY IV - IMPROVE GENERAL SYSTEMS**

Pertinent Functions

- IVA1.
- IVA2.
- IVB1.
- IVB3.
- IVB4.
- IVB5.
- IVB6.
- IVC.

Concept 740: COUPLER TO REPLACE HOOK OR SCREW COUPLER

Primary Bibliography Reference No.: 740

Related Reference Number(s) 501

Description of Concept - One piece casting

- Pivotal gathering wings disposed at a 45° angle from a horizontal plane.
- Head at one end of the shank provided with upper and lower sections defining a throat.

Compatibility with AAR Type "E" Coupler:

1. Can be added to Type "E"
2. Requires modification of Type "E"
3. Requires head adapter for Type "E"
4. Incompatible with Type "E"

- Lock mounted in upper section latch on one gathering wing.

X

**CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM**

Pertinent Functions

IA1.  
IA2.  
IA3a.  
IA3b.  
IA3c.  
IB1.  
IB2.  
IB3.

**CATEGORY II - IMPROVE MECHANICAL COUPLING**

Pertinent Functions

IIA1.  
IIA2.  
\* IIA3.  
IIB1.  
\* IIB2.  
IIB3.  
IIB4.  
IIC1.  
IIC2.  
IIC3.  
IID.

- Wings increase gathering

**CATEGORY III - IMPROVE MECHANICAL UNCOUPLING**

Pertinent Functions

\* IIIA1.  
IIIA2.  
IIIA3a.  
IIIA3b.  
IIIA4.  
\* IIIB1.  
IIIB2.

- Lock intended to prevent unintentional uncouplings

**CATEGORY IV - IMPROVE GENERAL SYSTEMS**

Pertinent Functions

IVA1.  
IVA2.  
IVB1.  
IVB3.  
IVB4.  
IVB5.  
IVB6.  
IVC.

# Concept 760: MODIFIED "E" COUPLER

Primary Bibliography Reference No.: 760

Related Reference Number(s) 502

Description of Concept - Improved lever member having roller contact with an associated cam element to improve opening coupler

- Spring actuated

## Compatibility with AAR Type "E" Coupler:

- |                                       |   |
|---------------------------------------|---|
| 1. Can be added to Type "E"           |   |
| 2. Requires modification of Type "E"  | X |
| 3. Requires head adapter for Type "E" |   |
| 4. Incompatible with Type "E"         |   |

## CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM

### Pertinent Functions

IA1.  
IA2.  
IA3a.  
IA3b.  
IA3c.  
IB1.  
IB2.  
IB3.

## CATEGORY II - IMPROVE MECHANICAL COUPLING

### Pertinent Functions

IIA1.  
IIA2.  
IIA3.  
IIB1.  
IIB2.  
IIB3.  
IIB4.  
IIC1.  
IIC2.  
IIC3.  
IID.

## CATEGORY III - IMPROVE MECHANICAL UNCOUPLING

### Pertinent Functions

IIIA1.  
IIIA2.  
IIIA3a.  
IIIA3b.  
IIIA4.  
\*IIIB1.  
IIIB2.

- Spring actuated lever member within the coupler head

## CATEGORY IV - IMPROVE GENERAL SYSTEMS

### Pertinent Functions

IVA1.  
IVA2.  
IVB1.  
IVB3.  
IVB4.  
IVB5.  
IVB6.  
IVC.

# Concept 761: MODIFIED KNUCKLE COUPLER

Primary Bibliography Reference No.: 761

|                                                                                                                                                                    |                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| Related Reference Number(s) 502                                                                                                                                    |                                                    |
| Description of Concept - Knuckle coupler<br>- Spring assembly to actuate the knuckle unlocking and opening.<br>- Assembly easily removed for maintenance purposes. |                                                    |
| Compatibility with AAR Type "E" Coupler:                                                                                                                           |                                                    |
| 1. Can be added to Type "E"                                                                                                                                        |                                                    |
| 2. Requires modification of Type "E"                                                                                                                               | X                                                  |
| 3. Requires head adapter for Type "E"                                                                                                                              |                                                    |
| 4. Incompatible with Type "E"                                                                                                                                      |                                                    |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                         |                                                    |
| Pertinent Functions                                                                                                                                                |                                                    |
| IA1.                                                                                                                                                               |                                                    |
| IA2.                                                                                                                                                               |                                                    |
| IA3a.                                                                                                                                                              |                                                    |
| IA3b.                                                                                                                                                              |                                                    |
| IA3c.                                                                                                                                                              |                                                    |
| IB1.                                                                                                                                                               |                                                    |
| IB2.                                                                                                                                                               |                                                    |
| IB3.                                                                                                                                                               |                                                    |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                          |                                                    |
| Pertinent Functions                                                                                                                                                |                                                    |
| IIA1.                                                                                                                                                              |                                                    |
| IIA2.                                                                                                                                                              |                                                    |
| IIA3.                                                                                                                                                              |                                                    |
| IIB1.                                                                                                                                                              |                                                    |
| IIB2.                                                                                                                                                              |                                                    |
| IIB3.                                                                                                                                                              |                                                    |
| IIB4.                                                                                                                                                              |                                                    |
| IIC1.                                                                                                                                                              |                                                    |
| IIC2.                                                                                                                                                              |                                                    |
| IIC3.                                                                                                                                                              |                                                    |
| IIC4.                                                                                                                                                              |                                                    |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                       |                                                    |
| Pertinent Functions                                                                                                                                                |                                                    |
| IIIA1.                                                                                                                                                             |                                                    |
| IIIA2.                                                                                                                                                             |                                                    |
| IIIA3a.                                                                                                                                                            |                                                    |
| IIIA3b.                                                                                                                                                            |                                                    |
| IIIA4.                                                                                                                                                             |                                                    |
| *IIB1.                                                                                                                                                             | - Spring loaded assembly facilitates lock opening. |
| IIB2.                                                                                                                                                              |                                                    |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                              |                                                    |
| Pertinent Functions                                                                                                                                                |                                                    |
| IVA1.                                                                                                                                                              |                                                    |
| IVA2.                                                                                                                                                              |                                                    |
| IVB1.                                                                                                                                                              |                                                    |
| IVB3.                                                                                                                                                              |                                                    |
| IVB4.                                                                                                                                                              |                                                    |
| IVB5.                                                                                                                                                              |                                                    |
| IVB6.                                                                                                                                                              |                                                    |
| IVC.                                                                                                                                                               |                                                    |

# Concept 890: IMPROVED KNUCKLE STRUCTURE

Primary Bibliography Reference No.: 890

|                                                                        |                                                  |
|------------------------------------------------------------------------|--------------------------------------------------|
| Related Reference Number(s) 501, 502a                                  |                                                  |
| Description of Concept - Knuckle coupler<br>- Convex gathering surface |                                                  |
| Compatibility with AAR Type "E" Coupler:                               |                                                  |
| 1. Can be added to Type "E"                                            | X                                                |
| 2. Requires modification of Type "E"                                   |                                                  |
| 3. Requires head adapter for Type "E"                                  |                                                  |
| 4. Incompatible with Type "E"                                          |                                                  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                             |                                                  |
| Pertinent Functions                                                    |                                                  |
| IA1.                                                                   |                                                  |
| IA2.                                                                   |                                                  |
| IA3a.                                                                  |                                                  |
| IA3b.                                                                  |                                                  |
| IA3c.                                                                  |                                                  |
| IB1.                                                                   |                                                  |
| IB2.                                                                   |                                                  |
| IB3.                                                                   |                                                  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                              |                                                  |
| Pertinent Functions                                                    |                                                  |
| * IIA1.                                                                | - Improved knuckle contour to improve gathering. |
| IIA2.                                                                  |                                                  |
| IIA3.                                                                  |                                                  |
| IIB1.                                                                  |                                                  |
| IIB2.                                                                  |                                                  |
| IIB3.                                                                  |                                                  |
| IIB4.                                                                  |                                                  |
| IIC1.                                                                  |                                                  |
| IIC2.                                                                  |                                                  |
| IIC3.                                                                  |                                                  |
| IID.                                                                   |                                                  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                           |                                                  |
| Pertinent Functions                                                    |                                                  |
| IIIA1.                                                                 |                                                  |
| IIIA2.                                                                 |                                                  |
| IIIA3a.                                                                |                                                  |
| IIIA3b.                                                                |                                                  |
| IIIA4.                                                                 |                                                  |
| IIIB1.                                                                 |                                                  |
| IIIB2.                                                                 |                                                  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                  |                                                  |
| Pertinent Functions                                                    |                                                  |
| IVA1.                                                                  |                                                  |
| IVA2.                                                                  |                                                  |
| IVB1.                                                                  |                                                  |
| IVB3.                                                                  |                                                  |
| IVB4.                                                                  |                                                  |
| IVB5.                                                                  |                                                  |
| IVB6.                                                                  |                                                  |
| IVC.                                                                   |                                                  |

Concept 891: COUPLER KNUCKLE STRUCTURE  
Primary Bibliography Reference No.: 891

Related Reference Number(s) 501

Description of Concept - Knuckle coupler with gathering surfaces.

Compatibility with AAR Type "E" Coupler:

- |                                       |   |
|---------------------------------------|---|
| 1. Can be added to Type "E"           |   |
| 2. Requires modification of Type "E"  | X |
| 3. Requires head adapter for Type "E" |   |
| 4. Incompatible with Type "E"         |   |

**CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM**

**Pertinent Functions**

|       |
|-------|
| IA1.  |
| IA2.  |
| IA3a. |
| IA3b. |
| IA3c. |
| IB1.  |
| IB2.  |
| IB3.  |

**CATEGORY II - IMPROVE MECHANICAL COUPLING**

**Pertinent Functions**

|         |
|---------|
| * IIA1. |
| IIA2.   |
| IIA3.   |
| IIB1.   |
| IIB2.   |
| IIB3.   |
| IIB4.   |
| IIC1.   |
| IIC2.   |
| IIC3.   |
| IID.    |

- Couplers may be misaligned by as much as 4-1/8 inch.

**CATEGORY III - IMPROVE MECHANICAL UNCOUPLING**

**Pertinent Functions**

|         |
|---------|
| IIIA1.  |
| IIIA2.  |
| IIIA3a. |
| IIIA3b. |
| IIIA4.  |
| IIB1.   |
| IIB2.   |

**CATEGORY IV - IMPROVE GENERAL SYSTEMS**

**Pertinent Functions**

|       |
|-------|
| IVA1. |
| IVA2. |
| IVB1. |
| IVB3. |
| IVB4. |
| IVB5. |
| IVB6. |
| IVC.  |

# Concept 892: COUPLER CONTOUR

Primary Bibliography Reference No.: 892

|                                                                                                                                                                                                |                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| Related Reference Number(s) 502                                                                                                                                                                |                                |
| Description of Concept - Knuckle coupler with modified 10A contour wherein pulling face of its pivoted knuckle is offset approximately 5/64 inch closer to the front face of the coupler head. |                                |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                       |                                |
| 1. Can be added to Type "E"                                                                                                                                                                    |                                |
| 2. Requires modification of Type "E"                                                                                                                                                           | X                              |
| 3. Requires head adapter for Type "E"                                                                                                                                                          |                                |
| 4. Incompatible with Type "E"                                                                                                                                                                  |                                |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                     |                                |
| Pertinent Functions                                                                                                                                                                            |                                |
| IA1.                                                                                                                                                                                           |                                |
| IA2.                                                                                                                                                                                           |                                |
| IA3a.                                                                                                                                                                                          |                                |
| IA3b.                                                                                                                                                                                          |                                |
| IA3c.                                                                                                                                                                                          |                                |
| IB1.                                                                                                                                                                                           |                                |
| IB2.                                                                                                                                                                                           |                                |
| IB3.                                                                                                                                                                                           |                                |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                      |                                |
| Pertinent Functions                                                                                                                                                                            |                                |
| IIA1.                                                                                                                                                                                          |                                |
| IIA2.                                                                                                                                                                                          |                                |
| IIA3.                                                                                                                                                                                          |                                |
| IIIB1.                                                                                                                                                                                         |                                |
| * IIIB2.                                                                                                                                                                                       | - 20% reduction of free slick. |
| IIIB3.                                                                                                                                                                                         |                                |
| IIIB4.                                                                                                                                                                                         |                                |
| IIIC1.                                                                                                                                                                                         |                                |
| IIIC2.                                                                                                                                                                                         |                                |
| IIIC3.                                                                                                                                                                                         |                                |
| IID.                                                                                                                                                                                           |                                |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                   |                                |
| Pertinent Functions                                                                                                                                                                            |                                |
| IIIA1.                                                                                                                                                                                         |                                |
| IIIA2.                                                                                                                                                                                         |                                |
| IIIA3a.                                                                                                                                                                                        |                                |
| IIIA3b.                                                                                                                                                                                        |                                |
| IIIA4.                                                                                                                                                                                         |                                |
| IIIB1.                                                                                                                                                                                         |                                |
| IIIB2.                                                                                                                                                                                         |                                |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                          |                                |
| Pertinent Functions                                                                                                                                                                            |                                |
| IVA1.                                                                                                                                                                                          |                                |
| IVA2.                                                                                                                                                                                          |                                |
| IVB1.                                                                                                                                                                                          |                                |
| IVB3.                                                                                                                                                                                          |                                |
| IVB4.                                                                                                                                                                                          |                                |
| IVB5.                                                                                                                                                                                          |                                |
| IVB6.                                                                                                                                                                                          |                                |
| IVC.                                                                                                                                                                                           |                                |

# Concept 895: CAR COUPLER

Primary Bibliography Reference No.: 895

|                                              |                                         |
|----------------------------------------------|-----------------------------------------|
| Related Reference Number(s)                  |                                         |
| Description of Concept                       |                                         |
| - Knuckle contour to facilitate gathering    |                                         |
| Compatibility with AAR Type "E" Coupler:     |                                         |
| 1. Can be added to Type "E"                  | <input type="checkbox"/>                |
| 2. Requires modification of Type "E"         | <input type="checkbox"/>                |
| 3. Requires head adapter for Type "E"        | <input type="checkbox"/>                |
| 4. Incompatible with Type "E"                | <input type="checkbox"/>                |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM   |                                         |
| Pertinent Functions:                         |                                         |
| IA1.                                         |                                         |
| IA2.                                         |                                         |
| IA3a.                                        |                                         |
| IA3b.                                        |                                         |
| IA3c.                                        |                                         |
| IB1.                                         |                                         |
| IB2.                                         |                                         |
| IB3.                                         |                                         |
| CATEGORY II - IMPROVE MECHANICAL COUPLING    |                                         |
| Pertinent Functions:                         |                                         |
| *IIA1.                                       | - Knuckle contour facilitates gathering |
| IIA2.                                        |                                         |
| IIA3.                                        |                                         |
| IIB1.                                        |                                         |
| IIB2.                                        |                                         |
| IIB3.                                        |                                         |
| IIB4.                                        |                                         |
| IIC1.                                        |                                         |
| IIC2.                                        |                                         |
| IIC3.                                        |                                         |
| IID.                                         |                                         |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING |                                         |
| Pertinent Functions:                         |                                         |
| IIIA1.                                       |                                         |
| IIIA2.                                       |                                         |
| IIIA3a.                                      |                                         |
| IIIA3b.                                      |                                         |
| IIIA4.                                       |                                         |
| IIIB1.                                       |                                         |
| IIIB2.                                       |                                         |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS        |                                         |
| Pertinent Functions:                         |                                         |
| IVA1.                                        |                                         |
| IVA2.                                        |                                         |
| IVB1.                                        |                                         |
| IVB3.                                        |                                         |
| IVB4.                                        |                                         |
| IVB5.                                        |                                         |
| IVB6.                                        |                                         |
| IVC.                                         |                                         |

# Concept 900: RAILWAY CAR COUPLER

Primary Bibliography Reference NO.: 900

|                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| Description of Concept<br><br><div style="text-align: center;">- Auxiliary lug is mounted on shelf carried on the lower portion of the coupler head</div>                                                                                                                                                                                                 |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| Compatibility with AAR Type "E" Coupler: <table border="1" style="float: right; width: 150px;"> <tr><td>1. Can be added to Type "E"</td><td></td></tr> <tr><td>2. Requires modification of Type "E"</td><td></td></tr> <tr><td>3. Requires head adapter for Type "E"</td><td></td></tr> <tr><td>4. Incompatible with Type "E"</td><td></td></tr> </table> |                                                                                                                                                          | 1. Can be added to Type "E" |  | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| <b>CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM</b>                                                                                                                                                                                                                                                                                                         |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IA1.<br>IA2.<br>IA3a.<br>IA3b.<br>IA3c.<br>IB1.<br>IB2.<br>IB3.                                                                                                                                                                                                                                                                    |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| <b>CATEGORY II - IMPROVE MECHANICAL COUPLING</b>                                                                                                                                                                                                                                                                                                          |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>*IIA1.<br>*IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                                                                                                                                                                                   | - Auxiliary lug has ramp portion to slidably engage the bottom forward edge of a shelf carried by an opposed mating coupler to permit coupler alignment. |                             |  |                                      |  |                                       |  |                               |  |
| <b>CATEGORY III - IMPROVE MECHANICAL UNCOUPLING</b>                                                                                                                                                                                                                                                                                                       |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IIIA1.<br>IIIA2.<br>IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIB1.<br>IIB2.                                                                                                                                                                                                                                                                 |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| <b>CATEGORY IV - IMPROVE GENERAL SYSTEMS</b>                                                                                                                                                                                                                                                                                                              |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                                                                                |                                                                                                                                                          |                             |  |                                      |  |                                       |  |                               |  |

# Concept 901: COUPLER KNUCKLE

Primary Bibliography Reference No.: 901

|                                                                                                                                                                 |                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                     |                                                                   |
| Description of Concept                                                                                                                                          |                                                                   |
| <p align="center">"F" Knuckle - Provision of a pair of spaced lugs on the knuckle arranged for full face engagement with existing shoulders of coupler head</p> |                                                                   |
| Compatibility with AAR Type "E" Coupler:                                                                                                                        |                                                                   |
| 1. Can be added to Type "E"                                                                                                                                     | X                                                                 |
| 2. Requires modification of Type "E"                                                                                                                            |                                                                   |
| 3. Requires head adapter for Type "E"                                                                                                                           |                                                                   |
| 4. Incompatible with Type "E"                                                                                                                                   |                                                                   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                      |                                                                   |
| Pertinent Functions                                                                                                                                             |                                                                   |
| IA1.                                                                                                                                                            |                                                                   |
| IA2.                                                                                                                                                            |                                                                   |
| IA3a.                                                                                                                                                           |                                                                   |
| IA3b.                                                                                                                                                           |                                                                   |
| IA3c.                                                                                                                                                           |                                                                   |
| IB1.                                                                                                                                                            |                                                                   |
| IB2.                                                                                                                                                            |                                                                   |
| IB3.                                                                                                                                                            |                                                                   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                       |                                                                   |
| Pertinent Functions                                                                                                                                             |                                                                   |
| * IIA1.                                                                                                                                                         | - Greatly increase bearing areas between knuckle and coupler head |
| IIA2.                                                                                                                                                           |                                                                   |
| IIA3.                                                                                                                                                           |                                                                   |
| IIB1.                                                                                                                                                           | - Claims to reduce failures because the lugs strengthen the nose  |
| IIB2.                                                                                                                                                           |                                                                   |
| IIB3.                                                                                                                                                           |                                                                   |
| IIB4.                                                                                                                                                           |                                                                   |
| IIC1.                                                                                                                                                           |                                                                   |
| IIC2.                                                                                                                                                           |                                                                   |
| IIC3.                                                                                                                                                           |                                                                   |
| IID.                                                                                                                                                            |                                                                   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                    |                                                                   |
| Pertinent Functions                                                                                                                                             |                                                                   |
| IIIA1.                                                                                                                                                          |                                                                   |
| IIIA2.                                                                                                                                                          |                                                                   |
| IIIA3a.                                                                                                                                                         |                                                                   |
| IIIA3b.                                                                                                                                                         |                                                                   |
| IIIA4.                                                                                                                                                          |                                                                   |
| IIIB1.                                                                                                                                                          |                                                                   |
| IIIB2.                                                                                                                                                          |                                                                   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                           |                                                                   |
| Pertinent Functions                                                                                                                                             |                                                                   |
| IVA1.                                                                                                                                                           |                                                                   |
| IVA2.                                                                                                                                                           |                                                                   |
| IVB1.                                                                                                                                                           |                                                                   |
| IVB3.                                                                                                                                                           |                                                                   |
| IVB4.                                                                                                                                                           |                                                                   |
| IVB5.                                                                                                                                                           |                                                                   |
| IVB6.                                                                                                                                                           |                                                                   |
| IVC.                                                                                                                                                            |                                                                   |

# Concept 910: INTERLOCKING KNUCKLE COUPLER

Primary Bibliography Reference No.: 910

|                                                                                                                                                                                          |                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Related Reference Number(s)                                                                                                                                                              |                                                                                  |
| Description of Concept - A spring loaded latch is attached to a coupler to slip into a space on the opposite coupler to provide vertical interlock even if only one coupler is equipped. |                                                                                  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                 |                                                                                  |
| 1. Can be added to Type "E"                                                                                                                                                              |                                                                                  |
| 2. Requires modification of Type "E"                                                                                                                                                     |                                                                                  |
| 3. Requires head adapter for Type "E"                                                                                                                                                    |                                                                                  |
| 4. Incompatible with Type "E"                                                                                                                                                            |                                                                                  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                               |                                                                                  |
| Pertinent Functions                                                                                                                                                                      |                                                                                  |
| IA1.                                                                                                                                                                                     |                                                                                  |
| IA2.                                                                                                                                                                                     |                                                                                  |
| IA3a.                                                                                                                                                                                    |                                                                                  |
| IA3b.                                                                                                                                                                                    |                                                                                  |
| IA3c.                                                                                                                                                                                    |                                                                                  |
| IB1.                                                                                                                                                                                     |                                                                                  |
| IB2.                                                                                                                                                                                     |                                                                                  |
| IB3.                                                                                                                                                                                     |                                                                                  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                |                                                                                  |
| Pertinent Functions                                                                                                                                                                      |                                                                                  |
| IIA1.                                                                                                                                                                                    |                                                                                  |
| IIA2.                                                                                                                                                                                    |                                                                                  |
| IIA3.                                                                                                                                                                                    |                                                                                  |
| IIB1.                                                                                                                                                                                    |                                                                                  |
| IIB2.                                                                                                                                                                                    |                                                                                  |
| * IIB3.                                                                                                                                                                                  | - Latch slips into a space on the opposite coupler to prevent vertical movement. |
| IIC1.                                                                                                                                                                                    |                                                                                  |
| IIC2.                                                                                                                                                                                    |                                                                                  |
| IIC3.                                                                                                                                                                                    |                                                                                  |
| IID.                                                                                                                                                                                     |                                                                                  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                             |                                                                                  |
| Pertinent Functions                                                                                                                                                                      |                                                                                  |
| IIIA1.                                                                                                                                                                                   |                                                                                  |
| IIIA2.                                                                                                                                                                                   |                                                                                  |
| IIIA3a.                                                                                                                                                                                  |                                                                                  |
| IIIA3b.                                                                                                                                                                                  |                                                                                  |
| IIIA4.                                                                                                                                                                                   |                                                                                  |
| IIIB1.                                                                                                                                                                                   |                                                                                  |
| IIIB2.                                                                                                                                                                                   |                                                                                  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                    |                                                                                  |
| Pertinent Functions                                                                                                                                                                      |                                                                                  |
| IVA1.                                                                                                                                                                                    |                                                                                  |
| IVA2.                                                                                                                                                                                    |                                                                                  |
| IVB1.                                                                                                                                                                                    |                                                                                  |
| IVB3.                                                                                                                                                                                    |                                                                                  |
| IVB4.                                                                                                                                                                                    |                                                                                  |
| IVB5.                                                                                                                                                                                    |                                                                                  |
| IVB6.                                                                                                                                                                                    |                                                                                  |
| IVC.                                                                                                                                                                                     |                                                                                  |

# Concept 912: "F" COUPLER HOOD

Primary Bibliography Reference No.: 912

|                                                                                                                                                                           |                                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| Related Reference Number(s) 502                                                                                                                                           |                                      |
| Description of Concept - "F" coupler hood which overlies the knuckle - receiving recess of the "F" coupler to afford vertical interlock when coupled with an "E" coupler. |                                      |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                  |                                      |
| 1. Can be added to Type "E"                                                                                                                                               | <input type="checkbox"/>             |
| 2. Requires modification of Type "E"                                                                                                                                      | <input type="checkbox"/>             |
| 3. Requires head adapter for Type "E"                                                                                                                                     | <input type="checkbox"/>             |
| 4. Incompatible with Type "E"                                                                                                                                             | <input type="checkbox"/>             |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                |                                      |
| Pertinent Functions                                                                                                                                                       |                                      |
| IA1.                                                                                                                                                                      |                                      |
| IA2.                                                                                                                                                                      |                                      |
| IA3a.                                                                                                                                                                     |                                      |
| IA3b.                                                                                                                                                                     |                                      |
| IA3c.                                                                                                                                                                     |                                      |
| IB1.                                                                                                                                                                      |                                      |
| IB2.                                                                                                                                                                      |                                      |
| IB3.                                                                                                                                                                      |                                      |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                 |                                      |
| Pertinent Functions                                                                                                                                                       |                                      |
| IIA1.                                                                                                                                                                     |                                      |
| IIA2.                                                                                                                                                                     |                                      |
| IIA3.                                                                                                                                                                     |                                      |
| IIB1.                                                                                                                                                                     |                                      |
| IIB2.                                                                                                                                                                     |                                      |
| IIB3.                                                                                                                                                                     | - Coupler hood overlies the knuckle. |
| IIB4.                                                                                                                                                                     |                                      |
| IIC1.                                                                                                                                                                     |                                      |
| IIC2.                                                                                                                                                                     |                                      |
| IIC3.                                                                                                                                                                     |                                      |
| ID.                                                                                                                                                                       |                                      |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                              |                                      |
| Pertinent Functions                                                                                                                                                       |                                      |
| IIIA1.                                                                                                                                                                    |                                      |
| IIIA2.                                                                                                                                                                    |                                      |
| IIIA3a.                                                                                                                                                                   |                                      |
| IIIA3b.                                                                                                                                                                   |                                      |
| IIIA4.                                                                                                                                                                    |                                      |
| IIB1.                                                                                                                                                                     |                                      |
| IIB2.                                                                                                                                                                     |                                      |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                     |                                      |
| Pertinent Functions                                                                                                                                                       |                                      |
| IVA1.                                                                                                                                                                     |                                      |
| IVA2.                                                                                                                                                                     |                                      |
| IVB1.                                                                                                                                                                     |                                      |
| IVB3.                                                                                                                                                                     |                                      |
| IVB4.                                                                                                                                                                     |                                      |
| IVB5.                                                                                                                                                                     |                                      |
| IVB6.                                                                                                                                                                     |                                      |
| IVC.                                                                                                                                                                      |                                      |

# Concept 913: VERTICALLY INTERLOCKING COUPLER

Primary Bibliography Reference No.: 913

|                                                                                                                                                                |                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| Related Reference Number(s) 501                                                                                                                                |                                             |
| Description of Concept - Knuckle coupler with vertical interlock shelf having a recess for receipt of the lower auxiliary interlock lug of a type "F" coupler. |                                             |
| Compatibility with All Type "E" Coupler:                                                                                                                       |                                             |
| 1. Can be added to Type "E"                                                                                                                                    |                                             |
| 2. Requires modification of Type "E"                                                                                                                           | X                                           |
| 3. Requires head adapter for Type "E"                                                                                                                          |                                             |
| 4. Incompatible with Type "E"                                                                                                                                  |                                             |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                     |                                             |
| Pertinent Functions                                                                                                                                            |                                             |
| IA1.                                                                                                                                                           |                                             |
| IA2.                                                                                                                                                           |                                             |
| IA3a.                                                                                                                                                          |                                             |
| IA3b.                                                                                                                                                          |                                             |
| IA3c.                                                                                                                                                          |                                             |
| IB1.                                                                                                                                                           |                                             |
| IB2.                                                                                                                                                           |                                             |
| IB3.                                                                                                                                                           |                                             |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                      |                                             |
| Pertinent Functions                                                                                                                                            |                                             |
| IIA1.                                                                                                                                                          |                                             |
| IIA2.                                                                                                                                                          |                                             |
| IIA3.                                                                                                                                                          |                                             |
| IIB1.                                                                                                                                                          |                                             |
| IIB2.                                                                                                                                                          |                                             |
| *IIB3.                                                                                                                                                         | - Shelf has recess for "F" interlocking lug |
| IIB4.                                                                                                                                                          |                                             |
| IIC1.                                                                                                                                                          |                                             |
| IIC2.                                                                                                                                                          |                                             |
| IIC3.                                                                                                                                                          |                                             |
| IID.                                                                                                                                                           |                                             |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                   |                                             |
| Pertinent Functions                                                                                                                                            |                                             |
| IIIA1.                                                                                                                                                         |                                             |
| IIIA2.                                                                                                                                                         |                                             |
| IIIA3a.                                                                                                                                                        |                                             |
| IIIA3b.                                                                                                                                                        |                                             |
| IIIA4.                                                                                                                                                         |                                             |
| IIIB1.                                                                                                                                                         |                                             |
| IIIB2.                                                                                                                                                         |                                             |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                          |                                             |
| Pertinent Functions                                                                                                                                            |                                             |
| IVA1.                                                                                                                                                          |                                             |
| IVA2.                                                                                                                                                          |                                             |
| IVB1.                                                                                                                                                          |                                             |
| IVB3.                                                                                                                                                          |                                             |
| IVB4.                                                                                                                                                          |                                             |
| IVB5.                                                                                                                                                          |                                             |
| IVB6.                                                                                                                                                          |                                             |
| IVC.                                                                                                                                                           |                                             |

# Concept 940: BRUSH UNCOUPLER

Primary Bibliography Reference No.: 940

|                                                                                                                                                                         |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Related Reference Number(s)                                                                                                                                             |     |
| Description of Concept - A Brush apparatus located alongside the track which provides the traditional manual function of pulling the lever to uncouple knuckle couplers |     |
| Compatibility with AAR Type "E" Coupler                                                                                                                                 |     |
| 1. Can be added to Type "E"                                                                                                                                             | N A |
| 2. Requires modification of Type "E"                                                                                                                                    |     |
| 3. Requires head adapter for Type "E"                                                                                                                                   |     |
| 4. Incompatible with Type "E"                                                                                                                                           |     |
| CATEGORY I - IMPROVE TRAIN AIR LINE SYSTEM                                                                                                                              |     |
| Pertinent Functions                                                                                                                                                     |     |
| IA1.                                                                                                                                                                    |     |
| IA2.                                                                                                                                                                    |     |
| IA3A.                                                                                                                                                                   |     |
| IA3B.                                                                                                                                                                   |     |
| IA3C.                                                                                                                                                                   |     |
| IB1.                                                                                                                                                                    |     |
| IB2.                                                                                                                                                                    |     |
| IB3.                                                                                                                                                                    |     |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                               |     |
| Pertinent Functions                                                                                                                                                     |     |
| IIA1.                                                                                                                                                                   |     |
| IIA2.                                                                                                                                                                   |     |
| IIA3.                                                                                                                                                                   |     |
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| IIA13.                                                                                                                                                                  |     |
| IIA14.                                                                                                                                                                  |     |
| IIA15.                                                                                                                                                                  |     |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                            |     |
| Pertinent Functions                                                                                                                                                     |     |
| IIIA1.                                                                                                                                                                  |     |
| IIIA2.                                                                                                                                                                  |     |
| IIIA3A.                                                                                                                                                                 |     |
| IIIA3B.                                                                                                                                                                 |     |
| IIIA3C.                                                                                                                                                                 |     |
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| IIIA499.                                                                                                                                                                |     |

# Concept 943: FLUID OPERATED UNCOUPLING MECHANISM

Primary Bibliography Reference No.: 943

|                                                                                                                                                                                                                                                                                                                                    |                                                                |                             |   |                                      |  |                                       |  |                               |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 517                                                                                                                                                                                                                                                                                                    |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept - Fluid operated uncoupling mechanism mechanically connected to the longitudinally swingable part of the coupler's locklift assembly<br><br>- Includes an actuator mountable on a head of the coupler having a pressure-advanced, spring returned piston connected to an operating shaft                    |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| COMPATIBILITY WITH AAL Type "E" Coupler: <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                        | X                                                              |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                               |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                              |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                      |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                         |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IAI.<br>IAZ.<br>IAJa.<br>IAJb.<br>IAJc.<br>IBI.<br>IBZ.<br>IBJ.                                                                                                                                                                                                                                             |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                          |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IIAI.<br>IIAZ.<br>*IIAJ.<br>*IIBI.<br>IIBZ.<br>IIBJ.<br>IIA4.<br>IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                                                                                                                                                            | - Positive locking provided even with pressure failure         |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                       |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IIIAI.<br>IIIAZ.<br>IIIAJa.<br>IIIAJb.<br>*IIIAJc.<br>*IIIBI.<br>IIIBZ.                                                                                                                                                                                                                                     | - Fluid operated actuator attached to the uncoupling mechanism |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                              |                                                                |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IVAI.<br>IVAZ.<br>*IVBI.<br>IVBJ.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                                                        |                                                                |                             |   |                                      |  |                                       |  |                               |  |

# Concept 960: UNCOUPLER LEVER

Primary Bibliography Reference No.: 960

|                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|---|--------------------------------------|--|---------------------------------------|--|-------------------------------|--|
| Related Reference Number(s) 508                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Description of Concept - Lever assembly for cars equipped with standard draft gear.<br>- Avoids substantial movement of lever handle                                                                                                                                                                                               |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Compatibility with AAR Type "E" Coupler: <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> </tr> </table> |                                                                                                                                                                                                                                                     | 1. Can be added to Type "E" | X | 2. Requires modification of Type "E" |  | 3. Requires head adapter for Type "E" |  | 4. Incompatible with Type "E" |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                        | X                                                                                                                                                                                                                                                   |                             |   |                                      |  |                                       |  |                               |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IAI.<br>IAJ.<br>IAJa.<br>IAJb.<br>IAJc.<br>IB1.<br>IB2.<br>IB3.                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                                                                                                                                                              |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IIIA1.<br>IIIA2.<br>IIIA3a.<br>IIIA3b.<br>IIIA4.<br>IIIB1.<br>IIIB2.                                                                                                                                                                                                                                        | - The portion of the handle section bar projecting inboard of the car from the slideway forms the portion of the adjuster accommodating take-up and let-out of the effective length of the lever assembly as required by coupler swing and impacts. |                             |   |                                      |  |                                       |  |                               |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |
| Pertinent Functions<br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                     |                             |   |                                      |  |                                       |  |                               |  |

# Concept 1020: UNLOCKING DEVICE FOR COUPLERS

Primary Bibliography Reference No.: 1020

|                                                                |                                      |
|----------------------------------------------------------------|--------------------------------------|
| Related Reference Number(s)                                    |                                      |
| Description of Concept                                         |                                      |
| <p>Japanese design</p> <p>- Device for lifting center pins</p> |                                      |
| Compatibility with AA Type "E" Coupler:                        |                                      |
| 1. Can be added to Type "E"                                    |                                      |
| 2. Requires modification of Type "E"                           |                                      |
| 3. Requires head adapter for Type "E"                          |                                      |
| 4. Incompatible with Type "E"                                  | X                                    |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                     |                                      |
| Pertinent Functions                                            |                                      |
| IA1.                                                           |                                      |
| IA2.                                                           |                                      |
| IA3a.                                                          |                                      |
| IA3b.                                                          |                                      |
| IA3c.                                                          |                                      |
| IB1.                                                           |                                      |
| IB2.                                                           |                                      |
| IB3.                                                           |                                      |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                      |                                      |
| Pertinent Functions                                            |                                      |
| IIA1.                                                          |                                      |
| IIA2.                                                          |                                      |
| IIA3.                                                          |                                      |
| IIB1.                                                          |                                      |
| IIB2.                                                          |                                      |
| IIB3.                                                          |                                      |
| IIB4.                                                          |                                      |
| IIC1.                                                          |                                      |
| IIC2.                                                          |                                      |
| IIC3.                                                          |                                      |
| IID.                                                           |                                      |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                   |                                      |
| Pertinent Functions                                            |                                      |
| IIIA1.                                                         |                                      |
| IIIA2.                                                         |                                      |
| IIIA3a.                                                        |                                      |
| *IIIA3b.                                                       | - Unit mounted at side of track      |
| IIIA5.                                                         |                                      |
| IIIB1.                                                         |                                      |
| IIIB2.                                                         | - Uses a boom mechanism to pull pins |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                          |                                      |
| Pertinent Functions                                            |                                      |
| IVA1.                                                          |                                      |
| IVA2.                                                          |                                      |
| IVB1.                                                          |                                      |
| IVB3.                                                          |                                      |
| IVB5.                                                          |                                      |
| IVB7.                                                          |                                      |
| IVB9.                                                          |                                      |
| IVC.                                                           |                                      |

# Concept 1043: SYSTEM FOR AUTOMATIC CONNECTION RELEASE

Primary Bibliography Reference No.: 1043

|                                                                                                                                                                                                                                                |                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| Related Reference Number(s) 1044                                                                                                                                                                                                               |                                                      |
| Description of Concept - Japanese invention.                                                                                                                                                                                                   |                                                      |
| <ul style="list-style-type: none"> <li>- Combination of electrical and penumatic controls in which a line for supplying air under pressure extends from locomotive to the cars to disconnect any desired car by air pressure force.</li> </ul> |                                                      |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                       |                                                      |
| 1. Can be added to Type "E"                                                                                                                                                                                                                    |                                                      |
| 2. Requires modification of Type "E"                                                                                                                                                                                                           |                                                      |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                          |                                                      |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                  | X                                                    |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                     |                                                      |
| Pertinent Functions                                                                                                                                                                                                                            |                                                      |
| IA1.                                                                                                                                                                                                                                           |                                                      |
| IA2.                                                                                                                                                                                                                                           |                                                      |
| IA3a.                                                                                                                                                                                                                                          |                                                      |
| IA3b.                                                                                                                                                                                                                                          |                                                      |
| IA3c.                                                                                                                                                                                                                                          |                                                      |
| IB1.                                                                                                                                                                                                                                           |                                                      |
| IB2.                                                                                                                                                                                                                                           |                                                      |
| IB3.                                                                                                                                                                                                                                           |                                                      |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                      |                                                      |
| Pertinent Functions                                                                                                                                                                                                                            |                                                      |
| IIA1.                                                                                                                                                                                                                                          |                                                      |
| IIA2.                                                                                                                                                                                                                                          |                                                      |
| IIA3.                                                                                                                                                                                                                                          |                                                      |
| IIB1.                                                                                                                                                                                                                                          |                                                      |
| IIB2.                                                                                                                                                                                                                                          |                                                      |
| IIB3.                                                                                                                                                                                                                                          |                                                      |
| IIB4.                                                                                                                                                                                                                                          |                                                      |
| IIC1.                                                                                                                                                                                                                                          |                                                      |
| IIC2.                                                                                                                                                                                                                                          |                                                      |
| IIC3.                                                                                                                                                                                                                                          |                                                      |
| IID.                                                                                                                                                                                                                                           |                                                      |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                   |                                                      |
| Pertinent Functions                                                                                                                                                                                                                            |                                                      |
| *IIIA1.                                                                                                                                                                                                                                        | - Pneumatic signal from locomotive releases coupler. |
| IIIA2.                                                                                                                                                                                                                                         |                                                      |
| IIIA3a.                                                                                                                                                                                                                                        |                                                      |
| IIIA3b.                                                                                                                                                                                                                                        |                                                      |
| IIIA4.                                                                                                                                                                                                                                         |                                                      |
| IIIB1.                                                                                                                                                                                                                                         |                                                      |
| IIIB2.                                                                                                                                                                                                                                         |                                                      |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                          |                                                      |
| Pertinent Functions                                                                                                                                                                                                                            |                                                      |
| IVA1.                                                                                                                                                                                                                                          |                                                      |
| IVA2.                                                                                                                                                                                                                                          |                                                      |
| IVB1.                                                                                                                                                                                                                                          |                                                      |
| IVB3.                                                                                                                                                                                                                                          |                                                      |
| IVB4.                                                                                                                                                                                                                                          |                                                      |
| IVB5.                                                                                                                                                                                                                                          |                                                      |
| IVB6.                                                                                                                                                                                                                                          |                                                      |
| IVC.                                                                                                                                                                                                                                           |                                                      |

# Concept 1044: REMOTE CONTROL CAR RELEASE

Primary Bibliography Reference No.: 1044

|                                                                                                                                                                                                                                                                                                 |                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| Related Reference Number(s) 1043                                                                                                                                                                                                                                                                |                                |
| Description of Concept - Actuating air supply line and instruction air line are connected from locomotive through the train.<br><br>- Operator manipulates on-off control valve in the locomotive by the number of times corresponding to the car number of the desired car to be disconnected. |                                |
| Compatibility with AAM Type "E" Coupler:                                                                                                                                                                                                                                                        |                                |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                     |                                |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                            |                                |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                           |                                |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                   | X                              |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                      |                                |
| Pertinent Functions                                                                                                                                                                                                                                                                             |                                |
| IA1.                                                                                                                                                                                                                                                                                            |                                |
| IA2.                                                                                                                                                                                                                                                                                            |                                |
| IA3a.                                                                                                                                                                                                                                                                                           |                                |
| IA3b.                                                                                                                                                                                                                                                                                           |                                |
| IA3c.                                                                                                                                                                                                                                                                                           |                                |
| IB1.                                                                                                                                                                                                                                                                                            |                                |
| IB2.                                                                                                                                                                                                                                                                                            |                                |
| IB3.                                                                                                                                                                                                                                                                                            |                                |
|                                                                                                                                                                                                                                                                                                 |                                |
|                                                                                                                                                                                                                                                                                                 |                                |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                       |                                |
| Pertinent Functions                                                                                                                                                                                                                                                                             |                                |
| IIA1.                                                                                                                                                                                                                                                                                           |                                |
| IIA2.                                                                                                                                                                                                                                                                                           |                                |
| IIA3.                                                                                                                                                                                                                                                                                           |                                |
| IIB1.                                                                                                                                                                                                                                                                                           |                                |
| IIB2.                                                                                                                                                                                                                                                                                           |                                |
| IIB3.                                                                                                                                                                                                                                                                                           |                                |
| IIB4.                                                                                                                                                                                                                                                                                           |                                |
| IIC1.                                                                                                                                                                                                                                                                                           |                                |
| IIC2.                                                                                                                                                                                                                                                                                           |                                |
| IIC3.                                                                                                                                                                                                                                                                                           |                                |
| IID.                                                                                                                                                                                                                                                                                            |                                |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                    |                                |
| Pertinent Functions                                                                                                                                                                                                                                                                             |                                |
| *IIIA1.                                                                                                                                                                                                                                                                                         | - Remote control air pressure. |
| IIIA2.                                                                                                                                                                                                                                                                                          |                                |
| IIIA3a.                                                                                                                                                                                                                                                                                         |                                |
| IIIA3b.                                                                                                                                                                                                                                                                                         |                                |
| IIIA4.                                                                                                                                                                                                                                                                                          |                                |
| IIIB1.                                                                                                                                                                                                                                                                                          |                                |
| IIIB2.                                                                                                                                                                                                                                                                                          |                                |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                           |                                |
| Pertinent Functions                                                                                                                                                                                                                                                                             |                                |
| IVA1.                                                                                                                                                                                                                                                                                           |                                |
| IVA2.                                                                                                                                                                                                                                                                                           |                                |
| IVB1.                                                                                                                                                                                                                                                                                           |                                |
| IVB3.                                                                                                                                                                                                                                                                                           |                                |
| IVB4.                                                                                                                                                                                                                                                                                           |                                |
| IVB5.                                                                                                                                                                                                                                                                                           |                                |
| IVB6.                                                                                                                                                                                                                                                                                           |                                |
| IVC.                                                                                                                                                                                                                                                                                            |                                |

# Concept 1045: HINES ELECTRIC UNCOUPLING SYSTEM

Primary Bibliography Reference No.: 1045

|                                                                                                                                                                                                                                                                                                                                        |   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                            |   |
| Description of Concept                                                                                                                                                                                                                                                                                                                 |   |
| Control system consists of a locomotive control box (car selector switch, rotary self-interrupting stepping switch, relays and operating switches), four individual circuit wires between cars and individual car control boxes (two stepping relays and two coupler unlatching solenoids);                                            |   |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                                                                               |   |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                            | X |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                   |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                  |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                          |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                             |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                    |   |
| IA1.                                                                                                                                                                                                                                                                                                                                   |   |
| IA2.                                                                                                                                                                                                                                                                                                                                   |   |
| IA3a.                                                                                                                                                                                                                                                                                                                                  |   |
| IA3b.                                                                                                                                                                                                                                                                                                                                  |   |
| IA3c.                                                                                                                                                                                                                                                                                                                                  |   |
| IB1.                                                                                                                                                                                                                                                                                                                                   |   |
| IB2.                                                                                                                                                                                                                                                                                                                                   |   |
| IB3.                                                                                                                                                                                                                                                                                                                                   |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                              |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                    |   |
| IIA1.                                                                                                                                                                                                                                                                                                                                  |   |
| IIA2.                                                                                                                                                                                                                                                                                                                                  |   |
| IIA3.                                                                                                                                                                                                                                                                                                                                  |   |
| IIB1.                                                                                                                                                                                                                                                                                                                                  |   |
| IIB2.                                                                                                                                                                                                                                                                                                                                  |   |
| IIB3.                                                                                                                                                                                                                                                                                                                                  |   |
| IIB4.                                                                                                                                                                                                                                                                                                                                  |   |
| IIC1.                                                                                                                                                                                                                                                                                                                                  |   |
| IIC2.                                                                                                                                                                                                                                                                                                                                  |   |
| IIC3.                                                                                                                                                                                                                                                                                                                                  |   |
| IID.                                                                                                                                                                                                                                                                                                                                   |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                           |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                    |   |
| IIIA1.                                                                                                                                                                                                                                                                                                                                 |   |
| IIIA2.                                                                                                                                                                                                                                                                                                                                 |   |
| *IIIA3a.                                                                                                                                                                                                                                                                                                                               |   |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                |   |
| IIIA4.                                                                                                                                                                                                                                                                                                                                 |   |
| IIB1.                                                                                                                                                                                                                                                                                                                                  |   |
| IIB2.                                                                                                                                                                                                                                                                                                                                  |   |
| - Feasible system if: (1) uncoupling can be accomplished by force from a solenoid and (2) solenoids can be adequately protected from malfunction from environment.                                                                                                                                                                     |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                  |   |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                    |   |
| IVA1.                                                                                                                                                                                                                                                                                                                                  |   |
| IVA2.                                                                                                                                                                                                                                                                                                                                  |   |
| IVB1.                                                                                                                                                                                                                                                                                                                                  |   |
| IVB3.                                                                                                                                                                                                                                                                                                                                  |   |
| IVB4.                                                                                                                                                                                                                                                                                                                                  |   |
| IVB5.                                                                                                                                                                                                                                                                                                                                  |   |
| *IVB6.                                                                                                                                                                                                                                                                                                                                 |   |
| *IVC.                                                                                                                                                                                                                                                                                                                                  |   |
| - Compatible as part of add-on control system.                                                                                                                                                                                                                                                                                         |   |
| - Feasible control system if: (1) electric intercar connection system available, (2) electric solenoids are available with capacity to meet force required to operate uncoupling valves while being sensitive enough to react to control pulses and (3) relay and stepping switches which are reliable under the required environment. |   |
| - Remote uncoupling will improve reliability.                                                                                                                                                                                                                                                                                          |   |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 1046: FLUID OPERATING UNCOUPLING MECHANISM

Primary Bibliography Reference No.: 1046

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|---|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------|--------------------------------------------|---------------------------------------|--------------------------------------------------------------------------------------------------|-----------|-------------------------------|----------|--|---------|--|-------|--|------|--|------|--|------|--|-----|--|
| Related Reference Number(s) 517                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| Description of Concept <ul style="list-style-type: none"> <li>- Liquid-operating uncoupling mechanism</li> <li>- Requires no operating slack</li> <li>- Can be operated conventionally from side of car or automatically</li> </ul>                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| Compatibility with AAR Type "E" Coupler: <table border="1"> <tr> <td>1. Can be added to Type "E"</td> <td>X</td> <td>- Applicable for cushioned underframe cars</td> </tr> <tr> <td>2. Requires modification of Type "E"</td> <td></td> <td>- Positive locking in the event of failure</td> </tr> <tr> <td>3. Requires head adapter for Type "E"</td> <td></td> <td></td> </tr> <tr> <td>4. Incompatible with Type "E"</td> <td></td> <td></td> </tr> </table>                                                                                                                              |                                                                                                                                             | 1. Can be added to Type "E"                | X | - Applicable for cushioned underframe cars | 2. Requires modification of Type "E"                                                                                                        |          | - Positive locking in the event of failure | 3. Requires head adapter for Type "E" |                                                                                                  |           | 4. Incompatible with Type "E" |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | X                                                                                                                                           | - Applicable for cushioned underframe cars |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             | - Positive locking in the event of failure |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM <table border="1"> <tr> <td>Pertinent Functions</td> <td></td> </tr> <tr><td>IA1.</td><td></td></tr> <tr><td>IA2.</td><td></td></tr> <tr><td>IA3a.</td><td></td></tr> <tr><td>IA3b.</td><td></td></tr> <tr><td>IA3c.</td><td></td></tr> <tr><td>IB1.</td><td></td></tr> <tr><td>IB2.</td><td></td></tr> <tr><td>IB3.</td><td></td></tr> </table>                                                                                                                                                                                                 |                                                                                                                                             | Pertinent Functions                        |   | IA1.                                       |                                                                                                                                             | IA2.     |                                            | IA3a.                                 |                                                                                                  | IA3b.     |                               | IA3c.    |  | IB1.    |  | IB2.  |  | IB3. |  |      |  |      |  |     |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING <table border="1"> <tr> <td>Pertinent Functions</td> <td></td> </tr> <tr><td>IIA1.</td><td></td></tr> <tr><td>IIA2.</td><td></td></tr> <tr><td>* IIA3.</td><td>- Positive locking in the event of failure retains this feature even with fluid pressure failure</td></tr> <tr><td>IB1.</td><td></td></tr> <tr><td>IB2.</td><td></td></tr> <tr><td>IB3.</td><td></td></tr> <tr><td>IB4.</td><td></td></tr> <tr><td>IC1.</td><td></td></tr> <tr><td>IC2.</td><td></td></tr> <tr><td>IC3.</td><td></td></tr> <tr><td>ID.</td><td></td></tr> </table> |                                                                                                                                             | Pertinent Functions                        |   | IIA1.                                      |                                                                                                                                             | IIA2.    |                                            | * IIA3.                               | - Positive locking in the event of failure retains this feature even with fluid pressure failure | IB1.      |                               | IB2.     |  | IB3.    |  | IB4.  |  | IC1. |  | IC2. |  | IC3. |  | ID. |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| * IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | - Positive locking in the event of failure retains this feature even with fluid pressure failure                                            |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| ID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING <table border="1"> <tr> <td>Pertinent Functions</td> <td></td> </tr> <tr><td>* IIIA1.</td><td>- To unlock the coupler a solenoid is energized to turn valve to a position in which its inlet port is connected to its advance outlet port</td></tr> <tr><td>* IIIA2.</td><td></td></tr> <tr><td>* IIIA3a.</td><td></td></tr> <tr><td>* IIIA3b.</td><td></td></tr> <tr><td>* IIIA4.</td><td></td></tr> <tr><td>* IIB1.</td><td></td></tr> <tr><td>IIB2.</td><td></td></tr> </table>                                                             |                                                                                                                                             | Pertinent Functions                        |   | * IIIA1.                                   | - To unlock the coupler a solenoid is energized to turn valve to a position in which its inlet port is connected to its advance outlet port | * IIIA2. |                                            | * IIIA3a.                             |                                                                                                  | * IIIA3b. |                               | * IIIA4. |  | * IIB1. |  | IIB2. |  |      |  |      |  |      |  |     |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| * IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | - To unlock the coupler a solenoid is energized to turn valve to a position in which its inlet port is connected to its advance outlet port |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| * IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| * IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| * IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| * IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| * IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS <table border="1"> <tr> <td>Pertinent Functions</td> <td></td> </tr> <tr><td>IVA1.</td><td></td></tr> <tr><td>IVA2.</td><td></td></tr> <tr><td>IVB1.</td><td></td></tr> <tr><td>IVB3.</td><td></td></tr> <tr><td>IVB4.</td><td></td></tr> <tr><td>IVB5.</td><td></td></tr> <tr><td>IVB6.</td><td></td></tr> <tr><td>IVC.</td><td></td></tr> </table>                                                                                                                                                                                                  |                                                                                                                                             | Pertinent Functions                        |   | IVA1.                                      |                                                                                                                                             | IVA2.    |                                            | IVB1.                                 |                                                                                                  | IVB3.     |                               | IVB4.    |  | IVB5.   |  | IVB6. |  | IVC. |  |      |  |      |  |     |  |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IVB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IVB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IVB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IVB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |
| IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                             |                                            |   |                                            |                                                                                                                                             |          |                                            |                                       |                                                                                                  |           |                               |          |  |         |  |       |  |      |  |      |  |      |  |     |  |

Concept 1061: UNCOUPLING LEVER  
Primary Bibliography Reference No.: 1061

|                                                                                                                                                                                        |   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Related Reference Number(s)                                                                                                                                                            |   |
| Description of Concept<br>Lever for cars equipped with impact absorbing device where there may still be substantial relative movement between center sill and the coupler and car body |   |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                               |   |
| 1. Can be added to Type "E"                                                                                                                                                            | X |
| 2. Requires modification of Type "E"                                                                                                                                                   |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                  |   |
| 4. Incompatible with Type "E"                                                                                                                                                          |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                             |   |
| Pertinent Functions                                                                                                                                                                    |   |
| IA1.                                                                                                                                                                                   |   |
| IA2.                                                                                                                                                                                   |   |
| IA3a.                                                                                                                                                                                  |   |
| IA3b.                                                                                                                                                                                  |   |
| IA3c.                                                                                                                                                                                  |   |
| IB1.                                                                                                                                                                                   |   |
| IB2.                                                                                                                                                                                   |   |
| IB3.                                                                                                                                                                                   |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                              |   |
| Pertinent Functions                                                                                                                                                                    |   |
| IIA1.                                                                                                                                                                                  |   |
| IIA2.                                                                                                                                                                                  |   |
| IIA3.                                                                                                                                                                                  |   |
| IIB1.                                                                                                                                                                                  |   |
| IIB2.                                                                                                                                                                                  |   |
| IIB3.                                                                                                                                                                                  |   |
| IIB4.                                                                                                                                                                                  |   |
| IIC1.                                                                                                                                                                                  |   |
| IIC2.                                                                                                                                                                                  |   |
| IIC3.                                                                                                                                                                                  |   |
| IID.                                                                                                                                                                                   |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                           |   |
| Pertinent Functions                                                                                                                                                                    |   |
| *IIIA1.                                                                                                                                                                                |   |
| IIIA2.                                                                                                                                                                                 |   |
| IIIA3a.                                                                                                                                                                                |   |
| IIIA3b.                                                                                                                                                                                |   |
| IIIA4.                                                                                                                                                                                 |   |
| IIB1.                                                                                                                                                                                  |   |
| IIB2.                                                                                                                                                                                  |   |
| - Operated from side of car which has a part connected to the coupler accommodating substantial longitudinal and some rotational movement of the coupler relative to the car frame     |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                  |   |
| Pertinent Functions                                                                                                                                                                    |   |
| IVA1.                                                                                                                                                                                  |   |
| IVA2.                                                                                                                                                                                  |   |
| IVB1.                                                                                                                                                                                  |   |
| IVB3.                                                                                                                                                                                  |   |
| IVB4.                                                                                                                                                                                  |   |
| IVB5.                                                                                                                                                                                  |   |
| IVB6.                                                                                                                                                                                  |   |
| IVC.                                                                                                                                                                                   |   |

# Concept 1063: UNCOUPLING LEVER

Primary Bibliography Reference No.: 1063

|                                                                                                             |                                                                 |
|-------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| Related Reference Number(s)                                                                                 |                                                                 |
| Description of Concept                                                                                      |                                                                 |
| <p align="center">- Uncoupling lever designed to accommodate long travel of cushioned sliding sill cars</p> |                                                                 |
| Compatibility with AAR Type "E" Coupler:                                                                    |                                                                 |
| 1. Can be added to Type "E"                                                                                 | X                                                               |
| 2. Requires modification of Type "E"                                                                        |                                                                 |
| 3. Requires head adapter for Type "E"                                                                       |                                                                 |
| 4. Incompatible with Type "E"                                                                               |                                                                 |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                  |                                                                 |
| Pertinent Functions                                                                                         |                                                                 |
| IA1.                                                                                                        |                                                                 |
| IA2.                                                                                                        |                                                                 |
| IA3.                                                                                                        |                                                                 |
| IA3b.                                                                                                       |                                                                 |
| IA3c.                                                                                                       |                                                                 |
| IB1.                                                                                                        |                                                                 |
| IB2.                                                                                                        |                                                                 |
| IB3.                                                                                                        |                                                                 |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                   |                                                                 |
| Pertinent Functions                                                                                         |                                                                 |
| IIA1.                                                                                                       |                                                                 |
| IIA2.                                                                                                       |                                                                 |
| IIA3.                                                                                                       |                                                                 |
| IIB1.                                                                                                       |                                                                 |
| IIB2.                                                                                                       |                                                                 |
| IIB3.                                                                                                       |                                                                 |
| IIC1.                                                                                                       |                                                                 |
| IIC2.                                                                                                       |                                                                 |
| IIC3.                                                                                                       |                                                                 |
| IID.                                                                                                        |                                                                 |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                |                                                                 |
| Pertinent Functions                                                                                         |                                                                 |
| IIIA1.                                                                                                      | - Designed to accommodate telescopic movement of a sliding sill |
| IIIA2.                                                                                                      |                                                                 |
| IIIA3a.                                                                                                     |                                                                 |
| IIIA3b.                                                                                                     |                                                                 |
| IIIA4.                                                                                                      | - Adapted for mounting along a sliding sill structure           |
| IIIB1.                                                                                                      |                                                                 |
| IIIB2.                                                                                                      |                                                                 |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                       |                                                                 |
| Pertinent Functions                                                                                         |                                                                 |
| IVA1.                                                                                                       |                                                                 |
| IVA2.                                                                                                       |                                                                 |
| IVB1.                                                                                                       |                                                                 |
| IVB3.                                                                                                       |                                                                 |
| IVB4.                                                                                                       |                                                                 |
| IVB5.                                                                                                       |                                                                 |
| IVB6.                                                                                                       |                                                                 |
| IVC.                                                                                                        |                                                                 |

Concept 1070: ACTUATING DEVICE FOR WHEEL GUIDANCE

Primary Bibliography Reference No.: 1070

|                                                                                                                                                                                                                  |                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Related Reference Number(s)                                                                                                                                                                                      |                  |
| Description of Concept - Spanish design<br>- To bypass difficulties during coupling or uncoupling of vehicles provided with guided wheels by providing simple bumper like device<br>- Bumpers are spring mounted |                  |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                         |                  |
| 1. Can be added to Type "E"                                                                                                                                                                                      |                  |
| 2. Requires modification of Type "E"                                                                                                                                                                             |                  |
| 3. Requires head adapter for Type "E"                                                                                                                                                                            |                  |
| 4. Incompatible with Type "E"                                                                                                                                                                                    | X                |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                       |                  |
| Pertinent Functions<br>IAI.<br>IAZ.<br>IAJa.<br>IAJb.<br>IAJc.<br>IB1.<br>IB2.<br>IB3.                                                                                                                           |                  |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                        |                  |
| Pertinent Functions<br>IIA1.<br>IIA2.<br>IIA3.<br>IIB1.<br>IIB2.<br>IIB3.<br>IIB4.<br>IIC1.<br>IIC2.<br>IIC3.<br>IID.                                                                                            | - Wheel guidance |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                     |                  |
| Pertinent Functions<br>IIIA1.<br>IIIA2.<br>IIIAJa.<br>IIIAJb.<br>IIIA4.<br>IIIB1.<br>IIIB2.                                                                                                                      |                  |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                            |                  |
| Pertinent Functions<br>IVA1.<br>IVA2.<br>IVB1.<br>IVB3.<br>IVB4.<br>IVB5.<br>IVB6.<br>IVC.                                                                                                                       |                  |

# Concept 1100: COUPLER POSITONING DEVICE

Primary Bibliography Reference No.: 1100

|                                                                                                                                                                                                                                                                                      |   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Related Reference Number(s) 508                                                                                                                                                                                                                                                      |   |
| Description of Concept - Swing lever positioned between the coupler and the car truck<br>- Uses cable structures extending between the respective ends of a swing lever and coupler shank - each includes preloaded tension springs to adjust the bias of the coupler into alignment |   |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                                                                                                             |   |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                          | X |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                 |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                |   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                        |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                           |   |
| Pertinent Functions                                                                                                                                                                                                                                                                  |   |
| IA1.                                                                                                                                                                                                                                                                                 |   |
| IA2.                                                                                                                                                                                                                                                                                 |   |
| IA3a.                                                                                                                                                                                                                                                                                |   |
| IA3b.                                                                                                                                                                                                                                                                                |   |
| IA3c.                                                                                                                                                                                                                                                                                |   |
| IB1.                                                                                                                                                                                                                                                                                 |   |
| IB2.                                                                                                                                                                                                                                                                                 |   |
| IB3.                                                                                                                                                                                                                                                                                 |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                            |   |
| Pertinent Functions                                                                                                                                                                                                                                                                  |   |
| IIA1.                                                                                                                                                                                                                                                                                |   |
| IIA2.                                                                                                                                                                                                                                                                                |   |
| IIA3.                                                                                                                                                                                                                                                                                |   |
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Concept 1101: COUPLER POSITIONING DEVICE

Primary Bibliography Reference No.: 1101

|                                                                                                                                                                                                        |   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Related Reference Number(s) 508                                                                                                                                                                        |   |
| Description of Concept - Positioning device for sliding sill underframe car                                                                                                                            |   |
| Compatibility with AAR Type "E" Coupler:                                                                                                                                                               |   |
| 1. Can be added to Type "E"                                                                                                                                                                            | X |
| 2. Requires modification of Type "E"                                                                                                                                                                   |   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                  |   |
| 4. Incompatible with Type "E"                                                                                                                                                                          |   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                             |   |
| Pertinent Functions                                                                                                                                                                                    |   |
| IA1.                                                                                                                                                                                                   |   |
| IA2.                                                                                                                                                                                                   |   |
| IA3a.                                                                                                                                                                                                  |   |
| IA3b.                                                                                                                                                                                                  |   |
| IA3c.                                                                                                                                                                                                  |   |
| IB1.                                                                                                                                                                                                   |   |
| IB2.                                                                                                                                                                                                   |   |
| IB3.                                                                                                                                                                                                   |   |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                              |   |
| Pertinent Functions                                                                                                                                                                                    |   |
| IIA1.                                                                                                                                                                                                  |   |
| IIA2.                                                                                                                                                                                                  |   |
| IIA3.                                                                                                                                                                                                  |   |
| IB1.                                                                                                                                                                                                   |   |
| IB2.                                                                                                                                                                                                   |   |
| IB3.                                                                                                                                                                                                   |   |
| IB4.                                                                                                                                                                                                   |   |
| IC1.                                                                                                                                                                                                   |   |
| IC2.                                                                                                                                                                                                   |   |
| *IC3.                                                                                                                                                                                                  |   |
| IID.                                                                                                                                                                                                   |   |
| - Coupler connected to end of swing lever by uncushioned cable connection; connecting cables are trained over sheaves at respective ends of the swing lever for connection to a shock absorbing device |   |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                           |   |
| Pertinent Functions                                                                                                                                                                                    |   |
| IIIA1.                                                                                                                                                                                                 |   |
| IIIA2.                                                                                                                                                                                                 |   |
| IIIA3a.                                                                                                                                                                                                |   |
| IIIA3b.                                                                                                                                                                                                |   |
| IIIA4.                                                                                                                                                                                                 |   |
| IIIB1.                                                                                                                                                                                                 |   |
| IIIB2.                                                                                                                                                                                                 |   |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                  |   |
| Pertinent Functions                                                                                                                                                                                    |   |
| IVA1.                                                                                                                                                                                                  |   |
| IVA2.                                                                                                                                                                                                  |   |
| VB1.                                                                                                                                                                                                   |   |
| VB3.                                                                                                                                                                                                   |   |
| VB4.                                                                                                                                                                                                   |   |
| VB5.                                                                                                                                                                                                   |   |
| VB6.                                                                                                                                                                                                   |   |
| VC.                                                                                                                                                                                                    |   |

# Concept 1140: MAGNETIC COUPLER

Primary Bibliography Reference No.: 1140

|                                                                                                                                                                                                                                                                                                                               |                                            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| Related Reference Number(s)                                                                                                                                                                                                                                                                                                   |                                            |
| Description of Concept                                                                                                                                                                                                                                                                                                        |                                            |
| <ul style="list-style-type: none"> <li>- Electromagnet at outer end of a piston rod of a double acting pneumatic cylinder</li> <li>- Electromagnet coupling a car to an armature of an adjoining car</li> <li>- Pneumatic cylinder serves to absorb the shock of the coupling impact and to draw the cars together</li> </ul> |                                            |
| Compatibility with AAL Type "E" Coupler:                                                                                                                                                                                                                                                                                      |                                            |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                   | <input type="checkbox"/>                   |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                          | <input type="checkbox"/>                   |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                         | <input type="checkbox"/>                   |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                 | <input type="checkbox"/>                   |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                    |                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                           |                                            |
| IA1.                                                                                                                                                                                                                                                                                                                          |                                            |
| IA2.                                                                                                                                                                                                                                                                                                                          |                                            |
| IA3a.                                                                                                                                                                                                                                                                                                                         |                                            |
| IA3b.                                                                                                                                                                                                                                                                                                                         |                                            |
| IA3c.                                                                                                                                                                                                                                                                                                                         |                                            |
| IB1.                                                                                                                                                                                                                                                                                                                          |                                            |
| IB2.                                                                                                                                                                                                                                                                                                                          |                                            |
| IB3.                                                                                                                                                                                                                                                                                                                          |                                            |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                     |                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                           |                                            |
| * IA1.                                                                                                                                                                                                                                                                                                                        | Electromagnet helps draw the cars together |
| IA2.                                                                                                                                                                                                                                                                                                                          |                                            |
| IA3.                                                                                                                                                                                                                                                                                                                          |                                            |
| IB1.                                                                                                                                                                                                                                                                                                                          |                                            |
| IB2.                                                                                                                                                                                                                                                                                                                          |                                            |
| IB3.                                                                                                                                                                                                                                                                                                                          |                                            |
| IB4.                                                                                                                                                                                                                                                                                                                          |                                            |
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| IC3.                                                                                                                                                                                                                                                                                                                          |                                            |
| ID.                                                                                                                                                                                                                                                                                                                           |                                            |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                  |                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                           |                                            |
| IIA1.                                                                                                                                                                                                                                                                                                                         |                                            |
| IIA2.                                                                                                                                                                                                                                                                                                                         |                                            |
| IIA3a.                                                                                                                                                                                                                                                                                                                        |                                            |
| IIA3b.                                                                                                                                                                                                                                                                                                                        |                                            |
| IIA3c.                                                                                                                                                                                                                                                                                                                        |                                            |
| IIIB1.                                                                                                                                                                                                                                                                                                                        |                                            |
| IIIB2.                                                                                                                                                                                                                                                                                                                        |                                            |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                         |                                            |
| Pertinent Functions                                                                                                                                                                                                                                                                                                           |                                            |
| IVA1.                                                                                                                                                                                                                                                                                                                         |                                            |
| IVA2.                                                                                                                                                                                                                                                                                                                         |                                            |
| IVB1.                                                                                                                                                                                                                                                                                                                         |                                            |
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| IVB6.                                                                                                                                                                                                                                                                                                                         |                                            |
| IVC.                                                                                                                                                                                                                                                                                                                          |                                            |

## Primary Bibliography Reference No.: 1150

**Novelty of concept** Figure 1 shows the novel concept of the proposed system. The system is designed to be a self-learning system that can learn from the user's feedback and improve its performance over time. The system is designed to be a self-learning system that can learn from the user's feedback and improve its performance over time.

1 Can be added to Page 1  
2 Requires modification of Page 1  
3 Requires new sample for Page 1  
4 Incompatible with Page 1

[illegible]

2015-2016  
 2016-2017

1961  
 1962

[illegible]

1. The first group of variables includes the variables that are used to explain the dependent variable. These variables are the independent variables.

DATE: 11/11/2011 11:11:11 AM

100-100000  
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**CATEGORY 1: IMPROVED FINANCIAL SYSTEMS**

**Fortieth**  
**Function**

# Concept 1160: ELECTRICAL CIRCUIT CONTROL APPARATUS

Primary Bibliography Reference No.: 1160

|                                                                                                                                                                                                     |                                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| Relate Reference Number(s)                                                                                                                                                                          |                                     |
| Description of Concept - Spring loaded contact pin for making and breaking circuits<br>- Not subject to electrical shock potential if exposed to weather<br>- Electrically insulated block assembly |                                     |
| COMPARISONS WITH AEC TYPE "E" COUPLER:                                                                                                                                                              |                                     |
| 1. Can be added to Type "E"                                                                                                                                                                         | <input checked="" type="checkbox"/> |
| 2. Requires modification of Type "E"                                                                                                                                                                | <input type="checkbox"/>            |
| 3. Requires head adapter for Type "E"                                                                                                                                                               | <input type="checkbox"/>            |
| 4. Incompatible with Type "E"                                                                                                                                                                       | <input type="checkbox"/>            |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                          |                                     |
| Pertinent Functions                                                                                                                                                                                 |                                     |
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| IA2.                                                                                                                                                                                                |                                     |
| IA3a.                                                                                                                                                                                               |                                     |
| IA3b.                                                                                                                                                                                               |                                     |
| IA3c.                                                                                                                                                                                               |                                     |
| IB1.                                                                                                                                                                                                |                                     |
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| IB3.                                                                                                                                                                                                |                                     |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                           |                                     |
| Pertinent Functions                                                                                                                                                                                 |                                     |
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| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                        |                                     |
| Pertinent Functions                                                                                                                                                                                 |                                     |
| IIIA1.                                                                                                                                                                                              |                                     |
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| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                               |                                     |
| Pertinent Functions                                                                                                                                                                                 |                                     |
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| IVZ20.                                                                                                                                                                                              |                                     |

# Concept 1190: KEYSTONE CENTERING DEVICE

Primary Bibliography Reference NO.: 1190

|                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s)                  |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Description of Concept                       | Coupler self-centering device utilizing the buffing force of the draft gear return spring to apply bias force to lateral extended bearing surfaces on the shank butt. Lateral movements of the shank cause the bearing forces to shift from the normal spherical mating surfaces (matched between butt and yoke) to the lateral lips on the butt and yoke. The return spring applies the bias force to the shank to aid centering. |
| Compatibility with AAR Type "E" Coupler:     |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 1. Can be added to Type "E"                  | X                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 2. Requires modification of Type "E"         |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 3. Requires head adapter for Type "E"        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 4. Incompatible with Type "E"                |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM   |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IA1.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IA2.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IA3a.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IA3b.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IA3c.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IB1.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IB2.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IB3.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| CATEGORY II - IMPROVE MECHANICAL COUPLING    |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIA1.                                        | - Compatible as part of revised draft gear system.                                                                                                                                                                                                                                                                                                                                                                                 |
| IIA2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIA3.                                        | - Self centering would be effective for recentering of lateral movements (beyond a designed "free force" center range). Greater buff forces (i.e., during emergency stops) would result in greater centering forces; therefore, reducing contour angling tendency the greatest under emergency stop conditions.                                                                                                                    |
| IIB1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIB2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIB3.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIB4.                                        | - Simple, maintenance free, full-time centering device for long car application.                                                                                                                                                                                                                                                                                                                                                   |
| IIIC1.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIIC2.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIIC3.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IID.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIIA1.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIIA2.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIIA3a.                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIIA3b.                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIIA4.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIIB1.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IIIB2.                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Pertinent Functions                          |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IVA1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IVA2.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IVB1.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IVB3.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IVB4.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IVB5.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IVB6.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| IVC.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                    |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

# Concept 1200: WABCO AIR CONNECTOR

Primary Bibliography Reference No.: 1200

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Related Reference Number(s) 511                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                |
| Description of Concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                |
| <p>Wabco air connector with electrical contactor (automatically positioned by air connector unit - such as Ref. 511b - and electrical contacts moved into or from mating position by following sequences:</p> <ol style="list-style-type: none"> <li>1. Seating of guide arm operates a valve in mating connector.</li> <li>2. Valve channels air line pressure (as quickly as available) to actuate a piston.</li> <li>3. Piston thrusts the clustered contact pins forward into mating position.</li> <li>4. Release of air pressure allows contacts to disengage from return spring pressure.</li> </ol> |                                                                                                                                                                                                |
| Compatibility with AA Type "E" Coupler:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                |
| 1. Can be added to Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | X                                                                                                                                                                                              |
| 2. Requires modification of Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |
| 3. Requires head adapter for Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| 4. Incompatible with Type "E"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                |
| CATEGORY I - IMPROVE TRAIN AIR-LINE SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                |
| IA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |
| IA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |
| IA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IA3c.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |
| IB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |
| IB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |
| CATEGORY II - IMPROVE MECHANICAL COUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                |
| IIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IIA3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IIB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IIB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IIC1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IIC2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IIC3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IID.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |
| CATEGORY III - IMPROVE MECHANICAL UNCOUPLING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                |
| IIIA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                |
| IIIA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                |
| IIIA3a.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                |
| IIIA3b.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                |
| IIIA4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                |
| IIIB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                |
| IIIB2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                |
| CATEGORY IV - IMPROVE GENERAL SYSTEMS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| Pertinent Functions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                |
| IVA1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | ** Proper operation of contacts is dependent on (1) adequate air pressure, (2) proper operation of complex air valve and (3) movement of sliding cylinder to move contact block into position. |
| IVA2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| * IVB1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                |
| * IVB3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | ** Number of contacts is limited to cross-section of a sliding piston.                                                                                                                         |
| IVB4.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IVB5.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IVB6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                |
| IVC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |

Notes: \*This concept embodies improvements in this function.  
 \*\*Denotes potential operating or safety problem.

### C.3 DATA ACCUMULATION FORM

#### SIGNIFICANT COUPLER CONCEPT DATA

##### GENERAL SUMMARY

- 1) Concept Description and Model No. \_\_\_\_\_
- 2) Manufacturer \_\_\_\_\_
- 3) State of concept development (check as applicable)
  - (a) Conceptual (pat. pen.) \_\_\_\_\_
  - (b) R & D Phase Complete \_\_\_\_\_
  - (c) Engineering prototype tested \_\_\_\_\_
  - (d) Field test completed \_\_\_\_\_
  - (e) Ready for pilot production \_\_\_\_\_
  - (f) In production \_\_\_\_\_
- 4) Environmental limitations (list differences from "E" coupler capabilities for: temperature, dirt or dust, vibration or impact damage susceptibility etc.) \_\_\_\_\_
- 5) Compatible with AAR type "E" coupler system? \_\_\_\_\_
- 6) Estimates of costs (based on 1975 dollars).
  - (a) Cost \$\_\_\_\_\_ and time \_\_\_\_\_ (months) to bring the concept up to a state of "ready for pilot production"
  - (b) System purchase price \$\_\_\_\_\_ (based on \_\_\_\_\_ units/year)
  - (c) System installation costs for: New construction \$\_\_\_\_\_ and retrofit on old cars \$\_\_\_\_\_ (cost/car)
  - (d) System maintenance \$\_\_\_\_\_ (est. average maintenance cost per year - annualized over first 10 years)
- 7) Summary of Functional Characteristics (attach detail data sheets.

##### Mechanical Functional Category

| Bibliog-<br>raphy<br>Ref. No. | I-Air Line<br>System<br>(Sheet 2) | II-Mechanical<br>Coupling<br>(Sheets 3 & 4) | III-Mechanical<br>Uncoupling<br>(Sheet 5) | IV-General<br>Systems<br>(Sheet 6) |
|-------------------------------|-----------------------------------|---------------------------------------------|-------------------------------------------|------------------------------------|
|-------------------------------|-----------------------------------|---------------------------------------------|-------------------------------------------|------------------------------------|

FUNCTIONAL CHARACTERISTIC DATA SHEET  
CATEGORY I - IMPROVE TRAIN AIR LINE SYSTEM

|                                                                           | System<br>Capability |     |
|---------------------------------------------------------------------------|----------------------|-----|
|                                                                           | Yes                  | No  |
| <u>Automatic Control</u>                                                  |                      |     |
| 1) Automatic connection with coupling                                     | ___                  | ___ |
| 2) Provide second air line system                                         | ___                  | ___ |
| 3) Automatic operation of air valves                                      | ___                  | ___ |
| (a) Coupling - open valves                                                | ___                  | ___ |
| (b) Uncoupling (intentional) - close valves                               | ___                  | ___ |
| (c) Uncoupling (unintentional) - open valves                              | ___                  | ___ |
| <br><u>Improved Performance</u>                                           |                      |     |
| 1) Improved integrity of air seal (lower leak rates or gasket wear rates) | ___                  | ___ |
| 2) Improved hose reliability against breakage, damage, or failure         | ___                  | ___ |
| 3) Reduce hose and/or glad hand maintenance cost                          | ___                  | ___ |
| <br><u>General Data (as applicable to explain concept capabilities)</u>   |                      |     |
| (a) Method of attachment of air connection system:                        | _____                |     |
| (b) Air line size(s) and capacity:                                        | _____                |     |
| (c) Describe operation of air attachment system:                          | _____                |     |
| (d) Describe air valve operation:                                         | _____                |     |
| (e) Explain reasons for improved reliability or reduced maintenance:      | _____                |     |

FUNCTIONAL CHARACTERISTIC DATA SHEET  
 CATEGORY II - IMPROVE MECHANICAL COUPLING  
 (As Compared to AAR Type "E" Coupling System)

|                                                                                                                      | Improve |       |
|----------------------------------------------------------------------------------------------------------------------|---------|-------|
|                                                                                                                      | Yes     | No    |
| <u>Automatic Engagement without Assistance</u>                                                                       |         |       |
| 1) Improve lateral gathering range (one coupler open, actual = + _____ in; both couplers open, actual = + _____ in.) | _____   | _____ |
| 2) Improve vertical gathering range (actual = + _____ in.)                                                           | _____   | _____ |
| 3) Positive locking of mated couplers                                                                                | _____   | _____ |
| How accomplished? _____                                                                                              |         |       |
| _____                                                                                                                |         |       |
| _____                                                                                                                |         |       |
| <u>Positive Retainment of Mated Couplers</u>                                                                         |         |       |
| 1) Positive coupling at wider speed range (actual from _____ to _____ mph.)                                          | _____   | _____ |
| 2) Reduce free slack (actual slack of mated couplers = _____ in.)                                                    | _____   | _____ |
| 3) Vertical interlock                                                                                                | _____   | _____ |
| 4) Absolute entrapment of broken coupler                                                                             | _____   | _____ |
| How accomplished? _____                                                                                              |         |       |
| _____                                                                                                                |         |       |
| <u>Coupler Location Control System</u>                                                                               |         |       |
| 1) Self centering                                                                                                    | _____   | _____ |
| How accomplished? _____                                                                                              |         |       |
| _____                                                                                                                |         |       |
| 2) Reduced contour angling capability                                                                                | _____   | _____ |
| How accomplished? _____                                                                                              |         |       |
| _____                                                                                                                |         |       |

CATEGORY II (CONT'D.)

- |                          | <u>Improve</u> |           |
|--------------------------|----------------|-----------|
|                          | <u>Yes</u>     | <u>No</u> |
| 3) Automatic positioning |                |           |
| Describe system _____    | _____          | _____     |
| _____                    |                |           |

Reduced Maintenance Requirements

How accomplished? \_\_\_\_\_  
\_\_\_\_\_

General Data (as compared to AAR type "E" coupling system):

- 1) System Strength Limitations: Buff \_\_\_\_\_ lbs.,  
Draft \_\_\_\_\_ lbs. Coupler Unit Weight \_\_\_\_\_ lbs.,  
Draft Strength/Coupler Weight Ratio = \_\_\_\_\_
- 2) Envelope dimensions \_\_\_\_\_  
\_\_\_\_\_
- 3) Coupled movement limits: Lateral swing \_\_\_\_\_  
Vertical swing \_\_\_\_\_ Angular rotation \_\_\_\_\_
- 4) Response time required for contract of mating couplers to  
achieve complete coupling: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- 5) Describe general coupling sequence: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- 6) Describe expected wear points as related to  
ultimate coupler failure mode: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

FUNCTIONAL CHARACTERISTIC DATA SHEET  
 CATEGORY III - IMPROVE MECHANICAL COUPLING  
 (As Compared to AAR Type "E" Coupling System)

|                                      | Improve |     |
|--------------------------------------|---------|-----|
|                                      | Yes     | No  |
| <u>Improve Uncoupling Capability</u> |         |     |
| 1) Alternate Side Lever              | ___     | ___ |
| 2) Side of car (push button) release | ___     | ___ |
| How accomplished? _____              |         |     |
| _____                                |         |     |
| 3) Automatic release from:           |         |     |
| (a) Within train                     | ___     | ___ |
| (b) External to train                | ___     | ___ |
| 4) Uncoupling in draft               | ___     | ___ |
| How accomplished? _____              |         |     |
| _____                                |         |     |
| _____                                |         |     |
| Force Required? _____                |         |     |
| _____                                |         |     |

|                                               |     |     |
|-----------------------------------------------|-----|-----|
| <u>Improve Recoupling Capability</u>          |     |     |
| 1) Knuckle automatically opened at uncoupling | ___ | ___ |
| How accomplished? _____                       |     |     |
| _____                                         |     |     |
| 2) Other (explain) _____                      | ___ | ___ |
| _____                                         |     |     |

General Data (as compared to AAR type "E" coupling system)

|                                      |
|--------------------------------------|
| 1) Describe coupling sequence: _____ |
| _____                                |
| 2) Other comments: _____             |
| _____                                |

# CATEGORY IV - IMPROVE GENERAL SYSTEMS

|                                                        | System Capability |     |
|--------------------------------------------------------|-------------------|-----|
|                                                        | Yes               | No  |
| <u>Automatic Brake Control with Uncouplings</u>        |                   |     |
| 1) Intentional uncoupling (with time delay provisions) | ___               | ___ |
| 2) Unintentional uncoupling (emergency set)            | ___               | ___ |
| Describe operation of brake control system: _____      |                   |     |
| <u>Electrical Train Line System</u>                    |                   |     |
| 1) Automatic connection make and break                 | ___               | ___ |
| Describe system _____                                  |                   |     |
| 2) Circuit capacities--(number, amps, volts)           |                   |     |
| 3) Automatic sequencing of contactors                  | ___               | ___ |
| Describe system _____                                  |                   |     |
| 4) Full environment protection of contactors           | ___               | ___ |
| How? _____                                             |                   |     |
| 5) Train sensing systems (list capabilities)           | ___               | ___ |
| _____                                                  |                   |     |
| 6) Train control systems (list capabilities)           | ___               | ___ |
| _____                                                  |                   |     |
| <u>Improve Operational Safety</u>                      |                   |     |
| How? _____                                             |                   |     |
| _____                                                  |                   |     |

## APPENDIX D

### BIBLIOGRAPHY

|                                           | <u>Page</u> |
|-------------------------------------------|-------------|
| D.1 Bibliography                          |             |
| D.1.1 Information Retrieval Search Topics | D - 2       |
| D.1.2 Bibliography                        | D - 3       |
| D.2 Interviews                            |             |
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| D.3 Patents                               |             |
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#### D.1.1 INFORMATION RETRIEVAL SEARCH TOPICS

- 1) Alignment Control
- 2) Automatic Coupler
- 3) Automatic Lock Set
- 4) Centering Device
- 5) Coupled
- 6) Coupler
- 7) Coupler, Type E
- 8) Coupler, Type F
- 9) Coupling
- 10) Coupling Circuit
- 11) Drawbar
- 12) Freight Car
- 13) Knuckle
- 14) Passenger Car
- 15) Positioning Device
- 16) Railroad
- 17) Railroad Car
- 18) Railroad Train
- 19) Self Aligning Coupler
- 20) Vertical Interlock
- 21) Vertical Separation Control

## D.1.2 BIBLIOGRAPHY

|     |                   | <u>Page</u>                                                                        |
|-----|-------------------|------------------------------------------------------------------------------------|
| 1)  | Reference 1-250   | RRIS - Railroad Research<br>Information Service                                    |
|     |                   | D - 4                                                                              |
| 2)  | Reference 251-275 | NTIS - National Technical<br>Information Service                                   |
|     |                   | D - 15                                                                             |
| 3)  | Reference 276-300 | ISMEC - Science Abstracts,<br>Mechanical Engineering and<br>Engineering Management |
|     |                   | D - 15                                                                             |
| 4)  | Reference 301-375 | R-TRIS - Regional Transporta-<br>tion Research Information<br>Service              |
|     |                   | D - 16                                                                             |
| 5)  | Reference 376-400 | COMPENDEX - Engineering<br>Index                                                   |
|     |                   | D - 20                                                                             |
| 6)  | Reference 401-425 | TRIS - Transportation Re-<br>search Information System                             |
|     |                   | D - 22                                                                             |
| 7)  | Reference 426-440 | AAR Specification and<br>Reference Documents                                       |
|     |                   | D - 24                                                                             |
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|     |                   | D - 24                                                                             |
| 9)  | Reference 446-450 | Other Railroad Industry<br>Specification and Refer-<br>ence Documents              |
|     |                   | D - 25                                                                             |
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# D.2.1 RAILROAD INDUSTRIES INTERVIEWED

| Bibliography  |  | Railroad Industry                                  |        |
|---------------|--|----------------------------------------------------|--------|
| Reference No. |  | Source Interviewed                                 | Page   |
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|               |  | National Castings Division                         | D - 29 |
| 503           |  | Ohio Brass Corporation                             | D - 30 |
| 504           |  | General Foods Corporation                          | D - 30 |
| 505           |  | Canadian Steel Foundries                           | D - 31 |
| 506           |  | Hawker Siddley - Thunder Bay                       | D - 31 |
| 507           |  | Stanray Corporation                                | D - 32 |
| 508           |  | Holland Company                                    | D - 32 |
| 511           |  | Westinghouse Air Brake Company                     | D - 32 |
| 513           |  | Dominion Foundries and Steel Limited               | D - 33 |
| 514           |  | New York Air Brake                                 | D - 33 |
| 515           |  | Freight Master                                     | D - 34 |
| 516           |  | Walton Products                                    | D - 34 |
| 517           |  | Dresser Transportation Equipment                   | D - 35 |
| 551           |  | San Francisco Bay Area Rapid Transit<br>System     | D - 35 |
| 552           |  | Cleveland Transit System                           | D - 35 |
| 553           |  | Southern Railway                                   | D - 36 |
| 554           |  | New York City Transit Authority                    | D - 36 |
| 555           |  | Chicago Transit Authority                          | D - 36 |
| 556           |  | Atchinson, Topeka and Santa Fe<br>Railroad Company | D - 37 |
| 557           |  | Washington Metropolitan Transit<br>Authority       | D - 37 |
| 558           |  | Toronto Area Transit Operating<br>Authority        | D - 37 |
| 559           |  | Canadian National Railways                         | D - 38 |

## D.2.2 SUMMARIES OF INTERVIEWS

### Bibliography

| <u>Reference No.</u> | <u>Industry Interviewed</u> |
|----------------------|-----------------------------|
|----------------------|-----------------------------|

|     |                                                                                        |
|-----|----------------------------------------------------------------------------------------|
| 501 | American Steel Foundry<br>1005 Prudential Plaza<br>Chicago, Illinois<br>(312) 644-4080 |
|-----|----------------------------------------------------------------------------------------|

Interview discussions included centering and positioning device issues, coupler modifications to increase the gathering range, and general research and development activities in the railroad industry.

Efforts to increase the coupler gathering range consist of changing the contour of the coupler knuckle, knuckle location and guard arm location.

The impact of mass transit couplers and proprietary couplers used on unit trains and in dedicated service was also discussed.

|     |                                                                                                                         |
|-----|-------------------------------------------------------------------------------------------------------------------------|
| 502 | Midland Ross Corporation<br>National Castings Division<br>2570 Woodhill Road<br>Cleveland, Ohio 44104<br>(216) 229-3400 |
|-----|-------------------------------------------------------------------------------------------------------------------------|

National Castings "Compatamatic" coupler was explained in detail. The "Compatamatic" is an "add-on" device which can be used with an "E" or "F" coupler. An automatic airline system can be included with the "Compatamatic." While cost estimates

Bibliography

| <u>Reference No.</u> | <u>Industry Interviewed</u> |
|----------------------|-----------------------------|
|----------------------|-----------------------------|

were discussed, because the device is still in the prototype stage, exact costs could not be quoted.

A contract was granted to National Castings in conjunction with European firms for conversion to the Willison (UIC) coupler. Characteristics of the coupler were explained and related to the "E" and "F" couplers.

Other National Castings activities and interests include knuckle contour modification, coupler strength enhancement, slack reduction, and locking and lock set.

|     |                                                                                                                                                   |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------|
| 503 | The Ohio Brass Company<br>Mining and Transit Department<br>Mansfield Division<br>380 North Main Street<br>Mansfield, Ohio 44902<br>(419) 522-7111 |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------|

A review was made of the current and past activities on the part of Ohio Brass in the area of railroad and mine car couplers. The type of designs which were reviewed include rigid, flat faced, matching horn/funnel, hinged hook type couplers, rigid, nonreversible type, male/female couplers, coupler location control systems, and coupler electrical systems.

|     |                                                                       |
|-----|-----------------------------------------------------------------------|
| 504 | General Foods Corporation<br>White Plains, New York<br>(914) 253-4452 |
|-----|-----------------------------------------------------------------------|

The General Foods proposed Integral Container Train (ICT) was discussed. An "F" coupler with thirty-six inch draft gear is used for inter-car coupling. Details of the intra-car

## Bibliography

### Reference No.

### Industry Interviewed

connectors are not defined at this time, however, they are expected to be a slight modification of connectors used in the Southern Railroad "auto-guard" car. Generally, these would be eight-foot long tubular draw bars with service shank pins.

505                      Canadian Steel Foundries  
                         Division of Hawker Siddley  
                         Canada, Ltd.  
                         P. O. Box 80  
                         Montreal, Quebec    HIU 3L7  
                         (514) 255-4041

Canadian Steel Foundries, a coupler manufacturer for the rail freight industry, is a division of National Castings. Accordingly, all coupler work related to research and development is conducted by National Castings under the direction of Mr. Damiano Albanese.

506                      Hawker Siddley Canada, Ltd.  
                         Thunder Bay, Ontario  
                         (807) 577-8431

Hawker Siddley, a major manufacturer of mass transit railcars, does not develop nor manufacture couplers for their mass transit cars. Instead, coupling systems, as specified by the mass transit users, are subcontracted out to either Waugh (Dresser), WABCO, or Ohio Brass. Thus, information regarding mass transit couplers and their components used by Hawker Siddley can be obtained only from these subcontractors.

**Bibliography**

**Reference No.**

**Industry Interviewed**

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507                    Stanray Corporation  
                      Standard Railway Equipment Division  
                      4527 Columbia Avenue  
                      Hammond, Indiana 46320

Stanray's primary involvement with coupler systems focuses on centering devices and coupler release rods.

Their current centering devices use leaf spring and single spring principles. The devices are usually installed on new cars rather than retrofit. The expected life of a centering device is eight years.

Two primary problems identified with centering device utilization is force and friction moving the coupler to center. The primary advantage gained in using centering devices is a reduction in end of car damage due to by-passed couplers..

508                    Holland Company  
                      747 East Roosevelt Road  
                      Lombard, Illinois 60148

The Holland Company has developed and at one time marketed a coupler positioning device. The functions of the positioning device were explained in detailed and operations were demonstrated through several films.

Economic issues were presented including purchase, installation, and maintenance estimates.

511                    Railroad Products Marketing  
                      WABCO - Westinghouse Air Brake Company  
                      Wilmerding, Pennsylvania 15148

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Reference No.

Industry Interviewed

The WABCO N2 and N2A mass transit couplers were discussed in detail. Specific issues pursued were the construction and repair of the devices, pneumatic coupler operation, and the use of centering devices.

An automatic air connector to be used in conjunction with National Casting's "Compatimatic" was explained. Conceptually, the devices would supplement the current air line system to provide compatibility for cars not equipped with the device.

Potential for electrical connections in freight service was discussed in light of current WABCO research and development activities.

513                    Dominion Foundries and Steel Ltd.  
                      P.O. Box 460  
                      Hamilton, Ontario  
                      Canada LBN 3J5

DOFASCO manufactures couplers to design specification, but has no coupler research and development activity. Accordingly, interview topics centered upon coupler manufacturing considerations - casting and machining components and strength of materials issues.

514                    New York Air Brake  
                      Starbuck Avenue  
                      Watertown, New York 13601

New York Air Brake develops and manufactures braking systems for passenger, rapid transit, and freight trains. End of car equipment reviewed during the plant visit was brake pipes, angle

## Bibliography

### Reference No.

### Industry Interviewed

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cocks, and air hoses. Considerations for including electrical connections within the freight air line system appears reasonable with NYAB developments.

This company is expanding the rapid transit business through import of a German coupler - the BSI coupler. Air system simulators and an operational model of the BSI coupler were available for demonstration.

515                      Freight Master  
                         P.O. Box 40555  
                         Ft. Worth, Texas 76140

The primary railroad product manufactured by Freight Master is the hydraulic end-of-car cushioning device.

Interview commentary included an explanation of the use of the devices, cost, installation, and maintenance considerations. Of particular interest were the special modifications affecting air systems and coupling systems such as special glad hand travels with some units.

516                      Walton Products  
                         868 Sussex Boulevard  
                         Broomall, Pennsylvania 19008

The Walton Electro-Pneumatic Coupling System and the Walton electrical system for rapid transit couplers were presented. The discussions included detail related to design considerations and operating characteristics of the coupler and electrical systems.

A model was available for demonstration purposes.

## Bibliography

### Reference No.

### Industry Interviewed

517                    Dresser Transportation Equipment  
                      Two Main Street  
                      Depew, New York 14043

Dresser manufactures both freight and rapid transit couplers and conducts research and development activities related to coupling systems. Several models are displayed for demonstration purposes.

In addition to the couplers, concepts behind the development efforts for their automatic trainline connector and their positioning device were reviewed.

551                    San Francisco Bay Area Rapid Transit  
                      800 Madison Street  
                      Oakland, California 94615  
                      (415) 465-4100

Operating characteristics of the current BART system couplers were presented from the users viewpoint. Problems with the coupler system were identified with the electrical system, the draft gear, and springs. In relating the BART coupler system to its potential for freight service, coupler strength was considered the major issue.

552                    Cleveland Transit System  
                      3420 East 93rd Street  
                      (216) 781-5000

The Cleveland Transit System coupler use and related problems were reviewed. Problems confronting the system are damage to electrical components upon coupling and ice and snow effects.

## Bibliography

### Reference No.

### Industry Interviewed

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553                    Southern Railway  
                      409 Henry Street  
                      Alexandria, Virginia

Knuckle failure was identified as a major problem with "E" couplers particularly with high load unit trains. Other problems are draft gear and yoke related and air hose connections and leakage.

It was felt that air connection enhancements should be given top priority for improving the overall freight coupling system.

554                    New York City Transit Authority  
                      370 Jay Street  
                      Brooklyn, New York 11201

The New York City Transit Authority has approximately seven thousand cars in service. The mechanical portion of the coupler presents no operational nor maintenance problems. The only suggestion for improving the coupling system was enhancing the electrical system possibly through the use of multiplexors.

555                    Chicago Transit Authority  
                      Chicago, Illinois  
                      (312) 664-7200

The Chicago Transit Authority uses couplers supplied by Ohio Brass. It was felt that the manufacturer could provide information pertinent to this study.

**Bibliography**

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**Industry Interviewed**

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- 556                    Atchison, Topeka and Santa Fe Railroad Co.  
                      80 East Jackson Boulevard  
                      Chicago, Illinois 60604  
                      (312) 427-4900

Problems with "F" couplers were identified as weak pin connection causing coupler detachment and potential for derailment and jackknifing in buff compression. "E" couplers cannot hold a broken mated coupler, has considerable wear potential, and considerable slack.

The use of the "Compatimatic" device and positioning devices were discussed in addition to potential for automatic air connections and electrical lines for freight service.

- 557                    Washington Metropolitan Transit Authority  
                      600 Fifth Street, N.W.  
                      Washington, D.C.  
                      (202) 637-1234

Washington Mass Transit Authority has a unique remote coupling capability on their system. The primary problem experienced with their coupling process is by-passed couplers and coupler alignment.

- 558                    Toronto Area Transit Operating Authority  
                      3625 Dufferin Street  
                      Downsview, Ontario M3K 1C2

Toronto Area Transit Operating Authority currently uses "H" couplers on their passenger trains. Because an objective is to

Bibliography

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Industry Interviewed

reduce manual effort required in coupling operations they are evaluating new couplers for future installation.

Problems confronting them were reviewed and include slack action, power cable flexing, and flexing and worn air hoses.

559                    Canadian National Railways  
                      935 Lagauchetiere Street, West  
                      Montreal, Quebec, Canada H3C 3N4

The primary problem experienced with the freight couplers on the Canadian National Railways system is knuckle breakage and long cars are highly subject to miscoupling damage.

Center devices have been used successfully on the cars to reduce the incidence of by-passed couplers.

Potential for electrical system installation in freight service was reviewed and endorsed.

### D.3.1 PATENT CLASSES

| <u>Class - Subclass</u> | <u>Title</u>                                         |
|-------------------------|------------------------------------------------------|
| 213 -                   | Railway Draft Appliances                             |
| 1.3                     | Combined coupler and electric connector              |
| 1.6                     | . with additional circuit-making or<br>braking means |
| 15                      | Cushioned, truck controlled                          |
| 20                      | Cushioned, centering devices                         |
| 75                      | Couplings                                            |
| 75A                     | . Operated by trackside mechanism                    |
| 75B                     | . Mine car                                           |
| 75TC                    | . Toy train                                          |
| 75D                     | . Magnetic                                           |
| 76                      | . Combined car and train line                        |
|                         | <u>Couplings, Counterpart</u>                        |
| 100R                    | . . Interengaging hooks or knuckles                  |
| 100W                    | . . . . Willison coupler                             |
| 101                     | . . . Arrowhead type                                 |
| 102                     | . . . . Plural                                       |
| 103                     | . . . Transversely sliding bill                      |
| 104                     | . . . Horizontally swinging                          |
| 105                     | . . . . Miller hooks                                 |
| 106                     | . . . . . Movable bill                               |
| 107                     | . . . . Star wheel                                   |
| 108                     | . . . . Plural                                       |
| 109                     | . . . . Janney type                                  |
| 110                     | . . . . . Always in coupling position                |
| 111                     | . . . . . Auxiliary and emergency                    |
| 112                     | . . . . . Transition construction and<br>devices     |

| <u>Class - Subclass</u> |     | <u>Title</u>                                               |
|-------------------------|-----|------------------------------------------------------------|
| 213                     | 113 | . . . . . Plural-tailed knuckles                           |
|                         | 114 | . . . . . Pinless knuckles                                 |
|                         | 115 | . . . . . Knuckle openers                                  |
|                         | 116 | . . . . . Springs                                          |
|                         | 117 | . . . . . Gravity                                          |
|                         | 118 | . . . . . Knuckles                                         |
|                         | 119 | . . . . . Combined locks                                   |
|                         | 120 | . . . . . Vertically movable and<br>horizontally rotatable |
|                         | 121 | . . . . . Vertically movable and<br>tilting                |
|                         | 122 | . . . . . Vertically sliding                               |
|                         | -   | <u>COUPLINGS</u>                                           |
|                         |     | . <u>Counterpart</u>                                       |
|                         |     | . . Interengaging hooks or knuckles                        |
|                         |     | . . . Horizontally swinging                                |
|                         |     | . . . . Janney type                                        |
|                         |     | . . . . . Knuckle openers                                  |
|                         |     | . . . . . Combined locks                                   |
|                         |     | . . . . . Vertically sliding                               |
| 123                     |     | . . . . . Pivotaly-attached member                         |
| 124                     |     | . . . . . Pivoted or rotatable                             |
| 125                     |     | . . . . . Lock operated                                    |
| 126                     |     | . . . . . Vertically-sliding locks                         |
| 127                     |     | . . . . . And rearwardly swinging                          |
| 128                     |     | . . . . . Vertically-swinging levers                       |
| 129                     |     | . . . . . Vertically-swinging locks                        |
| 130                     |     | . . . . . Horizontally-sliding locks                       |
| 131                     |     | . . . . . Lock operating                                   |
| 132                     |     | . . . . . Continuing movement                              |
| 133                     |     | . . . . . Horizontally-rotating shaft                      |

| <u>Class - Subclass</u> |     | <u>Title</u>                                |
|-------------------------|-----|---------------------------------------------|
| 213                     | 134 | . . . . . Pivoted levers                    |
|                         | 135 | . . . . . Sliding                           |
|                         | 136 | . . . . . Vertically                        |
|                         | 137 | . . . . . Separate movement                 |
|                         | 138 | . . . . . Rotating and sliding              |
|                         | 139 | . . . . . Gravity locks                     |
|                         | 140 | . . . . . Knuckle attached                  |
|                         | 141 | . . . . . Vertically swinging               |
|                         | 142 | . . . . . With lock set and anticreep       |
|                         | 143 | . . . . . With lock set                     |
|                         | 144 | . . . . . With anticreep                    |
|                         | 145 | . . . . . Vertically sliding                |
|                         | 146 | . . . . . With lock set and anticreep       |
|                         | 147 | . . . . . With lock set                     |
|                         | 148 | . . . . . With anticreep                    |
|                         | 149 | . . . . . Horizontally-sliding locks        |
|                         | 150 | . . . . . Horizontally-swinging locks       |
|                         | 151 | . . . . . Contour                           |
|                         | 152 | . . . . . Knuckle and head interengagement  |
|                         | 153 | . . . . . Vertical-disengagement prevention |
|                         | 154 | . . . . . Guard-arm construction            |
|                         | 155 | . . . . . Knuckle and knuckle pins          |
|                         | 156 | . . . . . Knuckle-pin bottom retainers      |
|                         | 157 | . . . . . Detachable ears                   |
|                         | 158 | . . . . . Lifter and lock-hole closures     |
|                         | 159 | . . . . . Uncoupling devices                |
|                         | 160 | . . . . . Emergency                         |
|                         | 161 | . . . . . Selectively movable               |
|                         | 162 | . . . . . Pull rods, chains or ropes        |
|                         | 163 | . . . . . Interengaging levers              |
|                         | 164 | . . . . . Vertically swinging               |

| <u>Class - Subclass</u> | <u>Title</u>                         |
|-------------------------|--------------------------------------|
| 213      165            | . . . . . Vertically swinging        |
| 166                     | . . . . . Rotating horizontal shafts |
| 167                     | . . . . . Journaled to coupler head  |
| 168                     | . . . . . Directly connected to lock |
| 169                     | . . . . . Horizontal link to lock    |
| 170                     | . . . . . Vertical link to lock      |
| 171                     | . . . . . Brackets                   |
| 172                     | . . . Vertically swinging            |
| 173                     | . . . . Vertical hook                |
| 174                     | . . . Rotating                       |
|                         | <u>Couplings, Link or Bar type</u>   |
| 175                     | . . Hook and catch                   |
| 176                     | . . Beveled link and swing catch     |
| 177                     | . . . Arrowhead                      |
| 178                     | . . Hook and link                    |
| 179                     | . . . Pivoted hook                   |
| 180                     | . . . . Multiple                     |
| 181                     | . . . Rails                          |
| 182                     | . . Headed link and shouldered slot  |
| 183                     | . . . Pivoted head                   |
| 184                     | . . . Rotating head or link          |
| 185                     | . . Beveled link and sliding catch   |
| 186                     | . . . Arrowhead type                 |
| 187                     | . . Beveled link and fixed catch     |
| 211                     | <u>Couplings, Uncoupling Devices</u> |
| 212                     | . . Central control                  |
| 213                     | . . Operable from car top to side    |
| 214                     | . . . Rotating vertical shaft        |
| 215                     | . . Operable from car top only       |
| 216                     | . . Rotating vertical shafts         |
| 217                     | . . Flexible                         |
| 218                     | . . Vertical swinging lever          |
| 219                     | . . Rotating horizontal shafts       |

| <u>Class - Subclass</u> |    | <u>Title</u>                        |
|-------------------------|----|-------------------------------------|
| 105                     | -  | Railway Rolling Stock               |
|                         | 2  |                                     |
|                         | 3  |                                     |
|                         | 4  |                                     |
| 180                     | -  | Motor Vehicles                      |
|                         | 14 |                                     |
| 188                     | -  | Combinations of Couplers and Brakes |
| 214                     | -  | Material or Article Handling        |
| 280                     | -  | Land Vehicles                       |
| 400                     |    |                                     |

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## APPENDIX F

### REPORT OF INVENTIONS

This report, a survey and assessment of automatic coupling concepts for rail freight cars, includes as Appendix C a previously unavailable listing and categorization of automatic coupling concepts. Section 5 provides estimated quantitative values of improvement in coupling systems from each concept. Cost estimates for candidate coupling systems composed of various concepts are found in Section 6 and they represent a new contribution.

## APPENDIX G

### PRELIMINARY DEVELOPMENT SPECIFICATION FOR AUTOMATIC TRAIN AIR LINE CONNECTOR

#### A.1 GENERAL PROVISIONS

1) Installation of the connector to the car must be possible with the coupler in place. Mounting must not interfere with existing car components (including hydraulic cushioning devices on long cars).

2) Connector must be suitable for mounting on both Type "E" and "F" couplers (including a double-shelf "E" coupler and a top shelf "F" coupler).

3) Replacement of damaged connector, or components, must be accomplished with a minimum of time and with no special tools.

4) Connector mounted to a car must not exceed clearance limits and must operate satisfactorily at the track curvature limits specified for freight cars in the AAR Manual of Standards and Recommended Practices. (Section C, pages C-4-1968 through C-7-1968, and in the AAR Specifications for Design, Fabrication and Construction of Freight Cars.) Connector must not restrict air flow through the brake pipe at the limits specified.

5) Connector must allow making a manual brake pipe connection from the connector face to a car having standard air brake hose.

6) Connector must be suitable for freight car service between temperatures of -50°F to 200°F.

7) Connector must not normally require periodic attention except for replacement of hose coupling gasket and hose.

8) Connector must operate within a pressure range of 0 to 150 psi.

9) Cost objectives must be compatible with satisfactory operating requirements.

10) Connector design shall provide space for a mechanical push-rod which is depressed by the full closure of the butt seal. (This push-rod will be incorporated as a part of a separate air valve control mechanism.)

## A.2 CONNECTION PROVISIONS

1) Connector concept must be suitable for installation of one air line and six to eight electrical contacts placed on the centerline below the air line port. (The electrical contacts can be contained in a separate detachable unit which could be securely attached as a later modification to the air connector unit.)

2) The basic connector design shall be "spread-wing" which will include the capability of subsequent design modifications to increase gathering capability while remaining compatible with original designs.

3) Connector must have the capability of gathering (a) horizontally, with the distance between the connector centers a maximum of  $\pm 5"$ , (b) vertically, with the distance between connector centers a maximum of  $\pm 5"$ , and (c) when the horizontal angle between connector center lines is a maximum of 17 degrees.

4) Connector must not be damaged by coupler by-pass or mis-couplings.

5) Connector should incorporate self-centering means to assure that the connector is on coupler center in an uncoupled position.

6) Connector should have a minimum number of parts, minimum amount of machining, be compact, sturdy and lightweight design in order to meet economic and serviceability/requirements.

7) Connector must permit necessary operations to be performed from either side of the car.

8) Connector shall incorporate a spring type self-loading capability having a thrust of at least 500 pounds force and a free longitudinal compression travel of at least 1-1/2 inches.

### A.3 AIR LINE PROVISIONS

1) The airline port shall be butt faced and shall include a compressible outer seal providing for at least 1/4 inch compression.

2) Car angle cock location to be maintained within present location as specified by AAR. (Manual of Standards and Recommended Practices, Section E, Pages E-31-1965 to E-33-1965.) However, design provisions shall be made for location of a second angle cock as may be required for use in coupling with a nonequipped car.

3) Air brake hose attached to connector must be removable without uncoupling cars. It must be possible to make the Single Car Test without uncoupling cars.

4) Connector must operate without leakage under worn coupler condemning gage limits and with maximum vertical distance between coupler center lines of 8-1/4". (Displacement for vertical curve negotiation of 7-1/4" is required by AAR Specification Design, Fabrication and Construction of Freight Cars 2.6.)

5) Use of standard air hose gasket is desirable, but not required. (AAR Manual of Standards and Recommended Practices, Section A, Page M-602-63.) Use of present standard air brake hose length of 22" is preferred, but not required.

6) Coupled connectors, with hoses, must have air flow capacity equivalent to at least a 0.984" diameter square edged, 1/16" thick, orifice.

7) The brake pipe opening at the gasket face of the connector must be the lowest point in the brake pipe line to permit draining of water from the brake pipe and there must be a continuous drop from the angle cock to the connector coupling gasket to prevent water pockets.