RAILROAD ACCIDENT REPORT

COLLISION OF
ILLINOIS CENTRAL GULF RAILROAD
COMMUTER TRAINS,
CHICAGO, ILLINOIS
OCTOBER 30, ,1972

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20591
REPORT NUMBER: NTSB-RAR-73-5

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ADOPTED: JUNE 28, 1973

U.S. NATIONAL TRANSPORTATION SAFETY BOARD,
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15.Supplementary Notes

This report contains Railroad Safety Recommendations R-73-28 through R-73-32.

16.Abstract

This report describes and analyzes the collision of two Illinois Central Gulf Railroad commuter trains in Chicago, Ill., on the morning of October 30, 1972. A train consisting of four new Highliner cars overran a station stop, attempted to back up to the platform, and was struck from the rear by another train operating on the same track. The first car of the following train overrode the underframe of the last car of the lead train and telescoped the car.

The National Transportation Safety Board determines that the probable cause of this accident was the reverse movement of train 416 (the lead train) without flag protection into a previously vacated signal block and the failure of the engineer of train 720 (the following train), while operating faster than the prescribed speed, to perceive the train ahead in time to avoid the collision. Ambiguous rules which caused confusion among employees regarding the necessity to flag within automatic-block signal system limits and the reduced importance of flagging in suburban service implied by the management's failure to enforce Rules 7, 35, 99, 896, and 1003 also contributed to the accident.

The report contains recommendations to the Illinois Central Gulf Railroad, the Chicago South Suburban Mass Transit District, the Federal Railroad Administration, and the Urban Mass Transportation Administration.

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F O R E W O R D

The accident described herein was designated a major accident by the National Transportation Safety Board under the criteria established in the Safety Board's regulations.

This report is based on facts obtained from an investigation conducted by the Safety Board, in cooperation with the Federal Railroad Administration. The investigation included a public hearing held by the Safety Board in Chicago, Illinois, on December 4 through 8, 1972. Representatives of the Illinois Commerce Commission and the Illinois Department of Transportation participated in the hearing. (On January 11, 1973, the two State agencies submitted a joint report to Governor Richard B. Ogilvie concerning their safety activities in relation to this accident.)

Parties to the public hearing were the Brotherhood of Locomotive Engineers, the Chicago South Suburban Mass Transit District, the Congress of Railway Unions, the Federal Railroad Administration, the Illinois Central Gulf Railroad Company, The St. Louis Car Division of General Steel Industries, Inc., and the Urban Mass Transportation Administration.

The conclusions, the determination of probable cause, and the recommendations herein are those of the Safety Board.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20591
RAILROAD ACCIDENT REPORT

Adopted: June 28, 1973

Collision of Illinois Central Gulf Railroad Commuter Trains, Chicago, Illinois October 30, 1972

I. SYNOPSIS

During the morning rush hour on October 30, 1972, Illinois Central Gulf Railroad (ICG) commuter train 416, which consisted of four new bi-level Highliner cars, overran the 27th Street station at Chicago, Ill. While backing up to the station platform, at 7:38 a.m., train 416 was struck from the rear by ICG commuter train 720, which consisted of six older cars and was operating on the same track as the train 416. A third train, passing on an adjacent track, sideswiped the wreckage.

The collision destroyed the rear half of the last car on train 416 and the first 10 feet of the lead car on train 720; 45 passengers were killed, and 332 persons were injured.

The National Transportation Safety Board determines that the probable cause of this accident was the reverse movement of train 416 without flag protection into a previously vacated signal block and the failure of the engineer of train 720, while operating faster than the prescribed speed, to perceive the train ahead in time to avoid the collision. Ambiguous rules which caused confusion among employees regarding the necessity to flag within automatic-block signal system limits and the reduced importance of flagging in suburban service implied by the management's failure to enforce Rules 7, 35, 99, 896, and 1003 also contributed to the accident.

Contributing to the high incidence of fatality was the over-riding of the underframe of the Highliner car by the older car, which allowed the older car to telescope the Highliner car.

II. FACTS

The Accident

At 7:06 a.m., on October 30, 1972, Illinois Central Gulf (ICG) commuter train 416 departed from the South Chicago station, on time, and headed north toward downtown Chicago. The train consisted of four new bi-level Highliner cars and was manned by an engineer, a collector, and a conductor. Earlier that morning, the traincrew reported to work at the 83d Street yard, where they inspected the train and tested the airbrakes. Before the train was taken to South Chicago for the start of its revenue run, the conductor instructed the engineer to make all stops enroute to downtown Chicago, including the flag stop at 27th Street.

The train's brakes seemed to operate perfectly at each of the 12 station stops between South Chicago and 53d Street. At the 53d Street station, train 416 waited for ICG commuter train 718 in order to transfer passengers, but left at 7:31 on track 3, when 718 did not arrive on time. Some passengers were standing in the first and last cars of 416 after the 53d Street stop.

As the train passed 31st Street, the conductor, standing in the center vestibule of the third car, announced the stop at 27th Street over the intercom. The train approached the 27th Street station in daylight under an overcast sky. The engineer testified that when he applied the brakes, 416 was traveling at 62 m.p.h. The train, however, passed the station platform at a speed estimated by several witnesses as between 20 and 50 m.p.h. When the train finally stopped, the rear car was about 600 feet north of the platform and about 400 feet north of Signal 3-3.10. (See Figure 1.)

The conductor proceeded to the center vestibule of the rear car, opened one of the doors on the platform (west) side of the train, and plugged his microphone into the train's intercom system. The engineer buzzed the conductor for permission to back up, and the conductor told him over the intercom to do so.

While the train backed toward the platform at a speed of between 5 and 15 m.p.h., the conductor remained in the center vestibule, maintained contact with the engineer, and leaned out the open door. The engineer simultaneously leaned out the east side of the train and looked back until he was forced to pull his head in by the approach of train 718 on the adjacent track. The collector was proceeding toward the engineer's operating compartment.

NOTE: TRACK NO.'S 1,2,3,& 4 ARE ELECTRIFIED AND ACCOMMODATE SUBURBAN TRAINS.
TRACK NO.'S 5 & 6 ACCOMMODATE FREIGHT AND OTHER PASSENGER TRAINS.

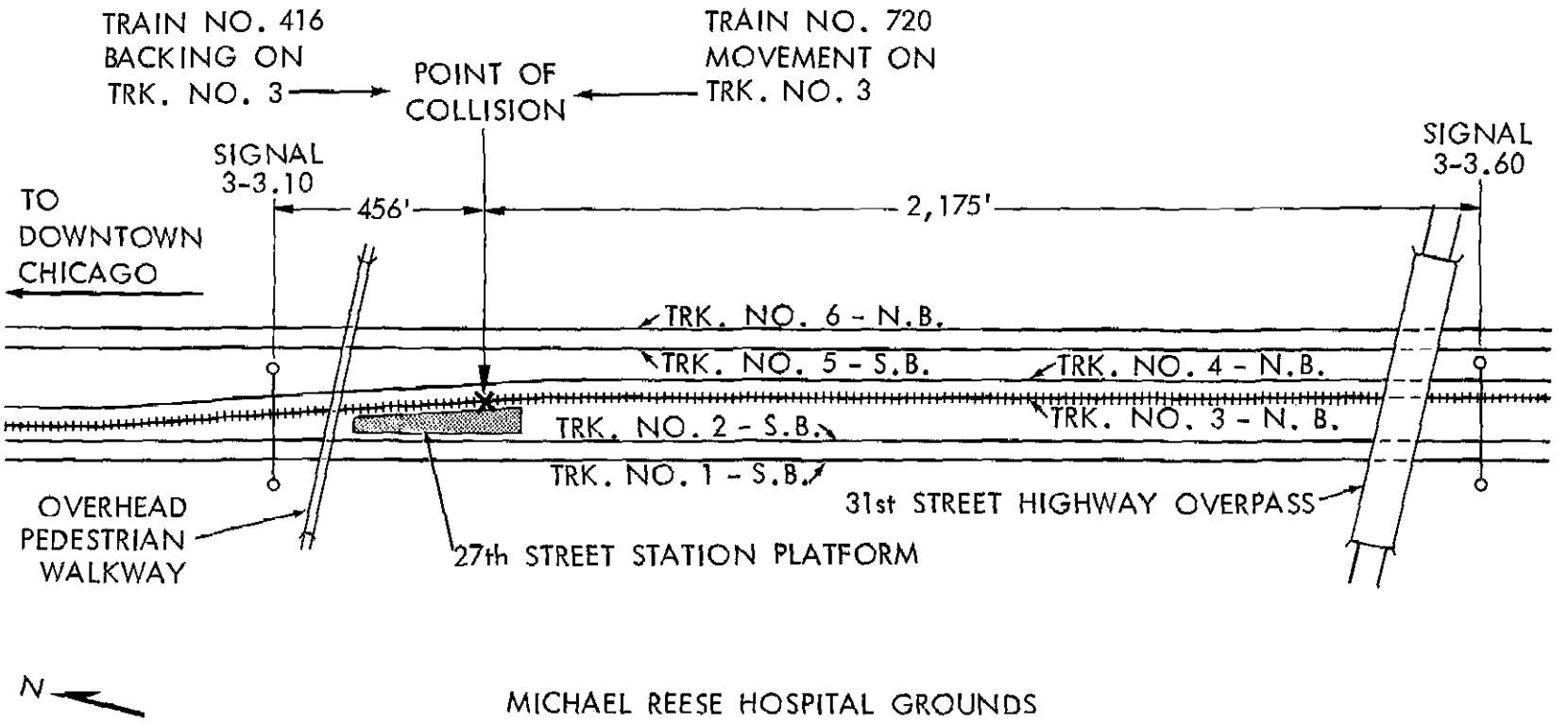


Figure 1. Accident Site

When the rear of train 416 came alongside the station platform, the conductor repeatedly instructed the engineer to stop. The train had almost stopped when it was struck from the rear at 7:38 a.m. by northbound train 720, which was also operating on track 3. The conductor remained on 416 until just before impact.

Train 720. Train 720 had started its revenue run at South Chicago 9 minutes after the departure of train 416. Train 720 consisted of six "old" cars and was manned by an engineer, a collector, and a conductor. The crew, like the crew of 416, had reported to work that morning at the 83d Street yard.

Train 720 had seven scheduled stops between South Chicago and Stony Island Avenue and then had no scheduled stops until Roosevelt Road (12th Street). The brakes worked properly at each of the seven stops, and the train departed from Stony Island Avenue on time. All seats were occupied, and some passengers were standing.

At 67th Street, train 720 was routed onto track 3. Because all signals enroute to Signal 3-3.60 (at 31st Street) displayed clear aspects, the engineer accelerated the train to the maximum attainable speed, which he estimated to be between 55 and 60 m.p.h. The train was not equipped with a speedometer.

Signal 3-3.60 displayed a yellow aspect as 720 approached. At that time, the collector was in the vestibule at the rear of the second car, and the conductor was in the fourth car. The engineer stated that because he expected to catch train 416, he had already set the brakes before he observed Signal 3-3.60. He said that he then further reduced air pressure, and 720 passed the signal at a speed which the engineer estimated to be about 40 m.p.h.

The engineer's view of Signal 3-3.10 from 31st Street was obstructed by an overhead walkway at 27th Street. The engineer first observed train 416 when 720 was "four to six car lengths from the (27th Street) platform." At that time, 416 was alongside the platform and still backing. The engineer of 720 applied the emergency brakes, threw the operating lever to the reverse position, blew the horn, and evacuated the operating compartment. He warned the passengers in the first car that a crash was imminent, and had just entered the passenger area when the collision occurred.

A passenger who was riding in the front vestibule of the first car had also sighted 416. She ran back into the passenger area before the engineer left his compartment and was about halfway down the aisle of the car when impact occurred.

The collision. The leading coupler of the first car of train 720 was broken off by the impact, and the car overrode the underframe of the rear car of 416. The first car of 720 then sheared off the collision posts on the rear car of 416, veered slightly to the right, and moved through the passenger section. (See Figure 2.) The lead truck on 720's first car was thrown from under the car and came to rest along the east side of the track. The rear truck was derailed and came to rest against the rear truck of the Highliner car.

The wreckage from the impact sideswiped the last car of train 718, which was passing by on track 4. Passengers in that car heard a noise like an explosion, saw flying glass and dust, and felt their car rock from the impact of the spreading debris. The car, however, did not derail.

Train 718. After having arrived too late to transfer passengers with train 416, train 718, which consisted of eight "old" cars, had departed the 53d Street station for Roosevelt Road. Although the train had no speedometer, the engineer estimated that the train reached a top speed of 60 to 65 m.p.h. in the vicinity of 45th Street. The train maintained this speed until it reached 23d Street, where braking was necessary in order to comply with a 25-m.p.h. speed restriction.

Somewhere between 39th and 35th Streets, train 720 caught up with and began to pass 718. The two trains then ran side by side for 1 or 2 minutes. The first car of 720 passed the fourth car of 718 but did not reach the second car when 720 started to drop back, in the vicinity of 31st Street. At that point, several passengers on 718 noticed that the engineer of 720 appeared to be alert and attentive to his duties.

As 720 dropped back, the collector in the sixth car of 718 noticed sparks coming from the wheels of 720. The engineer of 718 saw the last car of 416 at the north end of the platform as he passed 27th Street; other passengers on the train saw the rear of 416 as 720 dropped back. The passengers heard 720's whistle and sensed that a collision was imminent.

Figure 2. Trains After Collision.

Method of Operation

This accident happened on ICG Chicago Division track which had been electrified to accommodate suburban trains. Train operations were controlled by automatic-block signals, timetable, and special instructions. Train orders were not used in suburban service. Special instructions were generally issued as bulletin orders (for matters directly involving train operations) or bulletin notices (for matters involving other transportation matters).

The automatic-block signal system, which was installed from 1926 through 1929, consisted of signal lights which displayed red, yellow, and green aspects. The signals were suspended from overhead structures that spanned the tracks and were installed on tracks 3 and 4 to accommodate northbound traffic only. The red aspect of Signal 3-3.10 (at 27th Street) and Signal 3-3.60 (at 31st Street) indicated restricted proceed and did not indicate stop.

Suburban train movements were directed by the ICG load supervisor. Use of the tracks through the accident site was controlled by the operator at 67th Street Interlocking. Because train 416 stopped at most stations, it was always routed on track 3. The routing of train 720 depended on conflicts with other trains. Normally, 720 was routed on track 3, although it was not scheduled to stop between 67th Street and Roosevelt Road.

The maximum authorized speed for trains using tracks 3 and 4 through the accident site was 65 m.p.h. A 25-m.p.h. authorized speed applied to train operation north of 23d Street.

On weekday mornings between 7:30 and 8, 18 trains passed through the 27th Street station on tracks 3 and 4. Six of these trains were scheduled to pass 27th Street between 7:30 and 7:38. (The schedules for trains 416, 720, and 718 are contained in Appendix A.)

Train 416 was the only train that stopped at the 27th Street station between 7:30 and 8 a.m. Although the stop was listed in the timetable as a flag stop at 7:31, 416 actually stopped every morning to discharge workers of the nearby Michael Reese Hospital.

Train Equipment

Train 720. The six multiple-unit (MU) cars of train 720 were of steel construction and had been built between 1924 and 1926. The cars operated in pairs, with a motor car and a trailer car forming a semipermanent unit. The first car of 720 was a trailer car. A vestibule with side doors was located at each end of each car. The operating controls, which did not include a speedometer, were in the end vestibules of each pair of cars. (See Figure 3.)

Each car was 72 feet 7 inches long, 10 feet 6 inches wide, and 13 feet high, and could seat 84 passengers. The motor cars weighed about 142,000 pounds each, and the trailer cars weighed about 88,600 pounds each. Neither car was radio-equipped.

Traction motors were mounted on each of the four axles on each motor car, and the major electrical components were mounted under the car floor. Pantographs on the motor cars collected the 1,500-volt current from the overhead catenary system. The trailer cars had no electrical propulsion equipment. The train brakes were electropneumatic, with cast-iron brake-shoes.

Both the motor cars and the trailer cars had automatic tightlock couplers which included two air lines and a 32-wire electrical trainline connector. The rear of the coupler yoke was attached to the car by a radial connection hung beneath the underframe, and the front of the coupler was supported by a coupler carrier swung under the center sills. Except for the coupler, there was no anti-climbing feature on either the motor cars or the trailer cars.

The cars of train 720 were constructed prior to the establishment of Federal regulations for MU equipment and the couplers, the anti-climbing arrangement, and the collision posts did not comply with the requirements in 49 CFR 230.457.

Train 416. The Highliner cars were self-propelled, electric MU cars in which passengers were seated on two levels. Each car was 85 feet long, 15 feet 10 inches high, and 10 feet 6 inches wide, and weighed about 134,000 pounds. (See Figure 4.)

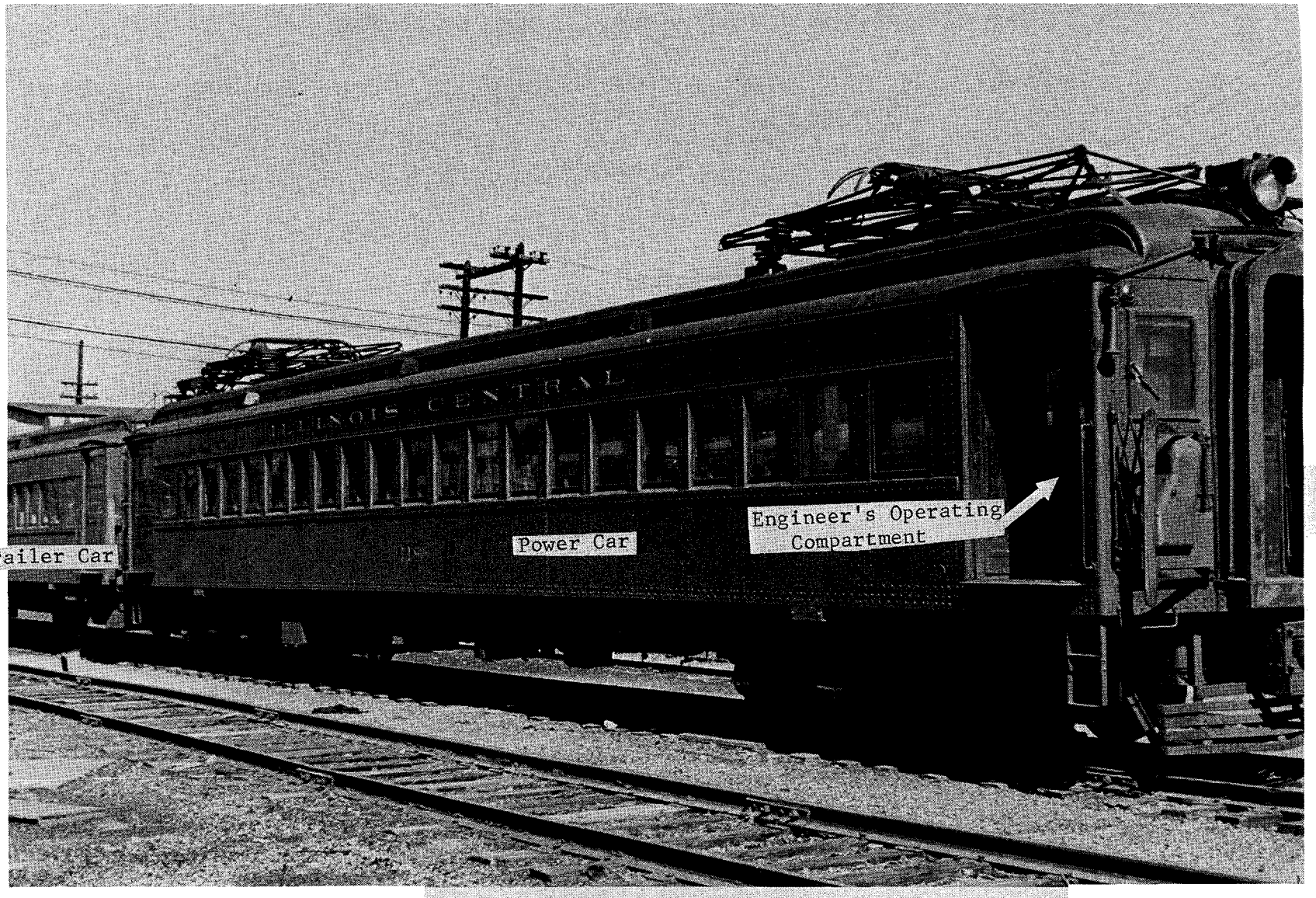


Figure 3. "Old" car, similar to those of train 720.

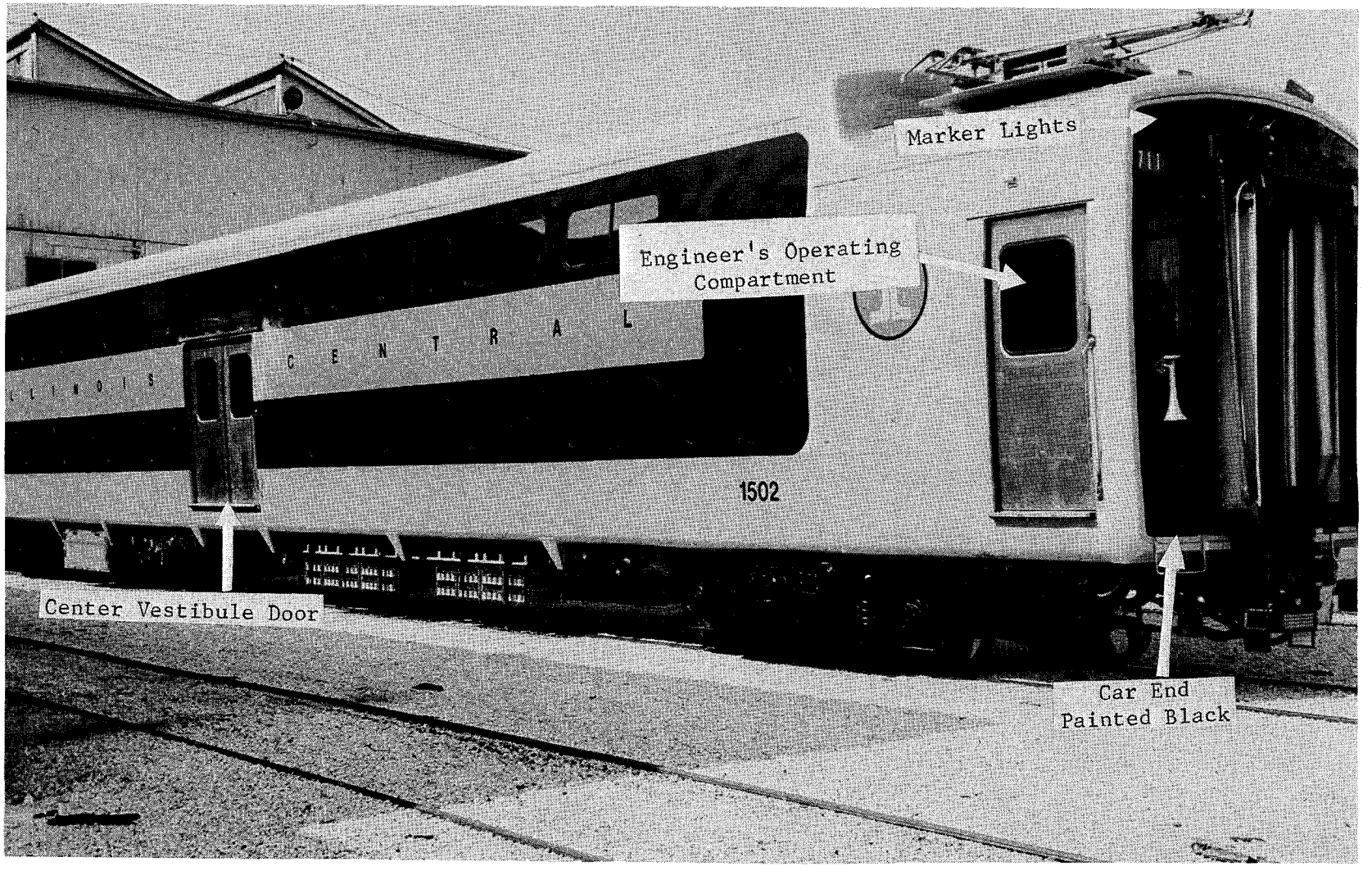


Figure 4. Highliner car, similar to those of train 416.

A vestibule 6 feet 6 inches wide extended across the center of each car. Controls on the vestibule walls could be used to operate all double doors on one side of the entire train or to operate the door at the vestibule location individually. At the same location, the conductor could plug his microphone into the train intercom system. On one of the walls across the vestibule from the door controls and microphone connection was an emergency brake valve. The operating compartment of each car was equipped with two-way radio and speedometer.

At one end of each car was a vestibule which contained the operating compartment. The cars were generally joined together at the "blind" ends into pairs. The operating controls, brake valve, and radio-intercom system were operable only in the cab in which the engineer was controlling.

There were two rows of double seats in the lower level of each car and two rows of single seats in the upper level. The section of the car next to the operating compartment seated 48 persons in the lower level and 30 in the upper level. The section at the "blind" end of the car seated 44 in the lower level and 43 in the upper.

The brake system employed dynamic braking as well as electropneumatic-hydraulic, on-tread braking, with composition brakeshoes. The engineer could use the electropneumatic braking alone or could select the combination, in which the dynamic braking blended automatically with the on-tread braking.

Fully automatic, flat-face, hook-type SW 800 couplers also automatically joined the air and electric lines. The couplers, yokes, and draft gears, which were mounted in the center sills, provided an anti-climbing arrangement which, in conjunction with the design of the car ends, complied with Federal regulations.

The car bodies were modified monocoques of Corten A steel. The underframe of each car was made from built-up sections welded together. The sides were 0.0677-inch-thick steel sheets, which were welded to the framing. (See Figure 5.)

At each end of the cars, there were two vertical end members (collision posts), designed to comply with Federal regulations. Each collision post consisted of a 3/8-inch channel with an 8-1/2-inch web and 3-inch flanges and extended from the underframe to the top framing of the roof. (The design of the attachment to the underframe is shown in Figure 5.)

The ends of each Highliner car were painted black, with a narrow silver border along each side and across the top. To indicate the rear of the train and the type of service, marker lights, which displayed either a red, green, yellow, or clear aspect, were provided in the upper corners of the vestibule end. Each lens was 1-1/2 inches in diameter and was lighted by a 30-watt, 75-volt lamp, which operated on 60 volts. A headlight was located over the vestibule-end center door.

Accident Losses

Fatalities and injuries. The collision killed 45 passengers and injured 332 persons. Most of the fatalities and serious injuries occurred in the rear car on train 416. Shortly after the collision, personnel from the Michael Reese Hospital, which was adjacent to the tracks, and police and fire-department rescue squads arrived. The quick emergency response precluded an even higher number of fatalities.

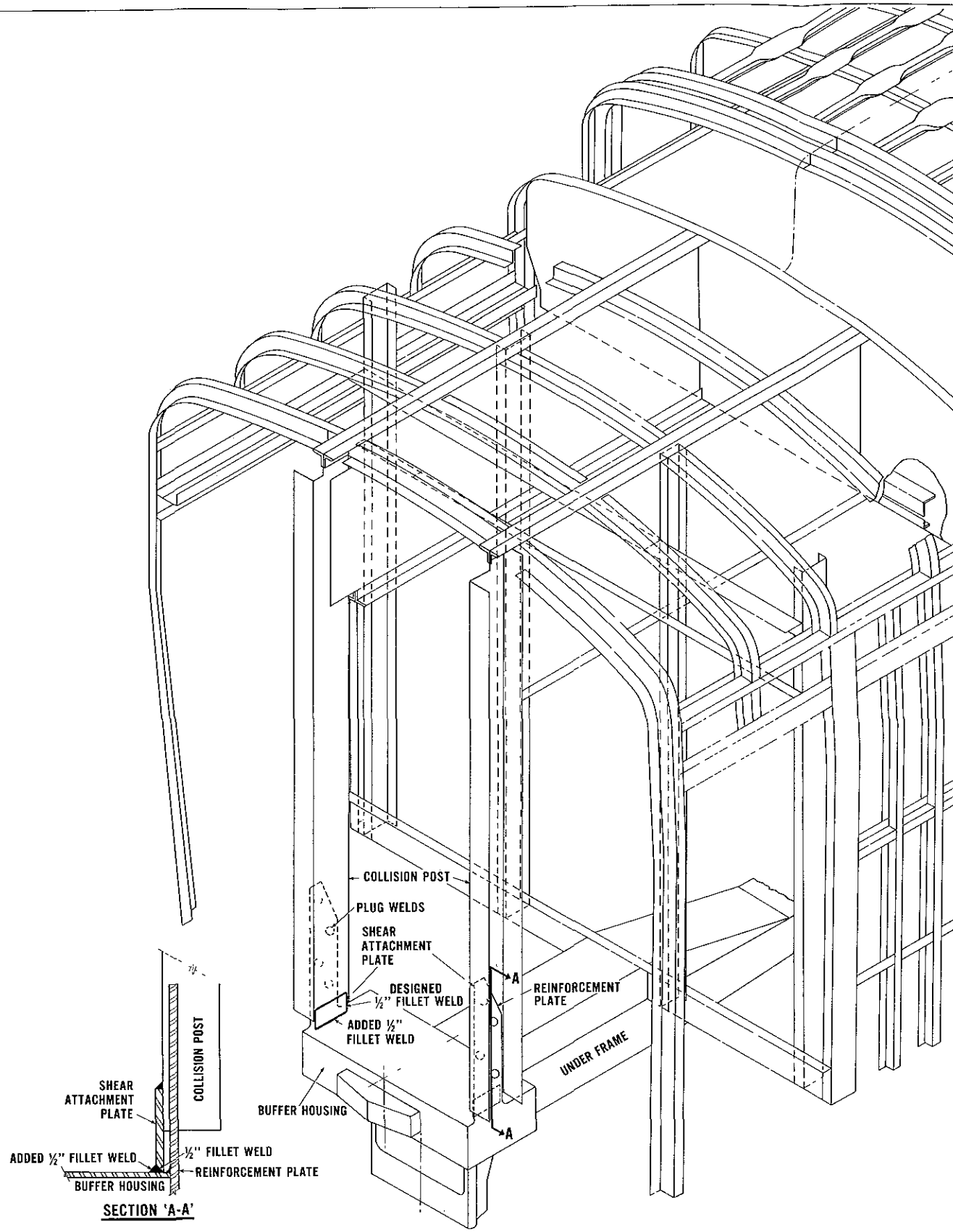
Train damage. The rear half of the last car of train 416 was demolished. The end of the car and most of the right side were sheared off at floor level. A portion of the left side and several seats on the upper level remained intact. All lower-level seats were destroyed. The underframe of the car was not buckled, and the three other cars of 416 received only minor damage and were returned to service.

The first 10 feet of the lead car of train 720 was demolished. The center sills and couplers on several of the other cars of the train were broken, and these cars sustained sufficient damage to prevent prompt return to service.

Track damage. Track 3 was slightly damaged, but the 27th Street platform was not damaged at all. The ICG estimated that track damage amounted to $200.

Crewmembers

The engineer of train 720 started his employment with the railroad as a locomotive fireman in 1948. The collector and the conductor of 720 started as trainmen prior to 1948. The crew had been assigned to 720 during the 2 years preceding the accident and had previously held similar positions on train 416.


COLLISION POST
PLUG WELDS
SHEAR ATTACHMENT PLATE
DESIGNED ½" FILLET WELD
ADDED ½" FILLET WELD
REINFORCEMENT PLATE
UNDER FRAME
BUFFER HOUSING
A
A
SHEAR ATTACHMENT PLATE
COLLISION POST
ADDED ½" FILLET WELD
½" FILLET WELD
REINFORCEMENT PLATE
BUFFER HOUSING
SECTION 'A-A'

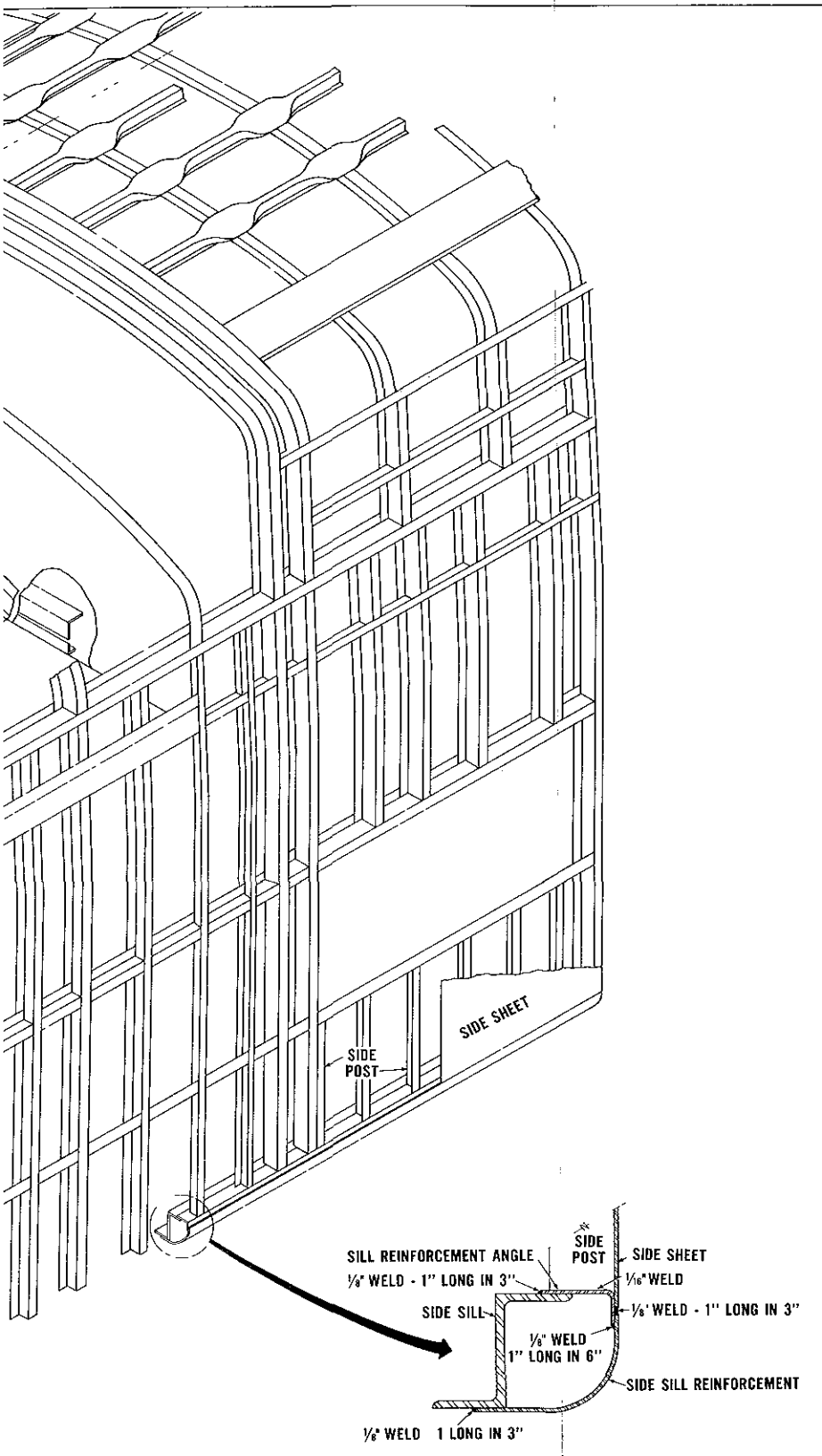


FIGURE 5

CAB END STRUCTURE
I.C G HIGH LINER

The engineer of train 416 had not worked as engineer of 416 before the day of the accident. He had been, however, an engineer since 1960 and had worked in suburban service for about 4 years. The conductor and the collector had worked on 416 for about 2 years and had previously held similar positions on train 720.

The medical histories of the crewmembers contained nothing to indicate that their physical or mental abilities may have been a factor in the accident.

Postaccident Tests and Inspections

Visibility and stopping distance. After the accident, tests were made (1) to determine the stopping distances of trains with consists similar to those of trains 416 and 720 and (2) to determine the visibility between trains in the vicinity of the accident. The three Highliner cars which were on train 416 on the day of the accident and one other Highliner (to replace the destroyed car) represented 416. Three pairs of older cars, each pair consisting of a motor car and a trailer car, represented 720. These "old" cars were ballasted to compensate for the weight of the passengers carried by the train at the time of the collision. Weather conditions during the tests were similar to those at the time of the accident.

Some of the tests, and their results, were as follows:

- A full service brake application was made on 416 at a point opposite the center of the 27th Street platform, while the train was moving at 63 m.p.h. The train stopped with the front end 1,713 feet north of the point of brake application.

- With train 720 standing at Signal 3-3.60, the engineer could not see 416 when it was more than 50 feet north of the 27th Street platform.

- With train 416 standing just north of Signal 3-3.10 and train 720 moving north, the engineer of 720 first could see 416 when 720 was 1,819 feet south of Signal 3-3.10; he could first see Signal 3-3.10 when 720 was 1,723 feet south of the signal.

- With train 720 standing 500 feet south of the collision point, the engineer could continually see train 416 as 416 moved northward from the point of impact for a considerable distance north of Signal 3-3.10.

- A service brake application was made as train 720 passed Signal 3-3.60 at a speed of 60 m.p.h. The speed was reduced to 30 m.p.h., and that speed was maintained until the train was 500 feet south of the collision point, where an emergency application of the brakes was made. The train stopped 299 feet south of the collision point.

- The emergency braking distance of train 720 from various initial speeds was measured. Results are shown below: 1/

Initial Speed (m.p.h.)	Braking Distance (feet)
58	1,437
45.9	762
29.6	340
15	91

- The red marker lights on the rear of 416 were not visible during any of the tests until after the end of the car became discernible.

Signal system. Postaccident tests were performed on the signal system by ICG employees and by representatives of the Federal Railroad Administration (FRA). No defects or abnormalities were found which could have contributed to the accident.

Train equipment. The collision posts of the Highliner car struck by 720 failed in the weld which attached the shear attachment plate to the underframe. Tests disclosed incomplete fusion between the plate and about 75 percent of the weld. The bottom edge of the plate was bevelled to permit the weld to penetrate through the plate to the underframe from one side. However, the bevel of the shear attachment plate extended only five-sixteenths of an inch into the plate, instead of the full one-half inch as designed. An additional 1/2-inch fillet weld which had been applied adjacent to the original weld failed in the parent materials of the underframe and shear plate. The plug welds which attached the reinforcing plate to the collision posts were fused incompletely. Further description of the design and failures of the collision posts can be found in Appendix G, which contains an interim recommendation made by the Safety Board to the FRA on April 25, 1973.

1/ These test results have been plotted on a graph, which is included as Appendix B.

Some of the side posts on the rear car were sheared off through the welds which attached the posts to the sill reinforcing angle. Other posts were sheared off above the welds and were bent outward, which contributed to the failure of the sill reinforcing angle. Many of the intermittent welds which attached the sill reinforcing angle to the side sill broke in the welds and thus permitted the sill reinforcing angle to be torn from the side sill for about one-half of the damaged area. The intermittent welds which attached the bottom of the side sheets to the sill reinforcing angle broke and allowed the side sheets to separate. (See Figure 5.)

The speedometer of the lead car of train 416 was malfunctioning after the accident. Tests indicated that it would not register above 63 m.p.h. All speeds above 63 m.p.h. registered as 63 m.p.h.

The brakes of the surviving cars of trains 416 and 720 were tested, and no deficiencies were discovered.

Applicable Standards

Contract specifications. Because Federal funds were not available to private companies for the purchase of equipment, the Highliner cars on train 416 were purchased by the Chicago South Suburban Mass Transit District (CSSMTD), assisted by a grant from the Urban Mass Transportation Administration (UMTA). Although ICG wrote the specifications for the Highliner cars, CSSMTD retained a consultant to recommend industrial design modifications. UMTA accepted the specifications, and the contract for the design and construction of 130 cars was awarded to the lowest bidder, the St. Louis Car Division of General Steel Industries. The approved specifications contained the following requirement:

> "Where applicable the cars shall be built in accordance with the latest requirements of the 'Association of American Railroads Standard Specification for the Construction of New Passenger Equipment Cars,' latest issue of the 'United States Post Office Department Specifications for Passenger Car Construction,' and in all respects with the latest Interstate Commerce Commission 'Rules and Instructions for Inspection and Testing of Multiple Operated Electric Locomotive Units Designed to Carry Freight and/or Passenger Traffic,' including amendments to date."

UMTA approved the design and strength calculations submitted by St. Louis Car. St. Louis Car subjected one of the cars to an 800,000-pound compression test, as required by Federal regulations. The specifications required no further tests.

Acceptance tests were performed after the cars were delivered to ICG tracks. During this testing, one Highliner car, moving at 16 m.p.h., collided with a standing Highliner car. There was no telescoping, but the underframes of the cars were so damaged that it was more economical to build two new cars than to repair the damage.

State regulations. Illinois Commerce Commission General Order No. 196, effective August 10, 1970, states that:

> "In connection with the movement of their locomotives, cars and trains within the State of Illinois, railroads shall not be required to provide manual hand-flagging protection against following trains in automatic block-signal territory when (1) an appropriate operating rule, governing the use of radio (or other equally effective communicating media) has been adopted and in force requiring crews of trains making an unscheduled stop or an unusual slowdown in automatic block-signal and traffic-control territory to communicate with any following train entering or moving in the same block, directly or through the dispatcher or other qualified and responsible railroad employee, advising as to the presence of their train ahead, and (2) when communication with such following train, either directly or through the dispatcher or other qualified and responsible employee has been established.
>
> "When communication with such following trains is not established as aforesaid a crew member shall station himself at the rear of the stopped or slowing train, maintaining a vigilant lookout, and shall flag against any following train entering or moving within the same block.
>
> "This rule shall not apply within interlocking and yard limits.
>
> "IT IS FURTHER ORDERED that the railroads, parties hereto shall prepare and place in effect appropriate operating rules to comply with General Order 196, as revised and within 90 days from the date of this order shall file with the Commission a copy of said operating rules."

In compliance with this order, ICG issued Bulletin Order No. 88 on June 4, 1970. This bulletin order, however, was not reissued after it expired on December 31, 1970.

There were no Federal regulations applicable to operating procedures or rules at the time of the accident.

Federal equipment regulations. Federal requirements for the construction, inspection, maintenance, and operation of MU equipment are contained in 49 CFR 230. Sections 417, "Trucks", and 457, "Body structure", are particularly pertinent to this accident. Section 417 requires that:

> "(b) Trucks shall be locked to the unit body and so arranged that the entire truck will lift with the unit body without disengaging the center plates. The attachments shall be of adequate strength and properly maintained. Such protection shall be made on units presently in service and not so equipped when the unit receives general repairs but not later than 24 months after April 1, 1958."

The Interstate Commerce Commission relieved ICG from equipping its "old" cars in this manner on September 22, 1954.

Information regarding body structure appears in the sections of this report entitled "Train Equipment" and "Accident Losses", and Appendices E and G.

As of October 30, 1972, the FRA did not know whether the design and construction of Highliner cars complied with Federal regulations. The FRA had no enforcement program for compliance of new equipment and depended instead on the railroads to see that new equipment met the requirements.

ICG Operating Rules and Practices

Overruns. Overruns of station platforms were common in ICG suburban operations and became more frequent after the introduction of Highliner cars. An overrun buzzer in the cab of the Highliner cars allowed the engineer to inform the conductor of a station overrun. The overruns generally did not exceed one car length, and it was unusual for an entire train to pass a platform. No witness at the Safety Board's public hearing could recall a train ever having passed beyond the limits of a block in a station overrun.

Several procedures were used in response to overruns. Sometimes, the train continued on to the next station. On other occasions, passengers were asked to walk back through the train or the train was backed up to the platform. A special instruction in Timetable No. 69, October 25, 1964, required an engineer to walk the length of the train and change controls when he was backing up. This instruction, however, was deleted from subsequent timetables, and the choice of how to handle a station overrun was left to the traincrew.

Flagging. Although traincrews in ICG suburban operations once included a crewmember with a title "flagman," an agreement between the United Transportation Union and the ICG on June 11, 1970, provided simply that suburban trains would be manned by a conductor and one additional trainman.

In recent years, there has been minimal flagging in suburban territory, and the ICG crewmembers who testified at the public hearing were unable to recall any recent instances of flagging. Flagging appliances had not been carried regularly by crew personnel nor had the appliances been consistently furnished on train equipment. During the 2 years preceding the accident, no discipline had been taken against employees for failing to have proper flagging equipment.

At the Safety Board's public hearing, the interpretation of Rule 99(a) came into question. This rule first appeared in Bulletin Order No. 66, dated September 17, 1964. The order stated that:

> ". . .99 is modified as follows:
> "When trains or engines are operating in automatic block signal . . . territory, protection against following trains or engines on the same track is not required. This modification does not apply to rear end protection of passenger trains. Any other rule, train order or State Law requiring flag protection must be observed."

This order was reissued in a modified form on January 1, 1965, and was eventually replaced by Rule 99(a),2/ which states that:

> "Within interlocking, Automatic Block System or Centralized Traffic Control System limits, flag protection is not required against following movements on same track."

2/ Excerpts from the ICG's Rules and Regulations of the Operating Department pertinent to the accident are contained in Appendix C.

ICG Rule 515 states that:

> "A train or engine having passed beyond the limits of a block must not back into that block except under protection as prescribed by Rule 99."

Rule training. The training of ICG employees on the operating rules consisted of rule classes in which the individual employee's supervisor gave verbal instructions and verbal examinations. In 1970, when the six crewmembers of train 416 and 720 were last re-examined, written questions were used for the first time. The 65 questions to both engine and train personnel encompassed all types of ICG railroad operations. The test consisted mainly of multiple-choice and true-or-false questions. The crewmembers of trains 416 and 720 answered 82, 71, 66, 83, 71, and 65 percent of the questions correctly. ICG supervisors indicated that after the examination, each employee who made an incorrect answer had the correct answer explained to him. The crewmembers who testified at the public hearing, however, did not generally support this contention. All six crewmembers were requalified on the rules on the date of the written examination.

One true-or-false question on the test was particularly pertinent to this accident:

> "A train or engine having passed beyond the limits of a block must not re-enter that block unless a member of the crew is sent far enough in advance of the movement to provide flag protection."

The correct answer, with which all of the crewmembers of the 416 and 720 responded, was true. On the Chicago division of the ICG, 171 operating employees answered "true" and 18 "false."

The examination did not address procedures required when a train is operating under the authority of an approach signal.

Rule enforcement. Each operating supervisor on the Chicago Division was required to check for rule compliance by conducting a minimum number of efficiency tests each month. Thirty-four different types of tests could have been used. The tests performed in the first 10 months of 1972 and the percentage of compliance are shown in Appendix D.

Ten of the 11 violations noted involved speed limits. Train speed was checked through use of radar or by a comparison of mileposts versus elapsed time. Because the "old" cars were not equipped with speedometers, an allowance of 5 m.p.h. was permitted on maximum running speeds for these cars. This allowance did not apply for restricted speed.

During the Safety Board's investigation, the six crewmembers were asked for their interpretations of various operating rules. The official ICG interpretation was furnished by the Manager, Rules and Training. The ICG interpretations, however, were given after the accident, and there were no documented interpretations which predated the accident. Table 1 compares the crewmembers' interpretations with those supplied by the railroad after the accident.

TABLE 1

INTERPRETATION OF OPERATING RULES
OR CIRCUMSTANCES BY THE
CREWMEMBERS OF TRAINS 416 AND 720

Question	No. of Crewmembers Questioned	Responses* Consistent with ICG Interpretation	Responses* Inconsistent with ICG Interpretation
What is the authorized speed in the accident area?	3	2	1
What is required upon observance of a signal displaying a yellow aspect?	5	0	5
What is required upon observance of a signal displaying a red aspect?	4	2	2
What is required upon observance of a signal with a number plate displaying a red aspect?	4	1	3
Where must one trainman be located during a back-up movement in suburban territory?	4	2	2
What is required when a train backs into a block that already has been passed?	6	4	2
What does running against the current of traffic consist of?	3	0	3
Totals	29	11	18

* Response used for tabulation was the one first offered as a reply to the question without prompting by the interviewer.

III. ANALYSIS

Operation of Train 720

An expert witness calculated that the deformation of metal in the two demolished cars absorbed about 40 million foot-pounds of energy. This same witness concluded that the speed of train 720 at impact must have been between 44 and 50 m.p.h. This estimate is corroborated by a comparison of the movements of trains 720 and 718 before impact.

Train 720 was running abreast of an inexact location on 718; it never passed ahead of the third car on 718. Train 718 was traveling at a constant speed, estimated to be 60 to 65 m.p.h. The engineer of 720 estimated his speed at the signal as about 40 m.p.h., and he stated that he then reduced his speed even further.

If these estimates are accurate, the 20-m.p.h. average speed differential between the trains from the signal to the point of impact would have permitted all of train 718 to pass 720. This would also hold true for a 10-m.p.h. differential, i.e., with 720 traveling at 50 m.p.h. However, the evidence clearly indicates that at least the last car of 718 had not passed 720 when the collision occurred. Thus, the average speed differential between the trains for the 2,175 feet south of the impact point was slightly less than 10 m.p.h., and train 720 was probably traveling at an average speed of between 50 and 55 m.p.h.

Train 416 must have been backing past Signal 3-3.10 at about the same time as 720 passed Signal 3-3.60. Although 416 was not visible to the engineer of 720 at that point, the sight-distance tests indicated that the engineer should have seen 416 a considerable distance before the braking limits of 720 were overrun. For example, if one assumes closing speeds of 11 m.p.h. for train 416 and 52 m.p.h. for train 720, 416 should have been visible when it was at least 369 feet from the point of impact, and when 720 was 1,760 feet from impact. The emergency braking distance for a train similar to 720, traveling at 52 m.p.h., is less than 1,200 feet.

Therefore, if the emergency brakes on train 720 had been applied at the time 416 first should have been discernible to the engineer of 720, the train should have stopped before the point of impact. Furthermore, if 720 had been running, as required, at 30 m.p.h., prepared to stop short of Signal 3-3.10, an emergency brake application at the time the engineer stated he first saw 416 would have stopped 720 in sufficient time.

The large difference between the 30-m.p.h. speed required by the operating rules and the 50 to 55-m.p.h. speed indicated by the evidence suggests that the presence of a speedometer on 720 perhaps would have reduced the overspeed but probably would not have prevented the collision. However, if the rear of train 416 or the red aspect of Signal 3-3.10 had been visible to the engineer as he passed Signal 3-3.60, the possibility of his taking effective preventive action would have been increased. Passengers on 718 stated that he appeared to be alert and looking ahead at that time.

Operation of Train 416

The only known equipment deficiency which could have contributed to the overrun of the station platform was the speedometer on 416, which registered a maximum of 63 m.p.h. If the train was going faster than 63 m.p.h., and the engineer applied the brakes at the normal spot for a station stop from 63 m.p.h., the train probably would have overrun the platform. Even a 10-m.p.h. overspeed, however would not have resulted in an overrun of the entire train of the distance that 416 experienced.

Since October 30 was the first day the engineer was assigned to train 416 and since 27th Street was a flag stop, it is probable that the engineer forgot about the conductor's instructions to stop until it was too late to prevent a station overrun.

Once the overrun occurred, Rules 106 and 886 made the conductor responsible for assuring that the reverse movement was accomplished safely. Furthermore, since the train stopped north of Signal 3-3.10, Rule 515 required that the reverse movement be protected by flagging. The conductor failed to comply with these rules.

The engineer should have known that the rear of his train had passed beyond the limits of the block of 3-3.10 and that flag protection would be required to return to the platform. He also should have known the conductor was in a center vestibule from the conductor's use of the intercom. The engineer did not question whether the train had passed beyond Signal 3-3.10 or whether a flagman had been sent out. At no time did he sound the whistle for a flagman. Therefore, the engineer did not take the precautions prescribed by Rules 106 and 1022.

Although Rule 106(a) required that the collector "must take immediate action to stop the train," it is doubtful whether the collector knew that an emergency existed. His location inside cars at the center of the train provided no direct view of the signals.

Rule Interpretation

Table 1 indicates that the crewmembers of trains 416 and 720 had a problem in interpreting Rules 285, 291, and 292, which concern the meaning of several aspects displayed by the automatic-block signal system. When questioned about what is required by a yellow aspect, five crewmembers, including the engineer of 720, responded with maximum train speeds. Although the speeds given varied, each crewmember failed to recognize that a signal showing a yellow aspect requires that a train be prepared to stop at the next signal.

Two of the four crewmembers questioned about the meaning of a red aspect displayed by a signal with a number plate also answered with maximum speeds. Such a signal aspect, however, also requires that a train be prepared to stop short of train, obstruction, etc.

There were two incorrect responses to the question regarding the meaning of a red aspect displayed by a signal without a number plate. The crewmembers who answered incorrectly combined the meaning of a stop indication, i.e., a red aspect displayed by a signal without a number plate, with the restricted proceed indication.

The meaning of Rules 285, 291, and 292 is explicit. There should be no need for more detailed interpretation. The incorrect interpretations by the crewmembers suggest that (1) the rule training, examination, and enforcement activities of the ICG were inadequate and (2) a rule that contains dual requirements or requirements similar to those contained in other rules can result in incomplete understanding.

This accident, however, also involved rules whose meaning or whose applications were unclear. Although they did not dispute the meaning of Rule 515, employee representatives at the Safety Board's public hearing argued that Rule 99(a) was an integral part of Rule 99 and that, therefore, Rule 99(a) relieved the crewmembers of 416 of the responsibility of flagging. However, this interpretation was contrary to the understanding demonstrated by the crewmembers in the 1970 examinations, when they were questioned about Rule 515 without reference to Rule 99(a).

Representatives of the railroad, on the other hand, maintained that Rules 99 and 99(a) were separate rules. They stated that the reference to Rule 99 in Rule 515 applied only to flagging. They further argued that 99(a) was not even involved, since when train 416 reversed direction, the "following movement" became an opposing movement. The ICG representatives, however, also argued that Rule D-99 did not apply, saying that 416 was not running against the current of traffic even though it was an opposing movement.

The railroad must stand as final authority in rule interpretation when the interpretation is given before an accident occurs. The different interpretations of these rules after the accident and misconceptions in rule examinations suggest the need for one authoritative interpretation for each situation, issued when a rule is initially written and then used for training and enforcement. Such an official interpretation, of course, is not as useful as a clearly written rule understandable in all situations without interpretation. An interpretation given only after an accident can be considered authoritative for later operations but is not authoritative at the time of the accident.

Management Practices

On September 8, 1970, an Illinois Central (IC) train collided with an Indiana Harbor Belt train on IC track at Riverdale, Ill. 3/ The accident occurred as the IC train was backing under the authority of a restricted proceed signal in automatic-block signal territory. Rules 99, D-99, 106, 106(a), and 291 were involved in the collision, and the Safety Board determined that inadequacies in operating rules, practices, and personnel training contributed. That these same factors contributed to the accident at 27th Street suggests that the railroad managment had not eliminated the inadequacies in the intervening 2 years. 4/

Employees who are advanced to positions of responsibility have the right to believe that their performances meet company standards. Train and engine crewmembers working on the Chicago Division failed to comply with Rules 7, 35, 896, and 1003 with full knowledge of their supervisors. This failure by management to discipline or reprimand employees for not carrying flagging equipment led to the degradation of the rules. Management's laxity in failing to provide flagging equipment on suburban trains further indicated to employees that the importance of flagging had diminished.

Station overruns and short backing movements had been accepted in the past by railroad management. This acceptance by ICG supervisors of questionable operating practices and the degradation of flagging rules may have contributed to the failure of the crew of train 416 to protect their train by flagging as it backed at the 27th Street station. Furthermore, the lack of rule understanding and enforcement disclosed during the Board's investigation is not consistent with the 99.54-percent efficiency in rule compliance claimed by ICG for Chicago Division employees.

3/ National Transportation Safety Board, Illinois Central Railroad Company and Indiana Harbor Belt Railroad Company, Collision Between Yard Trains at Riverdale, Illinois, on September 8, 1970, NTSB-RAR-71-3.

4/ In that same accident report, the Safety Board recommended that the FRA, in establishing operating rules, ensure that the rules are objective, understandable, and enforceable before an accident occurs as well as after the fact.

The ICG did not comply with Illinois Commerce Commission Order No. 196, since no operating rule or bulletin order was in force requiring implementation. Compliance with the intent of the order might have prevented this accident, although the order, as written, contains some of the same weaknesses as the ICG operating rules. For instance, it is questionable whether the station overrun at 27th Street would have been interpreted as an "unscheduled stop" or an "unusual slowdown." However, immediate radio communication between the two trains would have been an effective accident deterrent.

Systems Failure

In order for this accident to have occurred, a number of things, involving crewmembers, management, operating rules, train equipment, and environmental factors, had to go wrong. Since these factors are interrelated, the accident indicates a system breakdown.

For example, as train 416 was backing toward the station platform, the conductor had to stand in the center vestibule of the rear car in order to operate the intercom. Although Rule 915 does not state where on the rear car a trainman should be located during a back-up movement, it seems obvious that he should have a view to the rear.

Even if the conductor could have seen to the rear of the train from the center vestibule, the location of the various controls would have interfered to some degree with his carrying out his function. The conductor's door control and intercom were located across the vestibule from the emergency brake valve. If people were standing in the aisle, the conductor would have some difficulty in stopping the train.

Because the ends of the Highliner cars were painted black, they were difficult to distinguish from the station platform and other appurtenances at 27th Street under the overcast sky on the morning of the accident. The end marker lights on train 416 were very small. If train safety depends on the ability of an engineer or conductor to "stop short of train," then the markings of the car ends were incompatible with safety.

Although there is no prescribed sight distance for a train approaching a signal, the visibility of Signal 3-3.10 was a factor in this accident. Because the authority conveyed by a signal is not applicable until the signal is passed, the signal theoretically does not need to be visible until a train is directly upon it. However, since a signal is supposed to convey information to employees operating trains, a man-made obstruction such as the walkway at 27th Street is inconsistent with the purpose of the signal.

The engineer of train 720 did not comply with the yellow aspect displayed by Signal 3-3.60. The message conveyed by the aspect was "Caution! Train ahead." The engineer, however, was not particularly concerned that there was a train ahead--it was ahead every day.

The signal system was working as intended but did not prevent the accident. Traffic scheduled through the accident area during rush hours resulted in very close headways. Trains were commonly operated under the authority of red and yellow aspects. This system was safe as long as the rules were obeyed; there was no margin for disrespect. There are signal systems available (e.g., cab signals, automatic train control, automatic train stop) that place less reliance on rule enforcement to ensure safety.

The reverse movement of trains into previously vacated signal blocks was incompatible with the scheduled 2 to 3 minute headways of ICG commuter operation and the time required to implement flag protection. The more logical procedure after a train overruns a station more than a train length or overruns a signal was to continue on to the next station. The Safety Board's Recommendation No. 2 included as part of Appendix F proposed that ICG commuter trains be restricted from reentering a signal block unless protected by train order.

Federal Railroad Administration regulations cover the methods of installing signal systems. However, regulations specifying the type of signal systems to use for particular circumstances are minimal. These requirements seem as important as installation and maintenance requirements. The objectives of a signal system must be defined if safety is to be achieved through regulation.

Crash Factors

Each of the "old" cars and Highliners had a heavy underframe upon which a lighter superstructure was built. The underframes, designed to withstand coupling shocks, carried couplers at either end. The design of the couplers was so specified that, when joined, the couplers and the end design would prevent override in a collision.

When the two trains collided, the couplers on both trains functioned as intended, and there was no overriding of one car by another within either train. However, the coupler on the head of train 720 was displaced downward, which broke the coupler carrier. This destroyed any anti-climbing capability which might have existed between the two dissimilar cars. When the coupler ends came together, the direction of least resistance was upward. The wheel flanges and truck centerpin resisted movement sideways. The normal weight-bearing strength of the truck resisted downward movement. Only the weight of the front end of the car body resisted upward movement, because the front truck was not secured to the car body. This upward movement appears to have been the critical factor which placed most of the fatalities and serious injuries in the Highliner car.

The momentum of the collision permitted the underframe of the older car to carry away the collision posts of the Highliner car. The sidewall and roof of the Highliner were lighter than the collision posts; the underframe of the "old" car demolished the superstructure of the Highliner and penetrated almost to the midpoint of the Highliner.

The unattached trucks of the old car absorbed practically none of the energy of 720. Since there was no electrical equipment suspended under the lead car of 720, the major energy attenuation occurred in the demolition of the rear car of 416 and the front part of 720. If the front trucks of 720 had been attached to the underframe, they would have resisted the telescoping and would have dissipated some of the energy. Therefore, the intrusion into the Highliner would have been less severe, and fewer passengers in that car would have been affected.

This deep penetration of one car by another can also occur in cars of identical strength and design. In an accident which occurred at Darien, Connecticut, on August 20, 1969, 5/ two commuter cars, each with a steel and stainless steel superstructure, collided head-on. The trains were both moving at approximately 30 m.p.h. In the collision, one car overrode the frame of the other and a deep penetration occurred, which destroyed almost one-half of the passenger space, as well as both the sidewalls, the roof, and the seats of the penetrated car.

There is little doubt that anti-climbing arrangements could be designed which would prevent penetration of one car by another. If overriding and penetration were prevented, however, any impact would be transmitted through the frames of all the cars in a train which has been struck, and this could result in much higher crash accelerations and in other unpredictable events. The collision of two Highliners at 16 m.p.h. without overriding resulted in generalized distortion of the car body and underframe but no gross injury-causing damage. This is efficient from an injury-prevention point of view but requires the costly replacement of the entire structure. Thus, although it may be possible to equip some existing commuter cars and rapid-transit cars with effective anti-climbing arrangements, the Safety Board believes that such changes should not be made without full-scale crash testing. Such testing could easily result in major changes in car design.

In general, the Safety board believes that the problem of specifying collision resistance for lightweight transit cars can be solved only through a substantial research and development program. Major gains in practical crash resistance probably cannot be achieved through small-scale changes in car design.

5/ National Transportation Safety Board, Penn Central Company, Collision of Trains N-48 and N-49 at Darien, Connecticut, August 20, 1969, NTSB RAR-70-3.

In its Darien, Connecticut, report, the Safety Board repeated an earlier recommendation that the Federal Railroad Administration

> ". . .initiate studies to determine the relationship between rail passenger car design and passenger injury and, where practical, take action for correction in the design of future high-speed and rapid transit passenger cars."

Because of budget limitations, crashworthiness was not one of the areas of safety research performed by the FRA.

Safety Board observation of two Bay Area Rapid Transit (BART) cars which collided revealed a design concept which should be investigated. The underframe and coupler of the BART cars are designed to absorb impact energy between cars without resulting in serious damage to passenger compartments.

Without comprehensive crash testing, the impact froces which can be withstood by an MU car which meet Federal requirements cannot be determined. However, considering calculated collision forces, the Safety Board believes that collision posts designed to withstand specified shear forces without any consideration given to the bending and torsion which collisions impose on the posts are inadequate.

A well conceived research and development project could develop all requirements. Collision posts may or may not be a necessary structural member in a properly designed, crashworthy commuter car.

IV. CONCLUSIONS

1. The overrun of the 27th Street station platform by train 416 was caused by the failure of the engineer to initiate a brake application soon enough to stop the train at the platform from the speed at which the train was running.

2. Train 416 passed beyond the limits of the block of Signal 3-3.60 and stopped 400 feet beyond Signal 3-3.10.

3. Neither the engineer nor the conductor established whether train 416 had passed completely beyond the block of Signal 3-3.60 before they began to back up the train.

4. The conductor of train 416 failed to provide the flag protection prescribed by Rule 515.

5. The engineer of train 416 did not require that flagging be provided and thus did not fulfill the responsibilities assigned to him by Rules 106 and 1022.

6. The collector of train 416 was available to perform flagging duties, but did not do so nor was he so instructed by the conductor or engineer.

7. The conductor of train 416 located himself in the center vestibule of the rear car to direct the backup movement, a position necessary for communication with the engineer. From this position, he was unable to see train 720 until too late because of the curve of the track.

8. Signal 3-3.60 displayed a yellow aspect as train 720 approached it. The yellow aspect required that 720 reduce speed to 30 m.p.h. after passing the signal and approach Signal 3-3.10 prepared to stop.

9. The rear of train 416 was camouflaged from the view of the engineer of train 720. The back end of the Highliner blended with the background, and the marker lights were not distinctive enough to be discerned by the engineer of 720.

10. The speed of train 720 as it approached 27th Street exceeded the required 30 m.p.h. by at least 20 m.p.h., a speed difference large enough to be detected as in excess of 30 m.p.h. without a speedometer.

11. If train 720 had been traveling at 30 m.p.h., it could have stopped short of impact if emergency braking had been initiated when the engineer first sighted train 416.

12. If the engineer of train 720 had made an emergency brake application when train 416 first was clearly visible, the train could have stopped short of the impact point.

13. The crewmembers' interpretations of the various signal aspects were not consistent with the interpretations of ICG representatives.

14. Based upon the actions and knowledge displayed by the crewmembers of trains 416 and 720, the rule training, examination, and enforcement activities of the ICG were inadequate to insure rule compliance.

15. A rule that imparts dual responsibilities to an employee invites partial employee understanding. The crewmembers of trains 416 and 720 understood the need for medium speed under authority of an approach signal, but did not realize that the train must be prepared to stop at the next signal.

16. Although in the 1970 written examinations, the crewmembers interpreted Rule 515 to require that a crewmember be sent far enough in advance of the movement to provide flag protection, evidence indicated confusion on the part of some employees regarding the relationship between Rule 515 and Rules 99, 99(a), and D-99 as well. It was not clear whether Rule 515 referred to Rule 99 only or to 99(a) and D-99 as well.

17. Rules 7, 35, 896, and 1003, which require that proper flagging equipment be carried on trains, were not consistently enforced by management. This implied that flagging was not important in suburban service.

18. The absence of a crewmember with the title "flagman" was not pertinent to the accident.

19. The ICG did not comply with Illinois Commerce Commission General Order No. 196. It could not be determined whether this contributed to the accident.

20. The design of the cars, which located the conductor's controls in the center vestibule of the Highliner car, was incompatible with the operating requirements that he govern the reverse movement and see that the track was clear.

21. The walkway at 27th Street obstructed an approaching train's view of Signal 3-3.10 and diminished the effect of that signal.

22. The automatic-block signal system did not adequately transmit sufficient information to identify fully the hazard to the engineer of train 720.

23. The designs of the anti-climbing arrangements of the two trains prevented overriding between cars within the trains but did not prevent overriding between the two dissimilar cars which collided.

24. Federal regulations did not require a design which would prevent overriding of colliding trains.

25. The unsecured trucks of the first car of train 720 permitted the car to override the underframe of the Highliner car, which resulted in more penetration than would have occurred if the trucks had been secured.

26. The Interstate Commerce Commission allowed the trucks of the "old" cars to remain unsecured in an order dated September 22, 1954.

27. The collision posts of the Highliner car, even if constructed according to design, were not adequate to withstand the forces in the collision.

28. Because of the improper welds, the collision posts of the Highliner car did not meet the shear requirements of the Federal regulations.

29. It is probably technically feasible to design commuter cars to withstand crashes at moderate speeds without fatal injuries to the passengers.

30. Although the Highliner cars were financed with Federal assistance, the design of the cars was not subjected to a review for compliance with Federal regulations by FRA or to a safety review by UMTA.

31. FRA had no program to insure that design of new equipment complied with Federal regulations before the equipment was put in service. Instead, the FRA relied upon voluntary compliance.

IV. PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was the reverse movement of train 416 without flag protection into a previously vacated signal block and the failure of the engineer of train 720, while operating faster than the prescribed speed, to perceive the train ahead in time to avoid the collision. Ambiguous rules which caused confusion among employees regarding the necessity to flag within automatic-block signal system limits and the reduced importance of flagging in suburban service implied by the management's failure to enforce Rules 7, 35, 99, 896, and 1003 also contributed to the accident.

Contributing to the high incidence of fatality was the overriding of the underframe of the Highliner car by the older car, which allowed the older car to telescope the Highliner car.

VI. RECOMMENDATIONS

The National Transportation Safety Board has previously issued interim recommendations concerning this accident to the Illinois Central Gulf Railroad, the Federal Railroad Administration, the Chicago South Suburban Mass Transit District, and the Urban Mass Transportation Administration. (See Appendices F, G, and H, respectively.)

The National Transportation Safety Board recommends that:

1. The Illinois Central Gulf Railroad ensure that its employees understand and comply with its operating rules. In order to do this, the ICG should improve its training program by developing:

   (a) Books of standard interpretations of its rules in situations met both routinely and only occasionally to provide a basis for better use of the rule book in instruction; and

   (b) A system of regularly testing the ability of employees to interpret actions required in specific operating situations. (Recommendation No. R-73-28)

2. The Illinois Central Gulf Railroad review its organization systematically to ensure that safety is covered adequately in all interactions of equipment, personnel, rules, and procedures. For example, the Highliner design does not allow the conductor to use the intercom and emergency brake valve from the rear of the car, which is the logical location for supervising a reverse movement. (Recommendation No. R-73-29)

3. The Federal Railroad Administration and the Urban Mass Transportation Administration cooperate in sponsoring an independent study to justify or disprove the need for a requirement that high-speed commuter train operations be governed by some form of automatic train-control system or some special procedures that will prevent a collision of two trains. (Recommendation No. R-73-30)

4. The Federal Railroad Administration and the Urban Mass Transportation Administration initiate research to develop the technical approaches to crashworthiness in light-weight passenger cars for use in commuter or rail rapid-transit operations. These approaches should include crash testing as part of the design and development function for new equipment. (Recommendation No. R-73-31)

5. The Federal Railroad Administration revise 49 CFR 230, (D) to the extent that data are now available to provide better protection for passengers in collisions. Further, the FRA should enforce regulations on new cars before they are put into revenue service. (Recommendation No. R-73-32)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

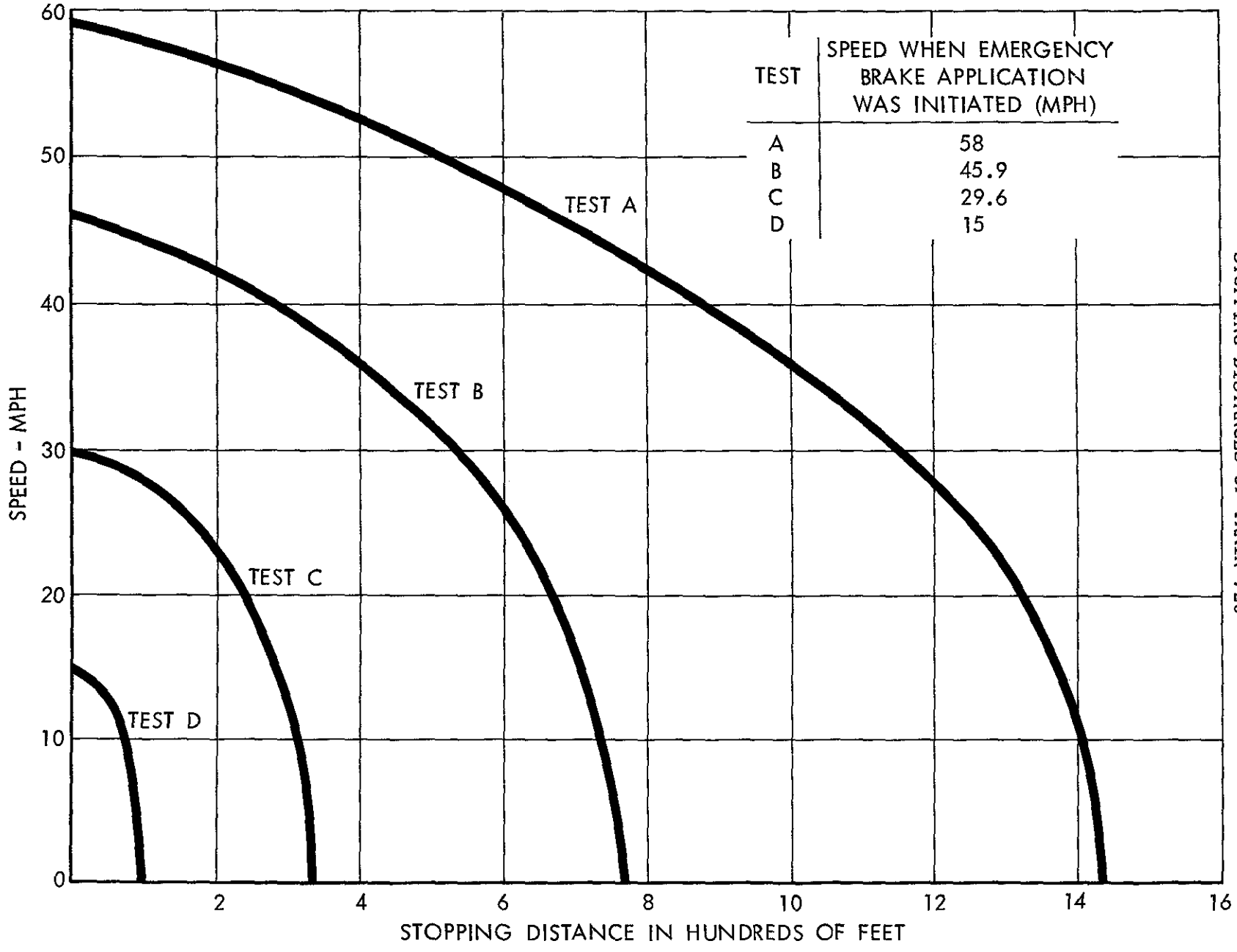
June 28, 1973

APPENDIX A

EXCERPT FROM ICG CHICAGO DIVISION, ELECTRIC TRAIN TIME TABLE NO. 5

RICHTON, SOUTH CHICAGO AND BLUE ISLAND DISTRICTS—Northward

Mileage Chart Northward	TIME TABLE No. 5 Taking Effect December 29, 1967	Distance between Stations	FIRST CLASS 710 Special Richton	714 Special Kensington	716 Express Blue Island	718 Special Richton	9200 C S S &S.B. No 200	416 Express South Chicago	1418 Express Blue Island	2418 Express South Chicago	418 Express Richton Blue Island So Chgo	720 Special South Chicago	1722 Special Blue Island
	STATIONS		Ex Sa & Su	Ex Sa & Su	Sat Only	Ex Sa & Su	Ex Sa & Su	Ex Sun	Sun Only	Sun Only	Sun Only	Ex Sa & Su	Sat Only
29 33	RANDOLPH STREET		A 7 30 AM	A 7 32 AM	A 7 35 AM	A 7 38 AM	A 7 40 AM	A 7 40 AM			A 7 40 AM	A 7 43 AM	
28 53	VAN BUREN STREET	80	*S* 7 28	*S* 7 30	*S* 7 33	*S* 7 36	*S* 7 38	*S* 7 38			*S* 7 38	*S* 7 41	
27 90	ROOSEVELT ROAD	63	*S* 7 25	*S* 7 28	*S* 7 30	*S* 7 33	*S* 7 36	*S* 7 36			*S* 7 36	*S* 7 38	
27 11	18 STREET	79						*S* 7 34			*F* 7 35		
26 65	23 STREET	46		*S* 7 25	*S* 7 27			*S* 7 32			*S* 7 34		
26 13	27 STREET	52						*F* 7 31			*F* 7 32		
23 43	47 STREET	2 70											
22 79	53 STREET	64	*S* 7 16	*S* 7 21	*S* 7 23	*S* 7 27		*S* 7 27			*S* 7 28		
22 34	57 STREET	45			*S* 7 22		*S* 7 28	*S* 7 25			*S* 7 26		
21 90	59 STREET	44						*S* 7 23			*S* 7 25		
21 41	63 STREET	49		*S* 7 19	*S* 7 21	*S* 7 25	*S* 7 26	*S* 7 22		A 7 24 AM	*S* 7 24		
21 00	67 STREET	41	7 14	*S* 7 17	7 19	7 24	7 25	7 20		*F* 7 23	*F* 7 23	7 29	
20 01	GRAND CROSSING	99		*S* 7 15	*S* 7 17						*F* 7 21		
19 34	CHATHAM	67		*S* 7 13	*S* 7 15						*S* 7 19		
18 95	AVALON PARK	39		*S* 7 11	*S* 7 13						*S* 7 18		
18 47	WOODRUFF	48		*S* 7 10	*S* 7 12						*S* 7 16		
17 96	CHESTERFIELD	51		*S* 7 08	*S* 7 10						*S* 7 15		
17 29	BURNSIDE	67		*S* 7 07	*S* 7 09						*S* 7 14		
16 27	103 STREET	1 02		*S* 7 05	*S* 7 07						*S* 7 12		
15 79	107 STREET	48		*S* 7 03	*S* 7 05						*S* 7 10		
15 38	PULLMAN	41		*S* 7 01	*S* 7 04						*S* 7 09		
14 84	KENSINGTON	54	7 06	L 7 00 AM	*S* 7 03	*S* 7 17	L 7 17 AM		A 7 05 AM		*S* 7 08		A 7 22 AM
12 00	RIVERDALE	2 84				*S* 7 12					*S* 7 03		
11 15	IVANHOE	85	*S* 7 02			*S* 7 10					*S* 7 01		
10 35	147 STREET	80				*S* 7 08					*S* 6 59		
9 33	HARVEY	1 02	*S* 6 59			*S* 7 06					*S* 6 57		
7 06	HAZEL CREST	2 27				*S* 7 02					*S* 6 53		
6 51	CALUMET	55				*S* 7 00					*S* 6 52		
5 82	HOMEWOOD	69	*S* 6 55			*S* 6 59					*S* 6 51		
4 40	FLOSSMOOR	1 42	*S* 6 52			*S* 6 56					*S* 6 48		
2 77	OLYMPIA FIELDS	1 63	*S* 6 49								*S* 6 46		
1 71	211 STREET	1 06	*S* 6 46								*S* 6 44		
1 09	MATTESON	62	*S* 6 44								*S* 6 42		
	RICHTON	1 09	L 6 42 AM			L 6 50 AM					L 6 40 AM		
3 94	STONY ISLAND AVE	77						*S* 7 19		*S* 7 21		*S* 7 28	
3 38	BRYN MAWR	56						*S* 7 17		*S* 7 19		*S* 7 26	
2 76	SOUTH SHORE	62						*S* 7 15		*S* 7 17		*S* 7 24	
2 16	WINDSOR PARK	60						*S* 7 13		*S* 7 15		*S* 7 22	
1 55	CHELTENHAM	61						*S* 7 11		*S* 7 13		*S* 7 20	
1 07	83 STREET	48						*S* 7 09		*S* 7 12		*S* 7 18	
53	87 STREET	54						*S* 7 07		*S* 7 10		*S* 7 16	
00	SOUTH CHICAGO	53						L 7 06 AM		L 7 09 AM		L 7 15 AM	
3 31	STATE STREET	1 11			*S* 7 00				*S* 7 02				*S* 7 19
2 85	STEWART RIDGE	46			*S* 6 58				*S* 7 00				*S* 7 17
2 23	WEST PULLMAN	62			*S* 6 56				*S* 6 58				*S* **7 15**
1 87	RACINE AVENUE	36			*S* 6 54				*F* 6 56				*S* 7 13
1 04	ASHLAND AVENUE	83			*S* 6 52				*F* 6 55				*S* 7 12
55	BURR OAK	49			*S* 6 51				*S* 6 54				*S* 7 10
	BLUE ISLAND	55			L 6 50 AM				L 6 53 AM				L 7 09 AM



APPENDIX B

STOPPING DISTANCES OF TRAIN 720

APPENDIX C

EXCERPTS FROM "RULES AND REGULATIONS OF THE OPERATING DEPARTMENT"

GENERAL RULES.

* * * *

A(1). Where, in rules, special instructions or train order, the terms conductors, engineers or enginemen appear, they will, when applicable, also apply as follows:

CONDUCTORS: To conductors, collectors, yard engine foremen, brakemen, flagmen, baggagemen, switchmen, and switchtenders.
ENGINEERS: To engineers and hostlers.
ENGINEMEN: To engineers, hostlers, firemen and hostle helpers.

The word "flagman" in rules, special instructions or bulletins refers to any employe of whatever designation to whom the word "flagman" is applicable under rules governing flag protection.

* * * *

DEFINITIONS

* * * *

SPEEDS

* * * *

MEDIUM SPEED. - A speed not exceeding 30 MPH.

* * * *

RESTRICTED SPEED. - Proceed prepared to stop short of train, obstruction, or switch not properly lined and look out for broken rail, but not exceeding 10 MPH. 1/

* * * *

1/ Speed changed to . . ."not exceeding 15 MPH." under authority of Superintendent's Bulletin Order No. 60 dated January 4, 1972.

TRACKS

CURRENT of TRAFFIC. - The movement of trains on a main track, in one direction, as specified by the rules or in special instructions.

* * * *

OPERATING RULES

* * * *

SIGNALS

7. Employes whose duties may require them to give signals must provide themselves with the proper appliances, keep them in good order and ready for immediate use.

* * * *

35. The following signals will be used by the flagmen:

Day Signals	A red flag, Torpedoes and Fusees.
Night Signals	Torpedoes and Fusees.

* * * *

84. A train must not start until the proper signal is given.

* * * *

99. When a train is moving under circumstances in which it may be overtaken by another train, the flagman must take such action as may be necessary to insure full protection. By night, or by day when the view is obscured, burning fusees must be thrown off at proper intervals.

APPENDIX C

When a train stops under circumstances in which it may be overtaken by another train, the flagman must go back immediately with flagman's signals a sufficient distance to insure full protection, placing two torpedoes, and when necessary, in addition, displaying burning fusees. When recalled, or relieved by another flagman, and safety to the train will permit, he may return.

When the conditions require, he will leave the torpedoes and a burning fusee.

The front of the train must be protected in the same way when necessary by the forward trainmen or fireman.

When day signals cannot be plainly seen, owing to weather or other conditions, night signals must also be used. Conductors and engineers are responsible for the protection of their trains.

99(a). Within Interlocking, Automatic Block System or Centralized Traffic Control System limits, flag protection is not required against following movements on same track.

* * * *

D-99. A train running against the current of traffic must protect itself as required by Rule 99.

* * * *

106. Both the conductor and the engineer are responsible for the safety of the train and the observance of the rules and, under conditions not provided for by the rules, must take every precaution for protection, but this does not relieve other employes of their responsibility under the rules.

106(a). When safety of trains and observances of rules are involved, all other crew members are responsible to the extent of their ability to prevent accident or violation of the rules.

When the conductor or engineer fails to take action to stop the train, and an emergency requires, other crew members must take immediate action to stop the train.

106(b). Conductors and engineers must see that their subordinates are familiar with their duties, ascertain the full extent of their experience and knowledge of the rules, and instruct them, when necessary, in safe and proper performance of their duties. Incompetence must be reported.

106(c). When the conductor is not present, brakeman on engine must promptly obey instructions of the engineer relating to the safety and protection of the train, and must immediately call attention of the engineer to any apparent failure to observe train orders, or to comply with any rules or instructions.

107. Trains or engines must run at REDUCED SPEED when passing a passenger train receiving or discharging traffic at a station, except where proper safeguards are provided. They must not pass between it and the platform at which traffic is being received or discharged, unless the movement is properly protected.

* * * *

RULES GOVERNING THE MOVEMENT OF TRAINS IN THE SAME DIRECTION BY BLOCKING SIGNALS.

251. On portions of the railroad, and on designated tracks so specified in the timetable, trains will run with reference to other trains in the same direction by block signals whose indications will supersede the superiority of trains.

* * * *

RULES GOVERNING MOVEMENT OF TRAINS BY BLOCK AND INTERLOCKING SIGNALS

* * * *

RULE 285

(Illustration depicts a signal showing a yellow aspect.)

INDICATION - PROCEED: PREPARING TO STOP AT NEXT SIGNAL. TRAIN EXCEEDING MEDIUM SPEED MUST AT ONCE REDUCE TO THAT SPEED.

NAME - APPROACH

* * * *

RULE 291

(Illustration depicts a signal with a number plate showing a red aspect.)

INDICATION - PROCEED AT RESTRICTED SPEED.
NAME - RESTRICTED PROCEED.

* * * *

RULE 292

(Illustration depicts a signal without a number plate showing a red aspect.)

INDICATION - STOP
NAME - ABSOLUTE STOP

* * * *

AUTOMATIC BLOCK SYSTEM RULES

* * * *

515. A train or engine having passed beyond the limits of a block must not back into that block except under protection as prescribed by Rule 99.

* * * *

CONDUCTORS

* * * *

886. The general direction and government of a train is vested in the conductor and all other persons employed thereon must obey his instructions, except when such instructions imperil the safety of train or persons, or involve violation of rules. Any misconduct or neglect of duty of employes on the train must be promptly reported.

They must not permit an employe to work on their train if his condition renders him unfit to do so.

Should there be any doubt as to authority or safety of proceeding, from any cause, he must consult with the engineer and be equally responsible with him for the safety and proper handling of the train and for such use of signals and other precautions as the case may require. He must be vigilant and cautious, not trusting alone to signals or rules for safety.

* * * *

896. Before leaving initial station, they must see that their trains are provided with proper tools and sufficient supplies of all kinds and know the cars in their train have been inspected.

* * * *

PASSENGER SERVICE

* * * *

APPENDIX C

915. When passenger trains are to be backed, conductors must station themselves on rear car, test the brakes by applying them by use of a back-up valve or back-up hose, ride the car and personally supervise the movement. The air whistle signal must be sounded at frequent intervals. When back-up move is to be a short distance due to over-running station platform or fuel and water facilities, trainman may function for conductor.

* * * *

PASSENGER FLAGMEN

* * * *

921. They must have the required flagging equipment, at proper location for immediate use, before starting each trip.

* * * *

ENGINEERS

* * * *

1001. They are under the direction of the conductor of the train with respect to its operation and must comply with his instructions, except when such instructions imperil the safety of train or themselves or involve violation of rules.

* * * *

1003. They must, unless otherwise provided, know that engine is furnished with necessary signals, tools, fuel, sand and other supplies.

They must also see the flagging equipment, in condition for immediate use, is on the engine.

* * * *

1020. If a train makes an improper station stop, it must not be moved until the conductor gives the proper signal to do so. If, after making stop, should it be necessary to move the engine, it must not be done while passengers are leaving or entering the train.

* * * *

1022. Engineer must be alert in all matters pertaining to safety and when it becomes evident that rear of train requires protection, immediately sound whistle signal for flagman and, if necessary, repeat the signal until protection is assured.

APPENDIX D

RESULTS OF EFFICIENCY TESTS
ILLINOIS CENTRAL GULF RAILROAD

Division Chicago Month Jan. thru Oct. 1972

Kind of Test	No. of Tests Conducted	Number Properly Observed	Number Improperly Observed	Per Cent of Efficiency
1. Hand stop signal given with red flag, burning fusee, lantern or other object	156	156	-	100.0
2. Burning fusee (unattended)	39	39	-	"
3. Torpedoes	5	5	-	"
4. Automatic block signal indicating Stop	51	51	-	"
5. CTC signal indicating Stop	3	3	-	"
6. Black signal indicating Proceed at Restricted Speed	338	338	-	"
7. Interlocking signal indicating Stop	219	219	-	"
8. Gate at railroad crossing against route to be used	5	5	-	"
9. Yard limit				
10. Trains standing on siding, at end of multiple track, or at junction, with headlight burning				
11. Markers displaying red to rear of train on siding				
12. Train order signal indicating Stop				
13. Protection of train				
14. Cab signal indicating Proceed at Restricted speed				
15. Approach signal	127	127	-	100.0
16. Signal governing facing movement over a spring switch indicating Stop	49	49	-	"
* * * * *				
17. Yellow rectangular sign				
18. Speed of trains	634	624	10	98.42
19. Whistle and bell signals at road crossings	184	184	-	100.0
20. Stop for railroad crossings, junctions and end of multiple track (where required)	36	36	-	"
21. Check of engine left unattended	84	84	-	"
22. Inspection of trains	12	12	-	"
23. Head end and rear end radio communication on requirement of train orders				
24. Head end and rear end radio communication before reaching point where train is restricted				
25. Spacing of trains by train crews				
26. Spacing of trains by train order signal				

APPENDIX D
RESULTS OF EFFICIENCY TESTS
ILLINOIS CENTRAL GULF RAILROAD

Division Chicago Month Jan. thru Oct. 1972

Kind of Test	No. of Tests Conducted	Number Properly Observed	Number Improperly Observed	Per Cent of Efficiency
27. Possession of standard watch, current inspection certificate and current timetable	101	101	-	100.0
28. Crew waiting the required time after opening switch and before fouling main track in block signal territory	63	63	-	"
29. Brake test	26	26	-	"
30. Check subordinate train crew members to see that they have been shown train orders and are familiar with their contents	18	18	-	"
31. Proper position of crew member(s) at switches	2	2	-	"
32. Crew members check switch points and test switch lock	29	29	-	"
33. Check train registers, operator's performance and files in train order offices	14	14	-	"
34. Special	177	176	1	99.44
Total	2372	2361	11	99.54
Same month last year				

APPENDIX E

Excerpts From Code of Federal Regulations Title 49 - Transportation

Subpart D—Multiple Operated Electric Units

§ 230 400 Definitions.

All rules and instructions contained in this subpart apply to electrically operated units designed to carry freight and/or passenger traffic operated by a single set of controls which are defined thus:

(a) Unit or units with propelling motors, control apparatus and one or more control stands

(b) Unit or units with propelling motors and control apparatus but without control stands

(c) Unit or units without propelling motors or control apparatus but with control stands.

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§ 230.417 Trucks.

(a) Truck center plates shall fit properly and be securely fastened The male center plate shall extend into the female center plate not less than ¾ inch, except on motor trucks constructed to transmit tractive effort through center plate or center pin the male center plate shall extend into the female center plate not less than 1½ inches

(b) Trucks shall be locked to the unit body and so arranged that the entire truck will lift with the unit body without disengaging the center plates The attachments shall be of adequate strength and properly maintained Such provision shall be made on units presently in service and not so equipped when the unit receives general repairs but not later than 24 months after April 1, 1956.

NOTE: Relief from the requirements of this rule will be granted upon an adequate showing by an individual carrier

(c) Truck bolsters shall be maintained approximately level

(d) Trucks with any of the following defects shall not be continued in service: Loose column, pedestal, or journal-box bolt; cracked or broken frame, unless properly repaired; loose tie bar; broken or defective motor suspension lug, spring, bar, or bolt; broken or cracked center casting; cracked or broken equalizer, hanger, gib or pin

(e) Suspension lugs or bars shall be of ample strength to keep motors secured and provision shall be made to prevent nose-supported motors from falling in case of failure of motor supports

§ 230.457 Body structure.

(a) Units built new after April 1, 1956 and operated in trains having a total empty weight of 600,000 pounds or more shall have body structure designed to meet or exceed the following minimum specifications:

(1) The unit structure shall resist a minimum static end load of 800,000 pounds at the rear draft stops ahead of the bolster on the center line of draft, without developing any permanent deformation in any member of the unit structure

(2) An anti-climbing arrangement shall be applied at each end, designed so that coupled units under full compression shall mate in a manner which will resist one unit from climbing the other This arrangement shall resist a vertical load of 100,000 pounds without exceeding the yield point of its various parts or its attachments to the unit structure

(3) The coupler carrier and its connections to the unit structure shall be designed to resist a vertical downward thrust from the coupler shank of 100,000 pounds for any horizontal position of the coupler, without exceeding the yield points of the materials used When yielding type of coupler carrier is used an auxiliary arrangement shall be provided, designed in accordance with these requirements

(4) The outside end of each unit shall be provided with two main vertical members, one at each side of the diaphragm opening Each main member shall have an ultimate shear value of not less than 300,000 pounds at a point even with the top of the underframe member to which it is attached The attachment of these members at bottom shall be sufficient to develop their full shear value If reinforcement is used to provide the shear value such reinforcement shall have full value for a distance of 18 inches up from the underframe connection, then taper to a point approximately 30 inches above the underframe connection

(5) Strength of locking means of truck to unit body shall be not less than the equivalent of an ultimate shear value of 250,000 pounds

(b) Units built new after April 1, 1956, and operated in trains having a total empty weight of less than 600,000 pounds shall have body structure designed to meet or exceed the following minimum specifications:

(1) The unit structure shall resist a minimum static end load of 400,000 pounds at the rear draft stops ahead of the bolster on the center line of draft, without developing any permanent deformation in any member of the unit structure

(2) An anti-climbing arrangement shall be applied at each end designed so that coupled units under full compression shall mate in a manner which will resist one unit from climbing the other This arrangement shall resist a vertical load of 75,000 pounds without exceeding the yield point of its various parts or its attachments to the unit structure

(3) The coupler carrier and its connections to the unit structure shall be designed to resist a vertical downward thrust from the coupled shank of 75,000 pounds for any horizontal position of the coupler, without exceeding the yield points of the materials used When a yielding type of coupler carrier is used an auxiliary arrangement shall be provided, designed in accordance with these requirements

(4) The outside end of each unit shall be provided with two main vertical members, one at each side of the diaphragm opening Each main member shall have an ultimate shear value of not less than 200 000 pounds at a point even with the top of the underframe member to which it is attached The attachments of these members at bottom shall be sufficient to develop their full shear value If reinforcement is used to provide the shear value such reinforcement shall have full value for a distance of 18 inches up from the underframe connection, then taper to a point approximately 30 inches above the underframe connection.

(5) Strength of locking means of truck to unit body shall be not less than the equivalent of an ultimate shear value of 250,000 pounds

UNITED STATES OF AMERICA
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: November 30, 1972

Adopted by the NATIONAL TRANSPORTATION SAFETY BOARD
at its office in Washington, D. C.
on the 20th day of November 1972.

FORWARDED TO:
Mr. Alan S. Boyd, President
Illinois Central Gulf Railroad Co.
135 East Eleventh Place
Chicago, Illinois 60605

SAFETY RECOMMENDATION R-72-37 thru 40

The National Transportation Safety Board's continuing investigation of the collision of two Illinois Central Gulf Railroad (ICGRR) commuter trains at the 27th Street Station in Chicago, Illinois, on October 30, 1972, has revealed several important safety problems. Although the Safety Board has not established finally the role these problems played in causing the collision and in contributing to the fatalities, the problems are involved sufficiently to warrant immediate corrective action to prevent similar accidents.

The ends of the ICGRR Highliner cars are painted a flat black color, which makes it difficult to distinguish the cars in certain lighting and background conditions. Specifically, a train similar to Train 416 of October 30, standing or backing slowly in the vicinity of the 27th Street platform, is difficult to distinguish against the dull, dark background when it is viewed from the operating compartment of an approaching train on the same track.

The rear end of a Highliner train can be rendered attention-getting and distinguishable in several ways. The existing marker lights, which are small and not easily seen in daylight, could be replaced by marker lights of a larger size and greater intensity. The end portions of cars, now painted black, could be painted with large zones of fluorescent color or with alternating light and dark striping in order to contrast with typical railroad backgrounds.

The National Transportation Safety Board therefore recommends that the Illinois Central Gulf Railroad and the Chicago South Suburban Mass Transit District:

1. Install attention-getting marker lights, which are effective in all light conditions, and provide definitive attention-getting colored markings at the ends of trains made up of Highliner cars. These actions should be considered also for other commuter passenger cars of generally dark coloration.

Until the causal factors related to signals and operating rules are determined, the Safety Board recommends that in order to guard against a repetition of the accident sequence, the ICGRR:

2. Revise Rule 515 in the current Illinois Central Rules and Regulations of the Operating Department to provide that train or engine which has passed beyond the limits of a block must not reenter that block without the protection of a train order.

This procedure, by removing the authority to reenter a block under a flag protection, also removes any possible uncertainties as to what flagging action would be required under Rule 99(a) in relation to Rule 515. Rule 99 of the ICGRR is the same as Rule 99 of the Association of American Railroad's Standard Code of Operating Rules. The Safety Board in its special study entitled "Signals and Operating Rules as Causal Factors in Train Accidents," adopted on December 2, 1971, pointed out some vague areas in Rule 99. The requirement for a train order will insure that any following train, if affected, will be notified. This procedure is practical on railroads, such as the ICGRR, which have radio communication.

The Safety Board also recommends that, as an interim measure, the ICGRR:

3. Establish procedures that will prohibit a train from entering a block already occupied by a passenger train except under protection of a train order.

Although it appears that the following train in this accident did not enter the block while the first train was still occupying it, the operating rules would allow such an entry at restricted speed. In this accident, the second train apparently passed an approach signal at 31st Street and was required to reduce to medium speed (30 m.p.h.) at once and to approach the next signal prepared to stop. The damage is evidence thatthe second train did not approach the collision point prepared to stop. Therefore, the Safety Board concludes that a second train can enter an occupied block on a restricting signal and strike an occupied train at a speed that can inflict serious and possibly

fatal, injuries to passengers and employees. This recommendation, in conjunction with the recommended change of Rule 515, will insure that two trains moving in the same direction on the same track will not occupy the same block except by a train order which will reduce to a minimum the risk of a collision between them.

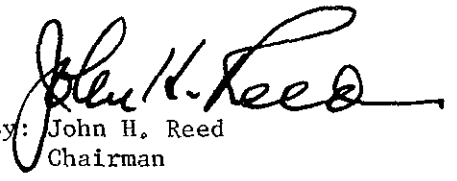
This accident also involves the maximum specified speeds for trains moving under various signal indications. All knowledge of train speed during the accident, however, must be based upon estimates of persons or indirect inference, because the older, following train was not equipped with any form of speedometer. In order to follow the rule the engineer of that train had to estimate his speed which is an unreliable method of determining speed. The new Highliner trains are equipped with speed indicators, and a speed indicator was installed in an older train by the railroad for the purpose of operating tests a few days after the accident.

The Safety Board recommends that the ICGRR:

4. Provide a reasonably accurate speedometer for the use of engineers required to operate trains wherever rules require limit or control of speed.

These recommendations will be released to the public on the issue date shown above. No public dissemination of the contents of this document should be made prior to that date.

Reed, Chairman, McAdams, Burgess and Haley, Members, concurred in the above recommendation. Thayer, Member, was absent, not voting.



By: John H. Reed
Chairman

73181

APPENDIX G

UNITED STATES OF AMERICA

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

ISSUED: April 25, 1973

Adopted by the NATIONAL TRANSPORTATION SAFETY BOARD
at its office in Washington, D. C
on the 11th day of April 1973

FORWARDED TO:
Honorable John W. Ingram
Administrator
Federal Railroad Administration
Washington, D.C. 20590

SAFETY RECOMMENDATION R-73-13 & 14

The National Transportation Safety Board developed evidence at the public hearing in Chicago, Illinois, during the week of December 4-8, 1972, concerning the design of the highliner cars. The cars referred to were manufactured by the St. Louis Car Division of the General Steel Industries Inc., and are owned by the Chicago South Suburban Mass Transit District. The Urban Mass Transportation Administration made a capital grant for a portion of the cost of these cars.

An analysis since the hearing indicates that the main vertical members (collision posts) in the highliner car involved in the collision of two commuter trains in Chicago, on October 30, 1972, did not meet the requirements of the Federal regulations. The conditions found indicate that the crash resistance of one collision post was reduced below the strength required by 49 CFR 230.457 and that this condition may exist in a number of other highliner cars. The Board believes, however, that this condition can be corrected.

It was disclosed at the hearing that there was incomplete fusion in about 75 percent of the weld attaching one collision post to the underframe. The collision post was secured to the underframe by a ½-inch-thick attachment plate, the bottom edge of which was beveled at a 45° angle for welding purposes. The depth of the bevel was only 5/16th of an inch instead of the full ½-inch thickness of the plate as originally designed and shown on the drawing. The

depth of the bevel did not provide access to permit welding over the full ½-inch thickness. In addition, only 25-percent fusion was achieved in the accessible area.

The possibility of not achieving a good weld with full penetration was quickly determined during the construction of the cars by the production department of St. Louis Car Division. The bevel was reduced in depth and an additional weld adjacent to the weld in the beveled area was added in an effort to compensate for any deficiencies of penetration. This effective design change was not, however, changed on the drawing. These factors are illustrated by the attached sketches based upon exhibits in evidence. The added weld is visible in this exhibit.

The added weld did not solve the problem. First, as can be seen in the sketch, the added weld material was distant from the location at which it could add to the strength of the weakest section. This section was limited by the 5/16-inch bevel. Second, the poor fusion at the weakest section could not be corrected by metal added to the outside of the plate.

Fusion to the full depth of the plate was assumed in the calculations for the collision posts based on the original drawing. Any reduction of cross section, such as that produced by the smaller bevel or poor fusion, would reduce the shear strength of the collision post to below the required 300,000 pounds.

It also appears that the welding design for the attachment of the collision post to the underframe relied upon assumptions not justified by documents of the current engineering practice. Specifically, the weld strength calculations made in allegedly meeting the Federal requirements assumed ideal welding conditions, whereas weaknesses of the actual conditions had been warned against in the American Welding Society's Welding Handbook, Sixth Edition, Section One, Paragraph 8.14. This paragraph states that joints made with single-bevel welds from one side:

"1. Are difficult to obtain a sound weld due to one perpendicular groove face. Vee and U grooves are preferred.

2. * * * should not be used when tension due to bending is concentrated at the root of the weld or when subject to fatigue, impact loading or service at low temperature.

* * * * *

4. Strength depends on degree of joint penetration, which is usually less than the depth of chamfering. * * *"

The reinforcing plate of the collision posts is attached to the underframe by welds of the type cited in the American Welding Society Handbook. A sound weld was not obtained in this case. The impact of a collision can subject these welds to severe bending stresses, as well as impact loading, both of which are warned against. The calculations assumed joint penetration to the full ½ inch depth of chamfering, although this is not supported by the handbook.

It appears that the reduced bevel of the attachment plate and the use of a single-bevel welds from one side were features of the method employed in welding the collision post attachment plate to the underframe in many of the Highliner cars. The Board has examined samples of welds taken from another Highliner car and found the smaller bevel in one of two welds.

In summary, because of the design of the attachment weld, incomplete fusion in the welding process and a reduced cross section of weld are likely to be present in other cars. Further, the assumptions as to the strength of the weld, even if properly fused, could not be fulfilled by the bevel actually used in construction. The added weld did not solve either the reduced dimension of the bevel or the poor fusion. The assumption that the original design weld would be fully effective does not appear justified, since competent welding manuals have warned against the single bevel weld in joints subject to bending or impact conditions.

The effect of these shortcomings in terms of fatalities and injuries in this accident has not been determined. This crash also involved a mismatch between the physical features of the older and newer cars, and the collision posts might have carried away, even if at full strength. However, there should be assurance that all collision posts meet current FRA requirements, which are at present the only defined form of crash protection. This assurance probably cannot be provided by visual inspection because the original design assumptions were deficient. However, it appears that retrofitted changes such as the addition of welded reinforcement could assure that the requirements are met.

The Safety Board has not determined whether compliance with current Federal regulations would have provided strength sufficient to resist this crash. The analysis of the evidence in that regard and any resulting recommendations will be included in the Board's final report.

The problem of the inadequately attached collision posts does not imply that the cars are unsafe to be operated in the sense that a crash would be caused. It does, however, imply that crash resistance of many collision posts would be found substantially below that intended to be provided by

Federal requirements, and that crash resistance could be inadequate, should a crash occur.

The hearing disclosed that the FRA relies on the railroad companies to comply with the requirements dealing with the strength design of locomotives and MU cars. This accident raises the question of whether this reliance is effective and suggests that specific enforcement action by the FRA to insure that regulations are complied with may be necessary.

The National Transportation Safety Board recommends that the Federal Railroad Administration:

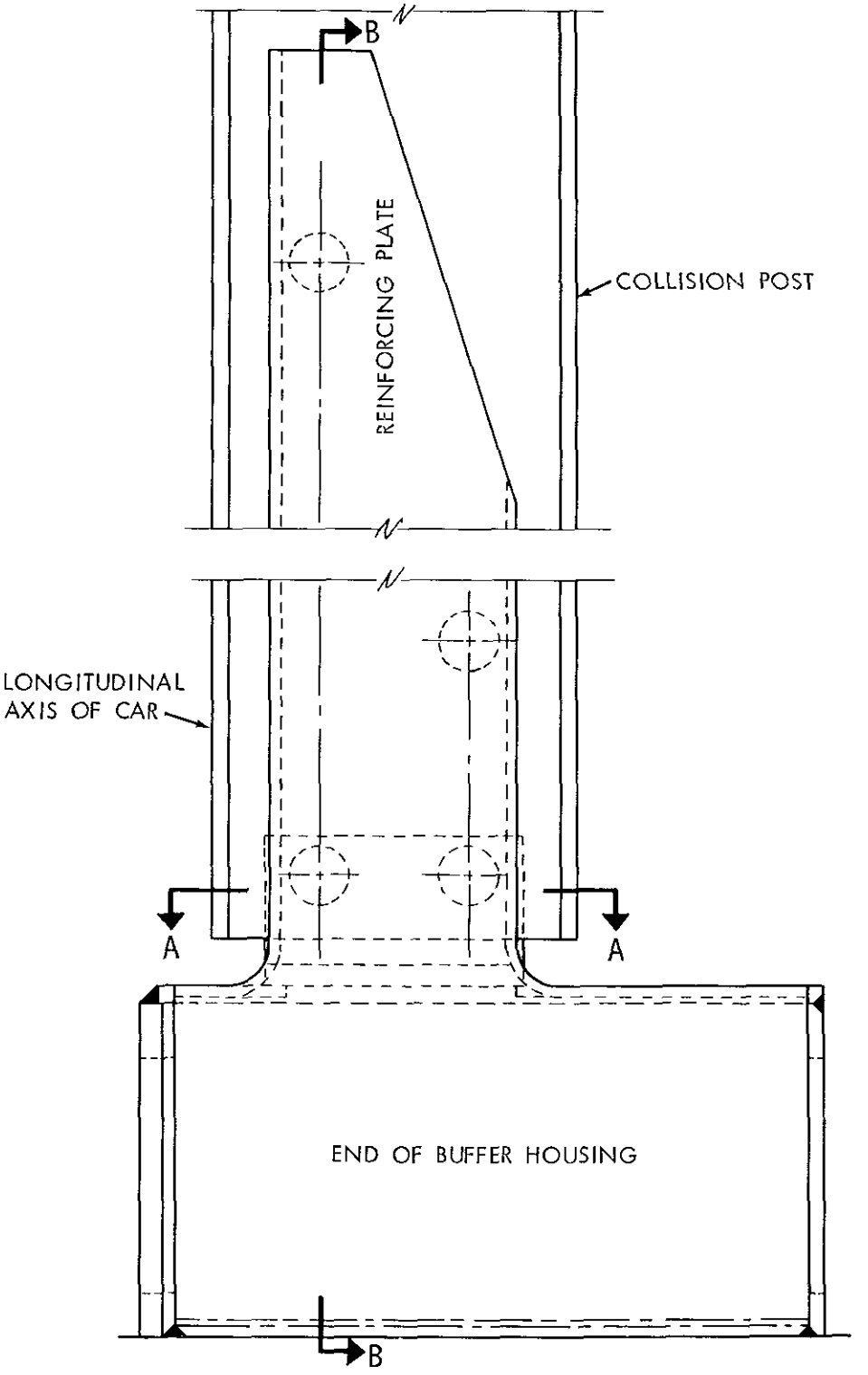
1. Review the current design of collision posts used on highliner cars and determine whether the attachments comply with the requirements of 49 CFR 230.457.

2. Take the necessary enforcement action to assure that highliner cars meet the requirements of 49 CFR 230.457.

These recommendations will be released to the public on the issue date shown above. No public dissemination of the contents of this document should be made prior to that date.

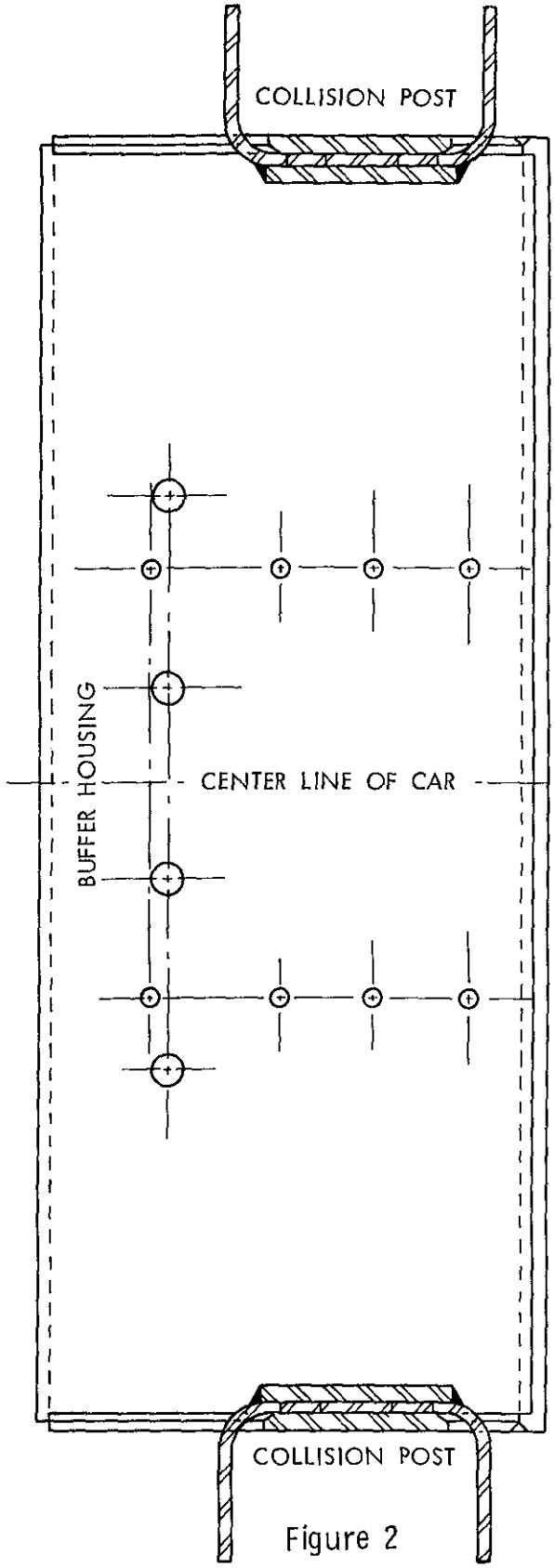
Reed, Chairman, McAdams, Thayer, Burgess, and Haley, Members, concurred in the above recommendations.

By: John H. Reed
Chairman



ELEVATION OF COLLISION POSTS
ILLINOIS CENTRAL GULF RR CAR NO. 1509
Figure 1

PLAN OF COLLISION POSTS
ILLINOIS CENTRAL GULF RR CAR NO. 1509



SECTION A-A

Figure 2

SECTION OF COLLISION POSTS
LOOKING TOWARD CENTER OF CAR

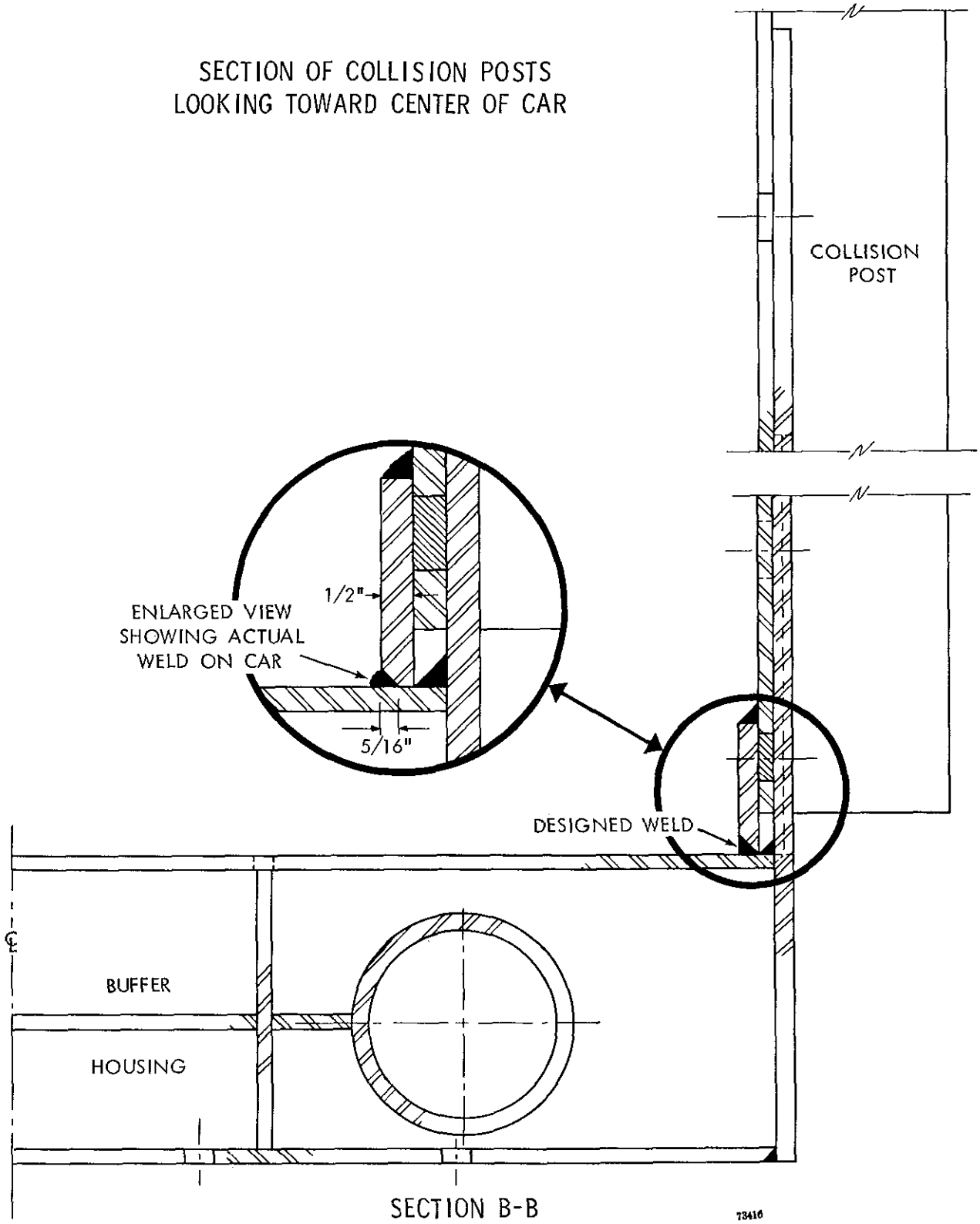


Figure 3

UNITED STATES OF AMERICA
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

ISSUED: April 25, 1973

Adopted by the NATIONAL TRANSPORTATION SAFETY BOARD
at its office in Washington, D C.
on the 11th day of April 1973

FORWARDED TO:

Honorable Frank C. Herringer
Administrator
Urban Mass Transportation
Administration
Washington, D.C. 20590

SAFETY RECOMMENDATION R-73-15 thru 18

After the collision of the two Illinois Central Gulf Railroad suburban trains in Chicago, on October 30, 1972, the State of Illinois and the Urban Mass Transportation Administration held up funds for the 15 additional highliner cars for use on the Illinois Central Gulf Railroad. Secretary Brinegar announced on February 20 a Federal grant of two-thirds funding for the Chicago South Suburban Mass Transit District to buy 15 new double-deck electric commuter cars subject to the following condition:

> "Approval of specifications for the 15 new bi-level commuter cars will be held in abeyance by the Urban Mass Transportation Administration pending results of the National Transportation Safety Board investigation of the above mentioned accident and any subsequent safety recommendations which may follow."

The National Transportation Safety Board agrees with UMTA's action. For good reason, the use of cars all of the same type would improve the safety of the commuters on the Illinois Central Gulf Railroad. Testimony at the public hearing and the Board's analysis indicate that the overriding of the frame of the new car and the resultant telescoping which produced most of the fatalities were influenced by the incompatibility of the highliner and the older car. The basic design strength of the older car was inferior to that of the newer car. However, the unsecured trucks of the older car and an incompatible anti-climbing arrangement contributed to the older car's overriding the new highliner.

The result was that the strongest part of the older car, its frame, struck relatively weaker parts of the newer car, above its frame. The Board believes that a collision between two highliner cars in good condition would have resulted in less intrusion into the passenger compartments of the cars. As long as the older cars continue in service, there is a possibility of similar results should a collision occur at the same speeds.

Other safety benefits also may be realized through the replacement of the older cars with new highliner cars. The differences between the braking characteristics of the two types of equipment, described at the public hearing, would be eliminated. In addition, because the new cars would be equipped with two-way radios and speedometers, operating safety would be improved.

The Board has already made interim recommendations to the Illinois Central Gulf Railroad concerning the visibility of the rear ends of trains and marker lights which could, with study by UMTA, be converted into specifications for the 15 additional highliner cars. The Board is also aware of agreements between the Illinois Commerce Commission and the Illinois Central Gulf Railroad to make radio and intercom available to trainmen on the rear ends of trains, to make conductor's brake valve available on rear ends of trains, and to make brake valves accessible to conductors while they are at the control panel in the vestibule. These matters could also be converted into specifications for the 15 additional highliner cars.

The Board has also made recommendations to the Federal Railroad Administration concerning design adequacy of a certain weld used to attach the collision posts to the underframe in highliner cars. It was recommended that FRA determine whether the current design of the attachment of collision posts used on other highliner cars comply with the regulations and that enforcement action be taken to assure that the requirements are met.

In making these recommendations, the Board pointed out that it had not determined whether the current Federal regulations, even if met, would have provided strength sufficient to resist this particular crash. Study of the crash has made it clear that the existing requirements based on the Locomotive Inspection Act do not address many of the factors in crash-resistant design of railroad passenger-carrying equipment. The Board believes that UMTA is capable of improving, through changes to newer cars, some other weaknesses of crash resistance which were not controlled by the existing Federal regulations. The recommended specification areas are meant to provide improvements within the same general design.

The weaknesses which can be improved include:

1) The present collision posts, made of channel members, are attached to the underframe, on only one side, in an unbalanced manner so that an impact force along the axis of the car can be converted into a twisting force (torque) at the post attachment point. The attachment point is not optimally designed to resist torque, and is only minimally able to resist lateral bending which is produced by twisting or by any deflection of impact to left or right.

2) The underframe design contains a number of single bevel welds which do not develop the full theoretical strength, are unpredictable, and not intended to resist impact optimally. Single bevel welds are warned against in the current edition of the Welding Handbook of the American Welding Society for impact-resisting purposes.

3) So-called "skip welds" were used in the attachment of the side sheets of the car to the underframe in the car involved in this accident. The welds developed only about one-third of the strength of a fully welded joint. Full welded joints would not have strengthened the walls sufficiently to prevent the penetration by the opposing car in the crash, but the destruction of full welds would have absorbed more crash energy and probably somewhat reduced the distance of telescoping penetration. The later cars in the previous highliner series included 100 percent welding of the side sheets to underframe, and the full welding is technically feasible.

For these reasons the Safety Board recommends that the following areas be included in specifications for the 15 additional highliner cars to be funded by UMTA:

1. Design specifications to require that all weld designs in the center sill area and in the underframe at ends of cars comply with specified current recommendations of engineering practices, and that single bevel welds not be employed.

2. Design specifications to require that welds, or other fasteners which join side walls to underframe and side walls to roof, develop a high proportion of the strength of the parent metal.

3. Design specifications to insure that the collision posts resist more adequately the impact loads which are likely to be applied by crash forces generally along the axis of the car. The design should not permit such impact loads to produce torque or lateral bending when applied at the logical points by an end to end collision. Collision posts and other structures should be designed to resist torque and bending efficiently.

There is also a lesson to be learned from an earlier collision of two highliner cars at 95th Street during the acceptance testing period, which was described in evidence. In that accident, two cars of current design crashed at speeds of 15 to 18 m.p.h., resulting in costly damage to both cars. There was small-scale, but generalized, permanent distortion of stressed skin caused by wrinkling and buckling of the underframe. The structure served effectively from an injury-prevention point of view, in that no override occurred, and there was no intrusion into the passenger area. However, the implications of the damage, which required complete structural replacement for both cars, are disquieting from the viewpoint of long-term operational costs. The Board believes that it is technically unnecessary to sustain such broad-scale damage in order to protect passengers. The Safety Board therefore recommends:

4. That UMTA require specific statements of intended capability of cars to resist low-speed collision damage in specifications for newly designed cars which are candidates for Federal capital grants. Such specifications should be coordinated with injury resistance specifications which may arise from current funded research.

These recommendations will be released to the public on the issue date shown above. No public dissemination of the contents of this document should be made prior to that date.

Reed Chairman, McAdams, Thayer, Burgess, and Haley, Members, concurred in the above recommendations.

By: John H. Reed
Chairman