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Motor Transportation—A Forward View

A Symposium

WITH DISCUSSION BY

MESSRS. F. LAVIS, EDGAR DOW GILMAN, GEORGE HARTLEY, ROBERT KINGERY, R. L. MORRISON, ROY F. BESSEY, BRUCE D. GREENSHIELDS, ROBERT B. BROOKS, H. GEORGE ALTVATER, W. W. CROSBY, THOMAS H. MACDONALD, AND LEROY C. SMITH.

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OINT RESPONSIBILITY OF THE AUTOMOTIVE AND THE CIVIL ENGINEER

By C. F. Kettering,[1] M. Am. Soc. C. E.

Synopsis

A number of years ago the writer was making a motor trip in Kentucky unning some tests, and had gone far off the main road. The map did not show ny roads leading away from the place it was so small. It was late in the fternoon and he wanted to return home before dark. Driving along a little ream bed (which was the only road there was) he overtook an old gentleman riving a donkey hooked to a stone boat loaded with milk cans. Question: Neighbor, what is the best way to go to Cincinnati from here?" Answer: Go right up to the forks in the road. Now, it don't make much difference hich fork you take but, to tell you the truth, Stranger, if I was going to Cinnnati I wouldn't start from here." Sometimes people get to thinking like he old Kentuckian; but they must first recognize that, whatever their desination, they must start from where they are.

The leaders of the automobile industry have never been able to predict hat the industry will offer the public two years in advance. If they knew hat the car of ten or twenty-five years in the future was going to be like they ould be making it now. To afford some idea of what the future might bring ithout taking all the responsibility upon his own shoulders the writer asked number of men, holding responsible positions in the automobile and allied ndustries. On some questions they were almost unanimous in agreement; on thers, they had entirely opposite ideas. All the various prophecies and predictions made in the past have been studied and, with these, the writer has tried o present, in some kind of complete picture, the requirements that will be emanded of those who will supply roads for the automobile of 1960.

All one can do now is to determine conditions as they are to-day, what they ere yesterday, and, by projecting a line through the two known points, reach ome idea of what the future may hold. It is an excellent idea for the road uilders and automobile makers to get together and exchange ideas concerning heir mutual problems. After all, the vehicle and the road must form a comlete transportation system. Each one is dependent upon the other for the uccess of the whole. Civil engineers have the most difficult job because of he time factor. They must build a road to last twenty or twenty-five years or vehicles whose average life is only seven or eight years. Before a road is

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one-third used up, there is an entire new generation of motor vehicles with their new requirements; and before the road is finally ready for replacement the requirements have changed several times over. The aim of this paper is to predict what changes this time factor will demand so that civil engineers can build accordingly.

Introduction

The greatest problem involved in all thinking is to determine the time rate of action. The time rate of gravitation is known. If a man jumps from a window the time it will take for him to hit the sidewalk can be computed. There are other natural laws which are just as fundamental as the law of gravitation. Each of them has an entirely different time rate of action, and these are not understood at all.

An interesting incident occurred in connection with the salmon fishing industry in one of the large rivers of the United States. The industry was persuaded that it would be a good thing to have a salmon fish hatchery and, therefore, two or three of them were built. Fish hatching was begun, and the product sent out, to return again after the proper cycle. One year, one of the hatcheries burned down, and there was an immediate demand for a new one. People went to the authorities to get an emergency appropriation for building a new fish hatchery; but the time rate of political action is not that fast. The subject had to be discussed and the hatchery was not built that year. Some of the opponents argued, "they had just as big a run of salmon the year after the fire as they had the year before." The result of the delay in building was that, when the proper year in the cycle came around, the salmon catch was small because of the absence of the product of the hatchery. This has happened in some other problems, such as road building. Eight or ten years ago engineers missed something; so "the run is not so good" this year. This time factor must be studied so that similar troubles will not recur. Maybe the place to start is with the politicians.

The writer belongs to a group of men who believe the world is not finished. Nothing is constant but change. Men work day after day, not to finish things, but to make the future better. They want the future just as nice a place as they can make it because they will spend the remainder of their lives in the future.

Many things need to be torn down and thrown away. The country needs to be rebuilt and made better than ever before. The economists and bankers say, "Where are you going to get the money?" The money will come from the same source as when the country was built this far. There was no money with which to start. All that the people did was to dig each building out of the ground. It has always been here in the country, only in a different form.

Man-hours can be used to convert material into anything that Man needs. An intelligent people will supply the work. When materials are converted into human utilities money is only used as conveyor to carry it from one point to another. Sometimes, people calculate entirely too much in dollars. The wealth of the nation is not in dollars; it is in useful products. The positive

...s of economics is the movement of useful material through the channels of ...de. That must always precede the return flow of money through the ...nting houses.

In preparing this paper the writer sent a list of eighteen questions involving ...tors that might affect road requirements in 1950 or 1970 to many people ...ho it was thought might have valuable information on at least some of them. ...eir opinions were requested on any particular one subject upon which they ...d information; or, if they wished, they could comment on all eighteen. The ...bjects upon which the questions were based were:

(1) Growth in registration of passenger cars.
(2) Growth in registration, use, etc., of trucks.
  (*a*) Will railroads pick up and deliver less than car-load lots?
(3) Growth in registration and use of buses.
  (*a*) Will buses supersede street cars in cities?
(4) Effect of the trailer on automobile design, roads, laws, traveling habits, trailer camps, home building, population movement, etc.
(5) Road speeds of passenger cars, trucks, and buses.
(6) Size and weight of road vehicles.
  (*a*) Will this make segregation of different types of traffic necessary?
(7) The future of other types of motive power, such as the Diesel engine and the problem of suitable fuels.
(8) Design changes in the automobile which will affect road-building requirements and make safer vehicles.
(9) Lighting on the vehicle and highway.
(10) The future of tires—changes in coefficient of friction, life, etc.
(11) Possibility of high-speed trunk highways and separate truck highways between cities.
(12) Will travel be overhead or underground in congested areas?
(13) Will the population live in larger cities or will the trend be back to smaller communities?
(14) What mechanical devices are practical to control traffic conditions and actions of the driver?
(15) How will parking in cities be solved?
(16) How will laws regulating traffic, vehicles, and the driver affect road requirements?
(17) Type, kind, and number of highways that should be provided for the future.
(18) Possibility of chemistry contributing better road materials or treatment.

Increase in Registrations

The probable growth in population in the United States for the next 25 yr ...quite easy to predict and such predictions have proved reliable in the past.

In Fig. 1, Curve (1) shows the population growth from 1900 to 1930, as taken from reports of the United States Census Bureau. From 1930 to 1960 the probable future population is shown as estimated by the American Petroleum Institute. The data represent the averages of five estimates from life insurance companies and others. Passenger-car registrations are plotted as Curve (2) with the estimated increase per 5-yr period to 1960. The estimated number of persons per car is plotted as Curve (3). Registrations in trucks are estimated to increase to 6 000 000 by 1960 (see Curve (4)). Curve (5), Fig. 1, shows the total estimated motor-vehicle registration by 1960 as more than 37 000 000 vehicles. The registration values were estimated by the American Petroleum Institute.

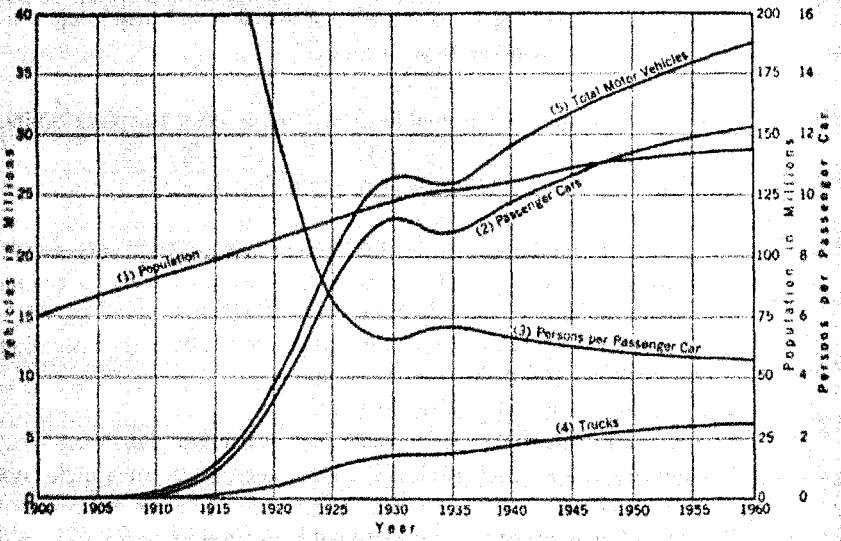

FIG. 1.—ESTIMATED MOTOR VEHICLE REGISTRATION TO 1960

From the foregoing it is apparent that engineers will have to provide roads for 50% more motor vehicles in the next 23 yr. Since many main roads are already inadequate to carry the traffic safely, it would seem that a tremendous task lies ahead. The area of the various countries per mile of road, and the number of cars per mile of highway, are as follows:

Nation	Area, in square miles per mile of road	Cars per mile of road
United States	1.0	8.2
Germany	0.8	4.4
France	0.5	4.9
Great Britain	0.5	10.3
Italy	1.1	3.6
Australia	6.3	1.3
Brazil	35.2	1.3

In comparison with most of the remainder of the world, highways in the United States are now congested. An increase in registration on the present system would almost prohibit much of the usual driving. What the optimum ratios should be is not known, but it is certain that more improved highways are badly needed.

Almost all those who answered the questionnaire believe that the population trend is away from congested areas. Railroads, unsupplemented by efficient highway transport, caused concentration of population at station points. Automobile transportation counters the railroad influence, and provides economic and social communication facilities, at greater distances from, and independent of, rails. Man has an inborn feeling for open spaces and a plot of ground, which he cannot lose entirely. There are a number of indications that the trend is away from cities and back to smaller communities. Several large manufacturers have definitely committed themselves to a policy of erecting new plants in small towns. One of the largest retail companies, with stores all over the country, is opening or building new stores only where large parking spaces can be obtained for the use of its customers. Traffic congestion and the problem of parking will have the greatest influence on this movement. A number of men think cities will be necessary for conducting many forms of business and government, but that a large percentage of the population can live more comfortably and find most of their needs cared for in small communities.

There are those who predict the "string" or "ribbon" city. This is an almost continuous population existing on both sides of a trunk highway. The ribbon city may be pictured as an elongated community like a long string with beads of different sizes strung upon it more or less erratically. The biggest beads are the large centers of population. They are certain to develop because of the need of centralizing large financial institutions, railway centers, ports, costly public facilities, such as water-works, gas-works, museums, libraries, and other agencies which have grown with large cities. Small "beads" will develop at strategic points and will consist of all gradations between the large city and the equivalent of small country cross-roads.

Others believe in the increase in importance and number of small communities which would be supported by a local industry. Each town would have at least one factory. Because of the greater amount of leisure which every one has, residents of small cities would be able to have plots of ground for cultivation and would raise part of their food requirements. This would make them less dependent upon manufacturing for their living. This type of rural life would make highways doubly important, both for pleasure and commercial use.

There are others who believe that faster means of transportation from outside into the center of large cities is coming. Workmen could live distances as great as fifty miles from their work. Homes would be situated on large plots in the open country. The city would be for work, business, and commerce. To accomplish this would require high-speed, limited-access trunk highways to the city limits. The city would have to have many elevated or depressed highways crossing it in every direction. Present level streets would be used for local travel. Local conditions will govern whether the thoroughfares are built underground or overhead.

Parking

City parking is one of the most serious problems. It is inconceivable that motor-car owners will long continue to park cars almost bumper to bumper along busy city streets and suffer the damage and inconvenience which result. The traffic capacity of the present city street system could be almost doubled by eliminating parking and using the streets for travel only, as they should be used.

Experience seems to indicate that drivers and store owners have unconsciously, but effectively, accepted the idea that cities must provide the parking space required for the ordinary transactions of business and pleasurable pursuits of their citizens. The only regret in the mind of the average person seems to be that he has not been able to find any method of placing more than two curbs along a given street. The people in Detroit, Mich., have even found a way to do that on a few streets.

Accepting the idea that cities must provide space, it would seem far cheaper for them to provide parking lots than to supply expensively improved streets for parking purposes. If it is right for a city to go so far as to condemn and acquire strips from the front of existing lots, and even buildings, to convert these strips into additional highway widths, to pave them expensively, and then to have large parts occupied permanently for parking, why is it not legitimate and much more logical to condemn cheap but well-located property for conversion into city-operated parking lots?

In residential areas there is a grass plot between the sidewalk and the street. Why should not this space be used for parking instead of the traffic area of a street built for heavy duty? There are even city ordinances prohibiting such a practice.

Parking garages, either separate or located within the building they are meant to serve, are growing in number. Every large building should provide adequate parking space for its tenants and customers. Several well developed means of doing this are in use. Double-decked or triple-decked exposed parking lots may be necessary in some areas. However, the problem of parking is not one for either the automotive engineer or the civil engineer to solve directly.

Passenger Cars

What possible changes in the passenger automobile might affect road requirements? The car has, in no way, reached a state of standardization and there is no indication that it will. The car of ten or twenty-five years from now (1938) will be just as different and will have just as many improvements as they have had in the past ten or twenty-five years. The 1937 car will certainly seem as antiquated to those who see it in 1960 as the 1912 car does now. It is the policy of the automobile industry to improve its product constantly.

Sometimes an idea of the future may be gained by looking at the past. Suppose a buyer had picked out a brand new 1912 car just as it came from the production line. At that time every one agreed that it was the best car that could be obtained. Suppose it was sealed in an air-tight glass case and the price ($2 000) marked in gold letters where every one could see. As the years passed the buyer went back to look over his perfect car. The second year, its

value had decreased to $1 800; and, as each year passed, its value decreased until in a short time (much less than the twenty-five years since it was sealed up) only the junk man would value it. Why? Remember it was sealed so that nothing could happen to it—no rust or corrosion, and no wear. The car remained exactly as on the day it was purchased; but what changes there have been since 1912 in the idea as to what an automobile should be! Cars now have self-starters, four-wheel brakes, better finishes, higher performance, improved appearance, fine riding qualities, and many more attributes than any one could mention. If a buyer were to do the same with a 1937 car now, he would surely have the same experience in 1960.

It is not possible to foretell exactly what the car of the future will be like. There are so many factors that might enter at any time to throw such prophecies out of line. It is feasible, however, to discuss some of the problems automobile engineers are talking about and experimenting with; questions they think important enough on which to put time and effort. The requirements for maneuvering and controlling the car, for example, are closely related to road conditions in many instances. These items are affected by such factors as steering, "hill climb," top speed, vision, lighting, riding quality, and ease of control, all of which are directly concerned with the safe use of the roads.

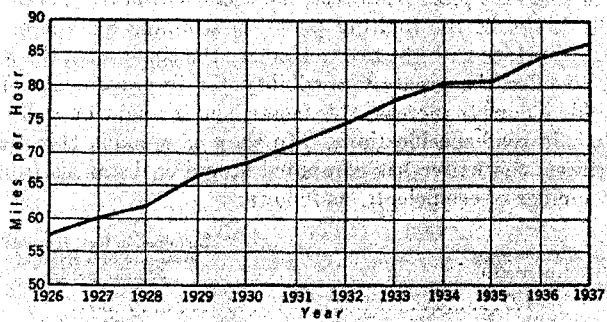

FIG. 2—CURVE OF MAXIMUM SPEED

Engineers do not always think of engine design as having anything to do directly with road building and safety and yet the power source may profoundly affect the type of surface upon which the car rides. It influences performance factors: Speed, acceleration, economy, flexibility, and "hill climb." From several sources of information one learns that there are indications that the practical usable maximum speed has been reached and that engineering emphasis will be placed on other factors in the future. Customer research surveys have shown that people, on the average, do not want to travel much faster than 60 miles per hr; but they want to go that fast without effort. Certainly, roads should not be designed for any less than 60 miles per hr. Other authoritative sources of information reveal that speed is an inherent reason for the widespread use of the automobile and that designers should do everything possible to maintain that advantage. As roads and cars become better, speeds may increase still further and with more safety than at present. Fig. 2 shows the trend in maximum speed of a representative group of cars for the eleven years, 1926–1937.

Although the question of maximum top speed may be controversial and may depend upon how safe the highways are made, every one insists that a higher average speed should be maintained between cities. This indicates the need for high-speed highways built to carry traffic safely. Elimination of grade crossings, limited access, separate lanes, and locations to pass around cities, are some of the requirements. These highways are necessary between main centers now, and their requirements will not depend upon changes in the vehicle that may be anticipated at the present time.

Acceleration and "hill climb" are closely akin. Accelerations will probably increase. This ability is important in "getting away" from a stop and increasing to traffic speed, to pass and return into line in a short distance, and to cross intersections without delay. It will affect the timing of traffic lights and regulating devices. It now appears that any passenger car will be able to negotiate a 10% grade without losing its speed. Undoubtedly, the trend is for the performance of trucks and buses to equal more nearly that of passenger cars. This will undoubtedly be true in the future.

The ability to stop is of major importance. Here is a problem that civil, as well as automotive, engineers can do much to solve. For its part the automobile industry will offer better and better brake equipment as it learns more and more how to do the job. However, the coefficient of friction between road and tire will always be the limiting factor in stopping distances. Although something may be done with the tire to increase the coefficient, the road surface itself seems to offer the greatest possibility for improvement. Everything possible should be done to increase this factor, and it might be well to include a minimum limit in road specifications. To show how much this may vary on different surfaces, the writer has computed stopping distances from 50 miles per hr for a number of coefficients, as follows:

Coefficients of friction	Distance, in feet, required to stop from a speed of 50 miles per hr
1.0	83
0.9	91
0.6	140
0.4	208
0.2	416

The large variations are clearly shown. Surfaces and materials vary the friction characteristics greatly and warrant important consideration in building new roads. The change with weather conditions also is of great importance. There is little that can be done with the tire to give higher values compared to the large variations encountered on present-day roads. At present, a coefficient of about 0.6 is all that can be relied upon in designing brakes.

The size of passenger cars will be determined largely by the space required to house the passengers. Probably this will not change very much. Road clearances of a little less than 8 in. have been common for a number of years and it would seem that nothing now being developed would reduce this value. Clearances are important in building alley intersections, intersection street grades, and driveways. Lower door clearances, apparently, are here to stay

and must be taken into account in constructing curbs. The height of the center of gravity has a bearing on the capability of the car to "hold the road." For a number of years it has been about 24 in. above the road. Any lowering would only slightly affect roads. Turning radius is important only in parking. This value has averaged about 26 ft for some years.

What will be the effect of the engine in the rear? This subject seems to be much before the public at present. There are some good reasons why this design would be desirable and some, equally good, why it might not prove so feasible in production. A rear-engined car would provide better visibility with clear vision directly ahead. It would probably eliminate much engine noise, heat, and odors, and allow lower floor-boards. However, maneuvering, particularly around a corner, requires an almost equal distribution of weight on the front and rear wheels. To accomplish this in a rear-engined car of reasonable wheel-base will require an engine of about one-half the weight of the present units. The rear-engined car with acceptable handling characteristics must await power plant and drive developments. Even with a rear-engined car, road requirements would not be changed materially unless accompanied by radical changes in performance.

The rubber tire is one of the most important factors that made the present automobile possible. It is interesting to note that Mr. Dunlop was not thinking of automobiles at all when he developed the pneumatic tire. He undertook to make a better tire for his son's bicycle. He took a wheel and put a canvas over it, and inside inserted a rubber tube blown up by a football pump. That was the beginning of the pneumatic tire. Finally, an unknown bicycle racer beat a champion because he used pneumatic tires and the bicycle trade took them up. When the automobile came along the tire was ready.

Tire mileages have increased from less than 1 000 in the early days until now (1938) a tire will last for more than 20 000 or 30 000 miles and the owner objects if he does not get that many. One place where tires may be greatly improved is in blow-out resistance. At one proving ground tires have often been blown out with dynamite caps at speeds of 70 miles per hr or more without hurting any one. In fact, motion pictures taken by a following car and aimed at the tire show only a slight sidewise movement when the tire burst. Such procedure is not recommended, of course, as serious accidents can be caused by blow-outs, especially in front tires.

The trend in tire development is toward improvements in compounding technique that will result in more heat-resisting rubber compounds. A new tire is being produced which has a strong rayon cord that maintains its strength at a high temperature. More than 20 000 tires have been produced and 500 000 000 miles of wear imposed on them to be sure that the development is a sound one. The outstanding characteristic of this tire is its freedom from carcass failure and blow-outs, particularly where trucks and buses are operated at high speeds and under heavy loads. One company cited tests by which these new tires outlasted the specially constructed test cars themselves in runs at 120 miles per hr over the salt beds of Utah. It seems that the tire chemist has scored again and motorists will not be limited in road speed by tire weaknesses.

Mechanical Devices to Control Cars

It is not difficult to conceive of mechanical devices on roads and highways that might act to reduce the accident rate. Photo-electric cells, relays, and mechanical devices have been proposed for stopping cars automatically. This could be done in a practical manner just as is now done on railway trains. It is doubtful, however, whether engineers could justify the expense and difficulties of enforcement in the use of such devices.

For several years there has been a presistent clamor for governors on all motor vehicles. Speed is claimed to be the cause of most of the accidents. However, the public would not allow the designer to govern the speed to less than 50 miles per hr. Only a very small percentage of accidents happen at greater speeds. Limiting the speed to 50 miles per hr would not affect accidents in the city, where maximum speeds seldom reach this value; and it would only prevent a few accidents on the open highway. Many surveys have shown that the average speed is less than 45 miles per hr on good roads and only a small proportion of cars travel as fast as 60 miles per hr.

Automatic devices that limit speed or take the control away from the driver may be the cause of accidents. It is often necessary to accelerate rapidly to cross an intersection, pass around a car and back into line, or enter traffic and increase the speed to avoid trouble.

Lighting—Road or Vehicle?

Authorities agree on one fact: Night-driving conditions are far behind day-time conditions, and for one reason—lack of adequate lighting and glaring headlights. Many studies have been made on the relative accident rates between day and night driving. Most authorities agree that night driving is three or four times more hazardous than day-time driving. The future must avoid this condition. Here is a problem which both groups—the automobile industry and road builders—will have to solve individually. It seems logical that many miles of congested highways, especially between large centers of population, could be lighted economically. The first cost and the upkeep are high; and, with any electrical equipment now in prospect, these items make it impractical to light all highways. It has been estimated that the upkeep alone of the lighting for roads in the United States would cost more than the total annual expenditure for roads in the entire nation.

However, the writer would like to outline what has been done in the past generation in lights for other purposes. The present tungsten incandescent lamp is about eight times more efficient than the original Edison carbon lamps. The new sodium vapor lights are said to give nearly three times as much illumination as the best tungsten lamps. It does not take a very good prophet to guess that this progress will not stop. The future will certainly see vast improvements in methods of producing light with small expenditures of power. Entirely new methods will surely be found for producing light without the great heat loss which now must be accepted. The firefly, deep sea fish, and other of Nature's means of producing light can teach engineers an entirely new technique. Already, a few unrelated facts are known which may prove to be

the starting point for large lighting industries. In a demonstration which the writer has often given, he pours two liquid chemical compounds together. Each is almost water-white and inert. When they are mixed, they create a pale blue light, strong enough to permit reading a newspaper in the dark, which persists for several hours. What this means for the future is difficult to say, but it is well known that many of the greatest industries are founded upon scientific facts as simple as this one.

For some time to come it seems likely that illumination on most roads will be supplied by the automobile itself. The problem is to obtain good vision without glare; and this the automobile engineer is working on all the time. From the crude oil lamps of twenty-five years ago the modern car has now progressed to fairly effective electric lights with several beams to suit varied conditions. This lighting can be improved still further, but how to do it is the problem. Since 1918, experimenters have tested thousands of means of eliminating glare, which would still provide adequate road illumination for the fast-driving pace most owners demand.

Only one solution has received widespread attention; that is, the use of polarized light. At first, this may seem to be the answer to the question, but there are still many problems to be solved before it can be utilized on a car. In this system a beam of polarized light is projected upon the road by a headlight which has a polarizing screen in front of the light bulb. The oncoming driver views the road through a screen in the windshield, or special glasses which have a polarizing screen set at right angles to that of the headlight of the oncoming car. Therefore, he sees only a small percentage of the light from the oncoming car, but the light from his own lights is little affected by the viewing screen. Glare is practically eliminated without much reduction in road illumination. The objection to the use of polarized light is that it requires about four to eight times the candle-power light of present systems to give the same visibility. To be effective, it would have to be fitted to all cars. The expense of the screens themselves is high, although this would undoubtedly be reduced with more experience in manufacturing.

Other systems have been proposed for providing adequate road illumination and, at the same time, eliminating glare from oncoming cars, such as a system of colored lights. Every car would be equipped with headlights capable of producing a beam of either one of two colors, together with viewing screens of these colors. Suppose the two colors were blue and orange-red. Cars traveling north and east, for instance, might be required to illuminate the road with the blue light and would use their blue viewing screen. Cars traveling south and west would use the orange-red light and screens. The colors would be selected so that the blue screen would transmit none of the orange-red and the orange-red screen would transmit none of the blue light. This would eliminate glare from oncoming cars although it appears that the efficiency of the system would be low.

A problem in road research closely akin to illumination is road color, and brightness, and their effect upon visibility, both day and night. This is probably one of the minor considerations in selecting road materials and yet it should be given some consideration. The related problem of visibility, front

and rear, from the driver's seat is an important subject which has commanded increased interest, and should lead to much better visibility in the future. Narrower front pillars, better seat positions, glass angles, and locations to eliminate reflections, sun-glare shields, front-end shape, and many other considerations are involved. From the standpoint of the road, good highways signs, elimination of blind corners, location of signal lights, center lines and markers, and road color are problems of importance to the driver, especially when he drives over a new route.

Buses and Trucks

There will be a great expansion in the use of trucks and buses in the future. From the road-builders' standpoint the size and weight of the vehicle will be important. Almost every one agrees that this factor will be settled by law and that maximum sizes and weights will not exceed present limits. The trend seems to be toward many more smaller, faster, more mobile units.

There will be a tremendous growth in the use of buses, especially to replace street cars. Although buses cannot supplant street cars entirely, in all cities, it appears that there is a certain population below which buses can take their place. It has been estimated that this size is between 100 000 and 200 000. For large cities, and particularly in cities in which there are arterial highways, the street car will remain the backbone of the transportation system.

The records show how rapidly the public has accepted the motor bus in cities and, in the final analysis, their wants will always control. In 1922, only 18 cities depended exclusively on motor coaches for transportation. Within a period of 10 yr, 300 cities were using buses exclusively. To-day (1938) the number is well over 420. During the past five years 75% of equipment bought by city operators has been gasoline buses.

For inter-city use the bus has shown similar strides forward in the twenty-five years, 1913–1938. Passenger service is supplied by buses in 48 500 communities in America which are not served by rail lines and are totally dependent on highway transportation. These are the modern "lost Provinces" which have again been discovered by highway transportation. In several mid-western States, from 20% to 40% of the communities come under the heading of "Lost Provinces."

The public has "sold" itself on the value of buses, and their speed, economy, and convenient schedules. Comfort, appearance, speed, acceleration, "hill climb," and safety have shown marked improvement in the past few years and the limit has not been reached in these factors. The trend has been toward large units, seating more than thirty passengers, but of considerably lighter weight than those of the past. Aluminum and pressed steel reduced the weight of one large bus by 6 000 lb and with an increase in structural strength. The motor bus has definitely found a place in the transportation system of the United States and will have to be provided for in any future highway program.

Statements that the truck will eventually drive the railroads out of business can only come from those not acquainted with the problems of trucking. A "long haul" in truck language means a "short haul" in railroad language. At present, the truck is usually not economical for distances greater than 250

miles, or for other than the higher grades of freight. There is plenty of business for both the truck and the railroad.

Railroads, themselves, are using trucks in ever-increasing numbers. Door-to-door delivery has been tried sufficiently to show its value and this service will expand in the future. For short hauls there will be more trucks of every kind, their maximum size being limited by laws and regulations.

The possibility of separate highways for commercial vehicles presents many problems, most important of which, perhaps, is the cost. In most instances, the commercial development that has come in the wake of motor transportation has been along the present highways. Even if separate truck highways were constructed, it would still be necessary for trucks and buses to use present highways to serve the industries and business places along them. If separate highways are necessary, in some places, perhaps they should be constructed for passenger cars and leave trucks where they are. Trucks could be kept off the special highway for the passenger cars, but they cannot be kept off the present highways regardless of the construction of other truck highways.

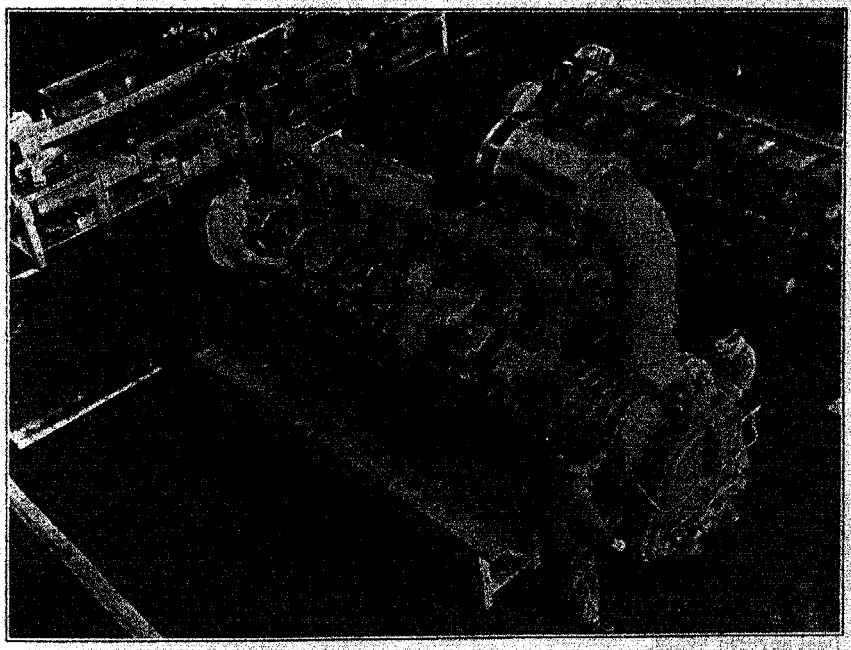

FIG. 3.—A MODERN TWO-CYCLE DIESEL ENGINE

DIESEL ENGINES FOR MOTOR VEHICLES

The Diesel engine is not new; it has been in use for more than forty years. Until given wide publicity by its use on the streamlined trains, it was little known by the public. Now, many car owners are talking Diesel engines as if they would displace the gasoline engine entirely in motor-vehicle transportation.

The Diesel is a remarkable engine for some purposes. It is the answer to many of the problems the railroad companies have been trying to solve for years. Passenger trains have been able to maintain faster schedules than they ever thought possible at a great saving in operation and fuel cost. Full-length trains have reached speeds exceeding 120 miles per hr. Time for upkeep in the roundhouse has been reduced one-half. Water is not a problem in dry, alkali areas because the loss of cooling water is negligible.

The Diesel engine is here to stay and will soon be common in large motor vehicles. Cross-country trucks and buses can now be obtained with Diesel engines and the future should show an increasing use of this economical form of power plant. The statement that they save one-half the fuel cost needs some explaining. One of the largest existing fleets of motor vehicles has a yearly gasoline bill of more than $2 000 000. To save one-half of that sum would be well worth while; but to do so, it would be necessary to spend more on the original equipment. It costs considerably more to make the Diesel engine, principally because of the expensive fuel injection system. By driving enough miles in a year, it may be possible to pay the extra first cost of the engine by savings in fuel, and still show a profit. This makes the Diesel engine possible in commercial vehicles, but not necessarily for passenger cars.

The main reason, however, why Diesel engines are not built in passenger cars is that no one knows how to build them. The writer has never seen a successful Diesel engine in automobile cylinder sizes. The larger the engine size (see Fig. 3) the easier it is to make a Diesel engine; and the smaller the size, the easier it is to make a gasoline engine. Truck and bus Diesels are still large engines as compared to passenger car engines. The use of Diesel engines should not materially affect road requirements in any event.

Trailers and Mobile Homes

A new factor that has entered the "picture" in the last few years is the house-trailer. Estimates vary as to the number now on the road, but it seems that there are several hundred thousand trailers, housing several million people. A conservative estimate is that 100 000 new ones were produced in 1937. These values are insignificant when compared to the 26 000 000 motor-vehicle registrations, but it must be remembered that trailer construction as an industry is just beginning. What the future holds, no one is sure. Opinions and prophecies vary from those by people who think that trailers are just a fad to those who predict that one-half the population of the country will be living in trailers within twenty years. There may be too much optimism in the trailer industry itself; and yet it has almost doubled itself every year for the past several years.

More than ten years ago (1926) the writer had some experience with living a trailer life. A stock bus was fitted out for living purposes and a party of seven took an 8 000-mile trip through the West. Traveling was surprisingly comfortable, and the accommodations, in many cases, were better than could be obtained in the country through which the party traveled. The present trailer is much better equipped and can find better parking places than it could ten years ago.

There are those who predict that the trailer will grow into a mobile modern home of several rooms, a home that can be moved when the head of the family changes locations of work. There are now several designs of expansible trailers which make three-room or four-room bungalows complete with all modern conveniences. They visualize a working population housed in these mobile homes, which can be moved from place to place as working conditions change. The owners would rent small plots of ground on the outskirts of industrial areas, where they could raise their own food, be out in the open country, and use the car for transportation to and from work. They would have all the benefits of owning their own home in the country, but would not be tied down because of high mortages or ownership of stationary property. Land could be rented from farmers and a new type of community life developed. After one studies some of the plans of these mobile homes, it becomes apparent that there are possibilities in this field, especially when it is realized that 80% to 85% of the present trailers are bought by working men for permanent homes.

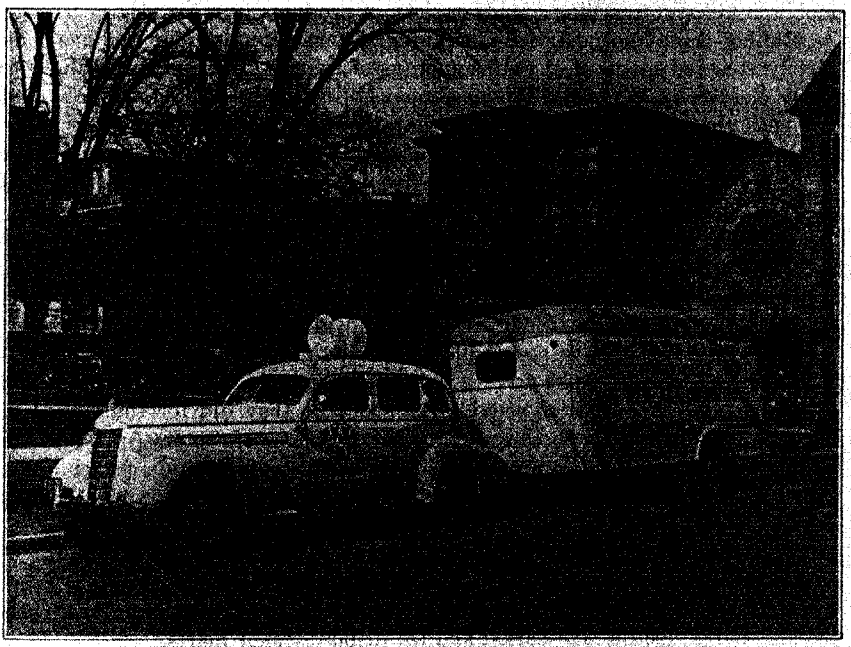

FIG. 4.—DISPLAY TRAILER USED TO PROMOTE HIGHWAY SAFETY

The small present type of trailer may serve two purposes. It makes a satisfactory temporary dwelling for vacations and it can be used as a sample display room for commercial products. With the trend definitely toward more leisure and earlier retirement of men in business, it is certain that some effect will be felt in the modern way of living. The trailer is one answer to those who retire on a modest income or who depend upon the Social Security Act for a living.

Already a number of businesses use trailers for commercial purposes. Almost every one can remember the old days when commercial salesmen, or "drummers," traveled their territories by horse and buggy or by train. Then, along came the automobile, and they could cover as much territory in a day as they could before in a week. Now another change is appearing in methods of selling—the display trailer. It is doubtful whether any one conversant with the problems of commercial selling will gainsay the advantages of display trailers as an effective tool in the hands of the salesman. To bring an alluring show window to the prospective buyer has been the ideal of many a sales manager. This is exactly what the display trailer is accomplishing. The adoption of the house-trailer to display use is certain to have some far-reaching effects on sales methods.

At present, the varied products being displayed in trailers range from medicines for pre-natal care, and obstetrical instruments, to caskets and religious instructions. Such vehicles have the advantage of full-line displays, privacy, mobility, and spot delivery of small articles. They may become mobile retail stores, selling a wide variety of products (see Fig. 4).

Rubber-tired transportation is an integral part of modern life and has completely changed many of the current ways of living. The future will hold as many changes in the use of this new means of transportation as the past. It has been the experience of the past that the second twenty-five years of an industry always shows the greatest progress. The motor-car industry is only well under way on its second twenty-five years. It will make more use of highway transportation as better, and more adequate, roads are provided.

Assuming that the trailer is here to stay and that its production is only in its infancy as an industry, road requirements will be changed to supply these new needs. Highways will have to be wider, with wider bridges. Many more turn-outs for parking, repairing, preparing roadside meals, and feeding the baby, will be necessary. The responsibility will have to be fixed for over-night parking facilities. Will there be private ventures promoted by gasoline stations and others, or will communities provide the space as they did for tourists using tents? Combined with these questions are problems of water supply, power outlets, and sanitation as well as social problems of education for children, taxation, effect upon the birth rate, police and fire protection, and a host of others.

It appears that trailer camps will fall into five general classes, according to the use to which they will be put. These uses can be listed as follows: (1) Stop-over camps; (2) vacation or recreational parks; (3) semi-permanent and permanent parks; (4) de luxe parks; and (5) display trailer marts.

Conclusion

The highway of the future must be as different from the present highway as the automobile of the future will be from the present automobile. One thing is certain; the future will demand change. As an automotive engineer, the writer does not know how the civil engineer will accomplish his results. There will be (in fact, there are now) certain fundamental requirements that have not always been incorporated in roads: The best road for the automobile

will have the least obstructions to the steady flow of traffic. Whether this means limited-access "free ways," such as Germany is building in its Reichsautobahnen, is difficult to state. Neither can one state definitely whether the engineer should build elevated highways, longer curves, wider roads, underground highways, more grade separations, better surfaces, or create new road materials, to solve the problems. Civil engineers are in a much better position to make surveys and to design roads than automotive engineers could ever be, if they are given the opportunity.

Neither group is suffering from a lack of information on how to handle the problem. Any expert could design and build a suitable safe road to connect two cities, or to cross a large urban area, if he were given the job to do it as he really thought it should be done; but there are too many other than straight engineering problems with which to contend. Probably one of the greatest problems is to prevent diversion of tax money collected for roads into other channels. The money collected for roads should be used for that purpose and not for building city halls, jails, and other projects. To concentrate on the worst of problems: First, solve the means of handling traffic on the most congested routes; and then build the main streets to handle their traffic faster and with greater safety. Instead of trying to solve all problems at once, solve the most pressing ones first. If this is done in a systematic manner, the highway system in the United States will be the best in the world within a few years.

Men in the automobile industry believe that a highway system, should be based on traffic surveys to determine requirements for the types of roads designed to carry traffic safely. Such a plan would require a primary system of high-speed highways crossing the country in all directions. It is estimated that about 50 000 to 60 000 miles of such super-highways would be sufficient. Leading from these would be a secondary system of good highways serving small cities and towns. The third system would consist of land service highways serving rural areas. In addition, a similar system is needed, in miniature, to carry the traffic in large cities.

The best type of road should embody all the knowledge the highway engineer has at his command for building a safe roadway to carry motor vehicles at a reasonably high speed. Where it is necessary, it should be above or below the ground. In any event, it should be a limited-access "free way" designed for the one purpose of carrying traffic smoothly. Where roads do lead into it, they should be provided with accelerating lanes so that traffic will not be interrupted by new vehicles entering from the side. Everything should be done to make for a free, uninterrupted flow of traffic. Crossings should be eliminated, curves should be banked, long-sight distances should be provided, bridges should be wide, and all "bottle necks" eliminated. Traffic lanes should be separated to prevent "side swipes" and head-on collisions. Surfaces should be non-skid. Where it is necessary, adequate signals and signs should be installed. The entire system should be governed by a uniform set of traffic regulations made to fit the new conditions.

This entire highway system should be paid for by the motorist. However, all the money collected from him in taxes should be used for this purpose. The automobile owner pays more than $1 000 000 000 per yr in taxes without much

complaint as long as he knows his money is going for good roads. In some years almost one-fourth of his money has been diverted, directly or indirectly, to other uses. This "rifling" of the road funds must stop if the United States is ever to have an adequate highway system.

Acknowledgments

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THE TREND OF MODERN HIGHWAYS

By Thomas H. MacDonald,[2] Esq.

Synopsis

Highway construction and use are undergoing changes that are relatively slow but none the less sure and continuous. Changes in motor vehicles, in the sources and amounts of highway revenue, and technical advances in road-building methods, are some of the more important factors that will influence future highway trends.

Scientific highway planning and administration are necessary to provide highways to serve urban and rural needs with the road-user taxes that can be made available. Factual data are being provided that will permit the scientific planning of State-wide and nation-wide systems. This is the outstanding trend in the highway field.

Stabilization of soils to produce foundations of predictable behavior, elimination of intersections at grade with railroads and other highways, and provision of facilities for free flow of traffic from congested to suburban areas, will be important parts of future work.

An important beginning has been made in construction of super-highways and such work will be continued. Present policies indicate that their location will be integrated with population centers, and that the layout will not be on the transcontinental basis.

Introduction

Any attempt to reach far into the future of highway development invades a speculative field if limited to isolated examples of the unusual. However, if taken as a whole, each of the major public undertakings changes slowly in character through definite causes. These changes, if relatively slow, are none the less sure and continuous, depending upon the rate of progress in science and invention and upon movements in the social structure.

The most important causes of change in highway utilization and improvement, viewed nationally and in the mass, have in themselves a variety of checks and balances which determine their actual course and influence. For example, the national market for large numbers of motor vehicles has resulted in the investment of so much capital, the growth of industrial plants of such large dimensions, and the establishment of such complicated routine of production, that year-to-year changes in the product are limited by the necessity of conserving the investment in plant, by the requirements of mass production, and by considerations of time. Thus, the change in the motor vehicle becomes definitely pronounced over a fairly long period, rather than from year to year.

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The most serious loss in the highway investment over the decade 1928–1938 is the obsolescence resulting from changes in the number and speed of motor vehicles operating on the highways.

The revenues accruing to the public treasuries from the special taxes levied upon the motor vehicle and its users in all the various forms have been increasing in their total over a long period except for the temporary recession during the worst of the depression years.

First intended and levied for highway improvement, the growth of income from these special taxes should permit highway officials to build more adequate and, consequently, more costly roads. However, because there have been large diversions of this income to other purposes, and because these funds have been spread over an ever-increasing mileage, many States are faced with a constantly growing financial dilemma.

Highway research is moving forward steadily on many "fronts," with definite objectives. The responsibility for carrying on intensive studies, in the physical and economic fields, has been accepted as a continuing obligation by highway engineers and scientists in allied fields. Concurrently, the necessity for greater street and highway safety has become a national emergency.

These are only a few of the factors that will determine the trend of modern highway development, but they are the most important.

Scientific Planning and Administration

Faced with the constantly increasing demand for the construction of new highways and the spreading of the income over a rapidly growing mileage, highway officials, State and Federal, realized the impossible situation which was developing and which, in a number of States, was actually current. Out of this situation was born the State-wide highway planning surveys which are now (1938) being conducted co-operatively in forty-four States and in the Territory of Hawaii. These surveys and supplemental studies will present a factual basis upon which to plan the complete administration of all the highways based upon sound principles and factual data. One of their important phases is the determination of the relation of the highways to other types of transportation and communication and to population distribution.

Beginning with water transportation and continued by railroad development, the influence of transportation in the past has been exerted to concentrate large populations in small areas. It is only necessary to examine maps of the United States, or any other country, to visualize clearly the concentrations of population in cities which have resulted inevitably from the characteristics of waterway and railway transportation.

Highway transportation by motor vehicle is the first great decentralizing transportation agency. The first notable effect of this dispersing influence is the formation of the wide bands of suburban development around the cities. Even cities of moderate size have developed, within a decade, a suburban band 5 to 10 miles in width (and depending upon topography) partly or completely enveloping the old city. The automobile, in conjunction with rail suburban service, has attracted city workers to make their homes in rural districts for distances easily as great as 50 miles from the city.

The next logical step is the break-down of over-sized industrial units into smaller units that will be free of many of the undesirable characteristics of over-concentration, yet will be of sufficient size to retain the economies of mass production. Sufficient progress in this direction has already occurred to indicate how inevitable must be this process even if slow. It is reasonably well established that economy of production can be secured in units of moderate size, and the national thought along social lines is becoming a potent force toward decentralization because of the opportunities presented for a more healthful and more desirable mode of life for the workers and their families.

It will be noted that no conjecture or uncertainty is involved in these statements, but simply a recognition of existing facts. The implications are clear that the scientific planning of highways and highway systems of State-wide and nation-wide dimensions will be the most characteristic trend in highway development.

Without such scientific administration there will be no possibility of providing adequate highways to serve both urban and rural needs, or to keep the cost of highway improvement, including maintenance, within the limits of revenues that can be raised by reasonable road-user taxes. This means a reversal of the present trend in many States where the maintenance cost of the rapidly growing mileage of local, poorly built roads is mortgaging far too large a portion of the highway budget. This situation has been produced largely by legal mandate and other public policies adopted and pushed into effect without any consideration for sound highway administration. The nation-wide movement, through the State and Federal highway departments, to place highway administration on a sound economic engineering basis, is not only the most important trend, but is also the cause of other trends which, on this account, may be predicted with some certainty. Out of the planning surveys will come definite specifications for the division of highways into groups classified by the service they are called upon to perform. By research and experience the details are being rapidly defined, that will determine the general type of highway design for each highway service group. In this field the principal items will be the alignment with limiting curves, sight distances, the number of traffic lanes, their widths, the shoulder widths, divided roadways for multiple-lane highways, and many other details.

Design Problems

The trend here is, first, to classify highways, based upon service, and then to design closely in accord with the classification—contrasting with the all too prevalent practice, in the past, of applying single standards to long mileages, and without change, to roads of widely varying traffic service requirements.

In the field of highway design, the most important single development is found in the possibilities of soil stabilization. The intensive research work of more than a decade has borne fruit in the understanding that now exists of the physical and chemical properties of soils, and methods of utilizing the knowledge no longer stop at mere superficial applications to the immediate sub-grade, but go further, to affect the entire graded road-bed in both cut and fill sections. Among the most important additions ever made to the highway organization are the soil technician and his specialized soils laboratory. The application

on a broad front, of this new knowledge will come as rapidly as engineers may be given the specialized training, and as a result there will be, for the first time, the possibility of building really scientifically designed roadway sections since these will be placed upon foundations of predictable behavior.

With a large program of grade separation under way at railway and highway intersections, and with the changed public policy in paying construction costs largely from public funds, grade-crossing elimination has become a fixed policy that will continue until all important railway-highway grade crossings have been eliminated, and minor ones protected by adequate devices.

This same policy is being rapidly extended to the separation of important highways at intersections, and one of the important trends of highway design in the immediate future will be to rule out intersections at grade as a possibility in efficient highway design.

In this connection, incidentally, the widespread use of "stop" and "go" lights is not a solution for traffic movement, but has been a development of necessity imposed upon a system of highways designed and built before the present dimensions or speeds of highway traffic were considered possible. Obviously, the trend of highway improvement in the future must be to provide flow arteries in the congested-area traffic that will permit continuous flow of traffic from down-town areas well into the suburban areas. Although the cost will be high, it is only through such arteries that capital, invested now in land and buildings in the hearts of the business districts, can be even reasonably preserved.

The pioneer roadway, even on main traffic routes, was conceived as the single important objective. Now, with the recognition of values inherent in highway transportation beyond the bare utility, the roadway design has come to embrace the entire right of way. The trend of modern design is to provide landscaping of the roadsides, sidewalks, foot paths, bridle paths, and to stop, and protect against, soil erosion. The required additional attention and expense are paying large dividends through greater durability and through the recreational values inherent in attractive waysides.

Super-Highways

There is more or less discussion in which the term "super-highways" is used without any adequate definition of what is intended by this term. Perhaps, it is more frequently used in connection with a very limited number of transcontinental highways designed for high speed and with multiple-lane roadways to carry traffic from coast to coast.

The German system of super-highways embodies this idea. In that country a system of about 4 500 miles of highways (which gives approximately three lines across the nation in each direction) is constructed on entirely new, wide rights of way without access from abutting lands, except at infrequent intervals. This design is for high-speed, motor-vehicle, through traffic. The travel section is composed of two roadways about 30 ft wide, separated by a parking. Both the horizontal and the vertical alignments are exceptionally good. All cross-traffic is directed over or under these highways. No detail that comes within the purview of highway engineering that will make a safer or more effi-

cient highway has been omitted. The most advanced highway design technique has been embodied in this development. The economic utilization is not so clear.

In the United States there is need for a considerable mileage of highways having similar characteristics, but the disposition of this mileage, to be most efficient, must be planned on the basis of the careful studies now going forward. The system of German roads is being built in advance of, and to promote the development of, highway transport. In the United States the situation is just the reverse. Highway builders are proceeding on the principle that the utilization of the highways must produce directly the revenues with which to finance their construction. As long as the United States adheres to this method of financing, the building of super-highways must be limited to areas where the present and prospective traffic will justify it. As a trend of highway development, it is apparent, from the important beginnings already made, that a considerable mileage of motor super-highways will be developed, that their location will be carefully integrated with the population centers, and that the layout will not be on the transcontinental basis.

In France, where a system of national roads has been developed over a long period, the present construction is to take care of the traffic around the metropolitan districts, particularly the vicinity of Paris, by a system of circumferential and radial roads in combination. The detail of outstanding importance in this design is the separation of cross-traffic.

From the developments abroad and in the United States, one can conclude that super-highways will be created, but only in the vicinity of metropolitan areas, for relieving traffic congestion within these areas and for connecting those that are separated by relatively short distances. The first function has already been served to a considerable extent by parkways. It is logical that there will be further developments of the type of the Blue Ridge Parkway designed to connect the Shenandoah and the Great Smoky Mountain National Parks. The development of such parkways recognizes the large use of motor vehicles for recreational purposes.

The Influence on Population Changes

Finally, the power of highway improvement to accelerate the shift of population from areas of low productive potentials to those more favorably conditioned will be consciously used in the national policies developed for the long-term attack upon land-use problems. A definite start is already being made in this direction and will become more apparent in the layout of the system of secondary or feeder roads. This thought definitely emphasizes that the country has completed the pioneer stage of road development and every trend of highway development of the future must be an intelligent meeting of the particular service to be rendered.

TRUNK-LINE HIGHWAYS IN METROPOLITAN AREAS

By Leroy C. Smith,[3] M. Am. Soc. C. E.

Synopsis

Elements essential to a master plan for trunk-line highways are discussed in this paper. The application of such a plan to the Metropolitan Area of Detroit, Mich., is offered as an illustration.

Introduction

Metropolitan areas in the United States are still in a condition of flux—the lines that might confine such an area to-day will, in general, be outgrown to-morrow; the uses made of any part of the area to-day may not be the uses of to-morrow; the pleasure route of to-day may become the industrial highway of to-morrow; the traffic and population of to-day will be greater to-morrow; the cross-roads at major highways of to-day may be a secondary center of to-morrow; and, unless the hub of the area of to-day is adequately served by arterial routes, it will not be, to the same extent, the hub of to-morrow.

Certainly, no one influence has been more responsible in giving impetus to the changes that are occurring in metropolitan areas, and to the uncertainties of the ultimate crystallization that may occur, than the automobile; and, certainly, there is no saturation point in evidence in the usage of automobiles or in their numbers. In the first place, the ratio of the number of automobiles to the number of people is still on the increase and, at the same time, the population is increasing. In the second place, it is becoming increasingly apparent that the sphere of use and influence of the truck and bus is enlarging, and it is dangerous to attempt to define their probable limitations.

This condition of flux and uncertainty as to the ultimate demands that may be made on trunk-line highways in metropolitan areas would present a much more complicated problem to the highway engineer in planning for the future, if it were not for the axiomatic fact that the essence of the solution lies in providing adequate right of way, and that such right of way is essential to any plan and to any use which may ultimately be made of any such highway.

Essential Elements of a Plan

The first step must be a plan providing for a system of trunk-line highways, so located and of such widths that the future highway requirements of the entire area can be met. Although, perhaps, it may be necessary to reinforce such a plan with layouts showing the ultimate developments requiring those widths, the engineer should remember that radically different details may be required to meet the results of changing conditions, but that with adequate right of way available the future can be viewed with confidence.

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[3] Chf. County Highway Engr., Wayne County Road Commrs., Detroit, Mich.

Such a plan will provide for certain distinct locations and frequency of trunk-line highways to serve the various primary needs of the area, and will include:

(1) Arterial highways piercing to the hub of the area from the hinterland outside the area.

(2) Traffic headers or trunk-line loops which may serve several purposes, such as:

(*a*) Permitting through traffic to by-pass congested areas and to avoid the hub of the metropolitan area.

(*b*) Distributing traffic of the several arterial highways to the local street system and *vice versa*.

(*c*) Meeting the demands of periods of peak loadings, such as Sundays and holidays in the case of pleasure traffic, or daily commercial peaks and seasonal conditions affecting industrial traffic.

(*d*) Cross-town arteries for local traffic. Ultimately, in many cases, this may become the major function of certain such headers or loops.

(3) Boulevards and parkways for the exclusive use of pleasure traffic and to serve the recreational needs of the area.

(4) Secondary highways which are not quite trunk line in character but which are dispersed at frequent intervals as major local streets within the trunk-line network.

(5) Some of these trunk-line highways must meet the present and ultimate needs of mass transportation, whether on rails or rubber.

(6) Express roadways with separated opposite-direction free-traffic lanes may be provided in certain highways; or, the entire highway may become an express-way from which local traffic is excluded, except at long intervals and definite points; and, in still other cases, the entire highway may become a free-way without vehicular access from abutting property.

(7) Such trunk-line highways must almost invariably serve the needs of the area as trunk lines for public utilities, and inadequacy of right of way, in addition to cramping the highway possibilities and increasing the cost of the ultimate highway development, will affect the utilities in the same way. The public pays the cost of both. The minimum provision for such utilities may become a controlling factor in determining the width of the right of way in certain special cases, as, for example, a trunk line that becomes a subway route.

(8) Super-highways having sufficient right of way to permit all highway functions to be combined in one highway at grade, including provisions for mass transportation and local service to abutting property and complete grade separation and interchange at major intersections. In certain conditions such a super-highway may carry several highway functions on an elevated structure in a right of way sufficient to contain such elevated structure adequately, and the elevated structure may become a free-way without depriving abutting property and local traffic from the use of the highway at grade.

(9) Double-decked streets in which the entire right of way is used on two levels. This is a special case applicable generally only in extremely congested

areas where a built-up condition and right-of-way costs preclude other solutions. This subject will not be dealt with in this paper.

(10) Parking facilities. It is a moot point whether such facilities should be provided in highways.

Except in the case of a few of the major metropolitan areas of the United States, and except for the present need of widenings or other provisions to relieve "bottle-necks" and lack of capacity existing on arterial streets of most cities, there is usually no immediate necessity for making or deciding the ultimate structural development of the system of trunk-line highways. The immediate need is for a system of rights of way of adequate width and location and if that need is recognized, the future is reasonably insured. Structural development of such rights of way can be progressive as the need arises.

Right-of-Way Width

The Master Plan for the Metropolitan Area of Detroit fixes a minimum width of 120 ft for right of way of trunk-line highways. For secondary highways, as mentioned in Item (5), the plan calls for a minimum width of 86 ft and, for super-highways, a width of 204 ft.

Boulevards serve as something more than traffic arteries and the right of way must be sufficient not only for traffic needs but also to permit some beautification and park characteristics. A right of way 150 ft wide is a practical minimum and will permit two roadways each 36 ft wide, a center parkway strip, 38 ft wide, and 20 ft on each side for pedestrians, plantings, etc.

Parkways are essentially long narrow parks, served by an included roadway which is not directly accessible to local abutting property, and are generally planned to have grades separated at major intersections. The right of way is usually variable to conform to local topographic features; at minimum sections, however, it should not be less than 200 ft. Topographically, parkways often follow streams; they utilize low-lying stream valleys and, in such locations, can often be carried into and through comparatively well developed areas at relatively small cost, thereby replacing unsightly stream-valley dumps with a value that will enhance parkway facility.

Master Plan for the Metropolitan Area of Detroit, Michigan

In 1925, acting in conjunction with the Rapid Transit Commission of Detroit, the authorities controlling streets and roads in the metropolitan area adopted a Master Plan for the area. Although the plan dealt primarily with conditions within a 15-mile circle from the City Hall, the essential elements extend over a much larger area.

The plan provided that on each section line a right of way 120 ft wide would be available and that at every third section line the right of way would be 204 ft wide. The right-of-way width for roads on quarter-section lines is 86 ft. In addition, it provided that the right of way for the six major radial arterial highways (Fort Street, Michigan Avenue, Grand River Avenue, Northwestern Highway, Woodward Avenue, and Gratiot Avenue) would be 204 ft wide beyond the Six-Mile Circle (approximately) and 120 ft wide within that

circle. Actually, these radial arteries have already been made 204 ft wide, and the system of 120-ft highways has been adhered to for many miles beyond the 15-mile limit of the original plan.

It may be well to explain that these radial arterial highways are of more than local significance and are, in fact, the major routes to the various sections of the State and to the neighboring States.

Five radial highways were established in 1825 under the direction of Governor Lewis Cass as the five great military highways for this section of the country. With a right-of-way width of 100 ft (which in many cases has since been encroached upon), they radiated in all directions and comprise the River Road, from Detroit to Perrysburg (Toledo), Ohio; Michigan Avenue, from Detroit to Fort Dearborn, in Chicago, Ill.; Grand River Road, from Detroit to the mouth of the Grand River, at Lake Michigan, on the west coast of the State; Woodward Avenue, from Detroit to Fort Saginaw, Mich., the major artery running north through the State; and Gratiot Avenue, from Detroit to Fort Gratiot north to Port Huron, Mich. (serving the "thumb" district of Michigan).

These five arteries are now super-highways under the plan, except River Road, the major portion of the traffic from which is locally taken by the Fort Superhighway. The sixth radial arterial highway, Northwestern Superhighway, is of recent origin and, although at present it terminates in the resort lake region of the adjacent county, it is ultimately projected to be extended northwesterly through the State to Ludington, on Lake Michigan.

Fig. 5 shows the Master Plan. It will be noted that more than 80% of the 204-ft rights of way for super-highways has already been secured as well as most of the land for all lesser widths. Furthermore, on the super-highway sections of the aforementioned six radial arteries, double pavement sufficient for present needs has been built, and the same is also true on seven other superhighways (Base Line, Mound, Kelly, Stephenson, Southfield, Schoolcraft, and, partly, on Telegraph).

In addition, 38 miles of the 42 miles of the Outer Drive have been constructed as a boulevard on a 150-ft right of way and many of the 120-ft trunkline highways have been developed. Several parks have been acquired and developed, a plan for parks and parkways has been adopted, and a parkway more than 8 miles long has been completed on right of way varying from 250 ft to approximately ½ mile in width.

This progress since 1925 (when practically no right of way wider than 100 ft existed for any of these highways and only an inconsiderable part of that width) has been attained on a pay-as-you-go basis, without bond issues, and has been largely due to the following factors: (1) The unanimous adoption of a plan; (2) legislation enforcing the plan on sub-dividers of property; (3) adequate condemnation legislation; and (4) conserving automobile taxes to highway uses.

In respect to radial arterial highways, the Master Plan provided that they would be super-highways and the reduction from 204-ft width to 120-ft width at the Six Mile Circle (approximately) was predicated in layouts showing that, by carrying provisions for mass transportation in a 4-lane or 4-track subway


Auburn
Road
Hall
Road
Rd.
Telegraph
Woodward
Road
Crooks
East
Long
R.
Lake
Dequindre
Road
Lahser
Road
Adams
John
Mound
East
Maple
Road
Fourteen
Mile
Road
Stephenson
Thirteen
Mile
Road
Gratiot
Twelve
Mile
Road
Reid Hwy
Eleven
Mile
Road
15-Mile Circle
Northwestern
Ten
Mile
Mound
Road
Kelly
Nine
Mile
Road
Base Line
Base Line
Middlebelt
Outer Drive
Woodward
Outer
Gratiot
Grand River
Drive
Schoolcraft
Plymouth
Plymouth
Joy Road
Greenfield
Warren
City Hall
Detroit
Ford
Riverside
RIVER
Tecumseh
Michigan
Windsor
Ford
Outer
Southfield
Drive
Sandwich
Vanborn
River Rouge
Ojibway
DETROIT
La Salle
6 Mile Circle
Goddard
Fort
Jefferson
Eureka
Toledo
Middlebelt
12 Mile Circle
Telegraph
Fort
River Road
LEGEND
Right-of-Way Widths
204-Ft Width Superhighway
120-Ft Width Major Thoroughfare
Right-of-Way Acquired
Supplementary Plan for Extension of 204-Ft Superhighways Through the City of Detroit
Pavement Widths
Greater than 20 Ft
20 Ft or Less
Gravel Roads
0 1 2 3 4 5
Scale in Miles

FIG. 5

below the 120-ft street, that street would have approximately the capacity of the 204-ft super-highway.

The congestion of surface traffic on these radial arterial streets within the Six Mile Circle had already reached a stage which demanded immediate widening, and the width adopted was 120 ft, with the aforesaid layout as a background. Since that time these widenings for Woodward, Gratiot, and Michigan Avenues have been almost completed, a start has been made on the others, and steady progress is under way toward ultimate completion of this element of the plan. Thus, the entire original Master Plan is almost a reality to-day (1938) in so far as ultimate widths of right of way with sufficient development for the needs of to-day are concerned.

Supplementary Plan

With these several great super-highways converging toward down-town Detroit, the Wayne County Road Commission believed that they should be extended into, and connected across, the city proper on similar widths of right of way. Accordingly, a plan to accomplish this end was presented in a report to the County Board of Supervisors and adopted in principle. This plan calls for the widening of unimportant streets through the unprosperous area of old Detroit to provide new 204-ft thoroughfares. By means of 61 miles of such highways, all the outlying super-highways will be connected to a down-town loop approximately 1 mile square. This supplementary plan is shown in Fig. 5.

In presenting this plan the Road Commission was influenced by the following considerations:

(1) It is improbable that the few arterial streets that are being widened to 120 ft will prove adequate if the central section of the city is to be properly served in the long future and if the high values and concentrated uses of the down-town area are to be preserved.

(2) The cost of utilizing these 120-ft streets ultimately to accommodate the future capacity of the 204-ft super-highways feeding into them, will be so great that the excess cost in sub-surface works would finance a better and less expensive plan and additional and more adequate arteries in other locations.

(3) The supplementary plan would open blighted areas to renewed prosperity and would traverse sections of the city now inadequately served. The street widening in stagnant sections, where lots and buildings are of little value, will increase values along these new thoroughfares, the highest type of development will be attracted to these broad thoroughfares, and the central area of Detroit will be enabled to expand to meet future demands.

(4) The width of 204 ft can often be secured at a cost not appreciably greater than a much lesser width.

Having in mind the general street layout it is found that, in condemnation processes to widen a street to 120 ft, the taking line, whether the widening is on one or both sides of the street, passes through all buildings. The result is that the award, besides covering the land taken and damages to the remainder of the land parcel, also includes a value for the part of the building taken and damages to the remainder of such building as well as an allowance for business loss during

alteration. These latter items approximate the reconstruction cost of th building.

On the other hand, if the widening is all on one side of the street and if th entire parcel is taken, only the present value of the property is involved, an that value may be less than the composite damages awarded. If the widenin is so laid out, it will generally produce a street width of at least 186 ft, includin the present street (say, 66 ft), the lot depth (say, 100 ft), and the alley widt (say, 20 ft). In many cases it will produce even more, but in any event th condemnation of an additional strip, 18 ft or less in width, off the rear of th next and much cheaper series of lots, will produce the desired 204 ft.

Rapid Transit by Rail and Express Highways

Rapid transit, whether on rail or rubber, demands freedom from traffi lights and from local traffic interference. Although express highways and free ways built at grade with grades separated at major intersections may b possible for outlying districts, the permanence and adequacy of such a solution as the future develops, is open to question. Exclusion of local traffic and o abutting property from use of the facility, if at grade, makes of it a Chinese Wal as the territory develops. To be effective rapid transit by rail and express highways must be above or below grade and local needs must be met at grade.

Layouts and perspectives prove the possibilities of the 204-ft right of way to permit facilities for mass and rapid transit on rail and on express highways, together with adequate surface facilities for local traffic. Furthermore, at intersections, such right of way will permit complete grade separation and, at the same time, complete local interchange. In the case where these rapid transit facilities are on an elevated structure, it will be noted that the area below the structure provides valuable parking space in addition to location for surface street cars. It will be noted, furthermore, that if in the future mass transportation on rubber rather than by rail becomes the rule, a much simpler structure can be adopted.

The usual objections to elevated structures are minimized or overcome if the street width is such that adequate roadways at grade flank the structure, and under such conditions the structure can become one of beauty rather than ugliness and, through proper design, noisiness can be reduced to a point where it becomes non-objectionable. In general, where such an elevated structure accommodates both rail and rubber express-ways the part of the width utilized at one point for express loading platforms will be used at another for local loading platforms of the rail facility, and at still other points will be utilized by the ramps to and from the motor express-way.

Another plan for express-ways or free-ways which is worthy of consideration to meet the needs of arterial highways in congested districts where property values are high, would entail the use of the alleys at the rear for single-direction elevated express-ways. This is particularly applicable if there is a legal method provided for condemning air rights.

Assuming a 20-ft alley, the construction of a 30-ft express-way would entail the use of approximately 8 ft of air rights on each side of the alley; a 40-ft express-way would require air rights over approximately 13 ft on each side.

In addition, unless it proved feasible to cantilever the part of the structure occupying the strip of air rights, it would be necessary to condemn occasional small areas (probably at the lot lines) to accommodate columns and footings.

At long intervals such express-ways would be served by ramps to and from the surface and, at those locations, additional condemnation will be unavoidable. The space under such a structure, on private property, could serve all present uses; or it could be enclosed to enhance those uses, or to provide new uses. The height of the structure would be governed by present uses and by minimum clearances at cross-streets or at crossings of similar elevated structures. The cost of increasing the height to meet local considerations is relatively small.

Given legal condemnation of air rights still another plan is applicable in certain instances. Predicated on the fact that railroad rights of way pierce most cities in a strategic manner, the use of air rights for elevated highways over such available routes would add express-ways or elevated highways for industrial uses where they would be most effective. However, consideration of such a plan must include weighing carefully certain opposing factors:

(*a*) It is important that the elasticity of the railroad facility to expand or to be altered to meet future needs be conserved (this is as important as any highway function).

(*b*) Such a plan may entail partial or complete electrification of the complicated terminals of the railroads at a cost that would preclude its further consideration.

Another general observation on the problem of rapid transit by rail or express-highways is that sub-surface structures are almost invariably much more costly than elevated structures. In many cases the excess cost of a facility of ample proportions below grade is so great that new and ample right of way in parallel locations can be secured and served by an elevated structure at less cost.

Furthermore, the use of sub-surface structures is much more inelastic; if designed for rails, it cannot (except with further additions at great expense) be used for highway traffic. On the other hand, the change from a rail facility to a highway facility, or *vice versa*, is easily accomplished in an elevated structure.

Parking

It is difficult to foresee what the future may demand in the way of parking facilities as an adjunct of the highway.

In considering long-range highway and street plans the engineer should not pass the parking problem with a gesture and the assertion that parking is not a highway function. Perhaps the following comments may point to a future trend:

(1) The automobile owner now pays the cost of parking and at a high rate. The money comes from the same pockets as the highway money, and the expense is an unavoidable part of the cost of the highway transportation system.

(2) The present investments in covered parking facilities run into millions and, in addition, the public pays an enormous price for parking in open lots.

(3) Perhaps the cost of this element of highway transportation would be less if it were planned to be included in the highway system and, with adequate rights of way, it is conceivable that sub-surface regions, or elevated layouts, could be utilized for the purpose. In cases where ultimate development of the trunk-line highway in congested districts is through the use of elevated structures flanked by streets at grade, the space at grade below the structures may become a valuable parking area and its value in that regard may be a partial justification for the adoption of any elevated plan.

(4) If often occurs that all of a parcel of property or of contiguous parcels may be secured quite apparently at no greater cost than the pay needed for the highway width. Perhaps, if parking were recognized legally as a highway function, there would be justification for, and necessity could be proved for, taking such excess property for such use.

(5) The value of such facilities is recognized by business, particularly those businesses which are responsible for the growing trend toward decentralization through the establishment of smaller concentrated business centers in outlying districts. In many such cases the store or group of stores involved are providing free parking facilities (sometimes on a large scale) for patrons. This is perhaps a major factor in the growing success of such outlying business centers.

To a large extent such decentralization is at the expense of existing businesses and property values in the heart of the metropolitan area. To the extent that a plan aims to conserve such central values it should, perhaps, take cognizance of the parking problem as being a considerable factor.

Legislation to Make Plans Effective

A plan of a system of trunk-line routes with adequate right of way, adopted by all highway authorities of the metropolitan area, is essential to real and steady progress; but it is impotent and unproductive in the absence of legislation to enforce it, to preserve it from encroachments or abandonments, and to provide adequate methods for obtaining right of way by condemnation and otherwise.

Perhaps a review of the legislation of Michigan which has been found effective in creating, rapidly, a network of adequate rights of way in accordance with a definite plan for the Metropolitan Area of Detroit, may not be amiss even if the underlying constitutional provisions, highway laws, etc., may not be quite duplicated in other States.

The fundamental highway laws of Michigan set up jurisdictions, etc., as follows:

(1) Except as affected by home-rule constitutional provisions in the case of incorporated cities and villages, the State Highway Commissioner has jurisdiction over State trunk-line highways and is required to meet one-half the cost of maintenance, widening, and betterment thereof in metropolitan communities of the population of Detroit.[4]

(2) All other highways and sub-division streets and alleys, except in incorporated communities, are under the jurisdiction of each County Road Com-

[4] PA 131 of 1931 amending Section 1 of PA 10 of 1919.

mission. With the consent of the incorporated community such commission may take jurisdiction over any street or part thereof within the community. Such commission is also empowered to take over, in whole or in part, the obligation of any such community arising out of a contract with the State Highway Commissioner in conection with the widening or improvement of a street which is a State trunk-line; and, in connection therewith, or as may be entailed on streets taken over by the commission, it may condemn property within the community.

Super-Highway Law.—Shortly after the Master Plan for the Metropolitan Area of Detroit was adopted by all municipalities and highway authorities, an effective legal instrument was made available in the super-highway law[5] which included the following:

(*a*) A contract may be entered into by boards of supervisors, and a super-highway commission can be formed by any two or more adjacent counties; and such commission includes the three members of the respective County Road Commissions and the State Highway Commissioner.

(*b*) Super-highways are defined as including highways of widths varying from 106 to 204 ft, or more.

(*c*) It is the duty of the super-highway commission to prepare and record a plan of the proposed highways and their widths, and where there are existing highways the plan must show on which side of the road private property is to be used for the widening. After recording of the plan no plat of land shall be accepted which does not conform thereto.

(*d*) The law sets up a limitation of 0.5 mill property tax in each county for the use of the commission. Except to cover the initial office expenses involved, this section of the law was never utilized and, in practice, each road commission has acquired right of way at its own expense from other funds (automobile tax revenues).

(*e*) The commission can accept donations of land and property and dedications of land, and may purchase, option, or condemn land.

The major effect of this legislation was to enforce the plan on sub-dividers of property and through that provision alone dedication of many miles of frontage in accordance with the plan was secured without cost, thereby saving millions of dollars.

Approval of Plats.—If a plat of property includes county roads or State trunk-line or Federal Aid roads, it must be submitted to the County Road Commission or the State Highway Commissioner for approval before being eligible for recording.[6]

Abandonments.—Although a Court may vacate a plat, it cannot abandon any part of a county road or State trunk-line highway. Such highway can be abandoned in whole or in part only by the County Road Commission or the State Highway Commissioner as the case may be. Abandonment by the County Road Commission must be recorded. Thus, the right of way, once secured, cannot be abandoned except by these authorities.[7]

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[5] PA 381 of 1925.

[6] Sections 31 to 37, PA 172 of 1929.

[7] Section 66 of PA 172 of 1929; Section 18 of Ch. 4, PA 283 of 1909 being Section 3293 of Compiled Laws (1929) as amended by PA 135 of 1935.

Encroachments.—Title to any part of the right of way of a highway cannot be secured by adverse possession.[8]

Condemnations.—County road commissions and the State Highway Commissioner have several methods of condemnation available: (1) By jury under two Acts;[9] (2) by a commission of three appointed by the Circuit or Probate Court;[10] and, (3) immediate possession after hearing of necessity and after tender of damages estimated by the County Road Commission. If tender is not accepted, condemnation must be done by processes provided to determine damages.[11]

Set-Backs Without Excess Condemnation.—If lots at the rear of the lots desired can be secured by agreement and if owners of front lots will accept a set-back by agreement, this process can be adopted. In outlying districts this provision has enabled the purchase of much frontage at the price of interior lots.[12]

Conveying Title.—By statute, County Road Commissions are incorporated bodies and are empowered to convey title to lands held by them and which are not a part of, or required to be used for, a road or park.[13]

May Condemn All of a Lot.—County Road Commissions can take all of a lot (if such part is required for the public improvement) as will destroy the value of the remainder as a single parcel or lot.[12]

Needed Legislation.—To meet the future, as the need presents itself, legislation may become necessary for condemnation of air rights, and for the exclusion of abutting property from access to free-ways. Free-way legislation has been enacted in the States of New York and Rhode Island.[14] Quoting from *Information Bulletin No. 36*, issued by the Regional Plan Association of New York:

"This act [the Rhode Island act] is to be recommended for its directness and simplicity of treatment.

"The adoption of freeway legislation by these two States may be hailed as the beginning of the most significant movement in several years in the progress of highway development. A look into the future would envision the idea extended to the other states of the Nation, expanded to include county and local highway departments and perhaps influencing the program of Federal highway aid."

[8] PA 46 of 1907 and PA 314 of 1915.
[9] PA 149 of 1911 and PA 124 of 1883.
[10] PA 352 of 1925; PA 283 of 1909, as amended, being Sections 3986 to 3991 of Compiled Laws of 1929
[11] PA 352 of 1925.
[12] Section 1(a) of PA 124 of 1883, being Section 3785 of Compiled Laws of 1929.
[13] PA 283 of 1909, being Section 3984 of Compiled Laws of 1929.
[14] Chapter 2537 of the laws of 1937.

DISCUSSION

F. LAVIS,[15] M. AM. SOC. C. E. (by letter).—The writer has been much interested in the paper by Mr. MacDonald, whose point of view is based on actual practice; but so much has been written during the past year or two about the "Highway of the Future" that the layman will expect this to develop at once into a clear, uninterrupted, wide pavement with cars "sailing along" at 100 miles per hr, or faster, with no stops for traffic lights or interference by traffic police, no grade crossings, no cars stopped on the pavement or traveled way, all traffic lanes separated, and perhaps (the Utopia) no noticeable expansion joints to mar the smoothness of the pavement.

With this ideal situation, pipes, sewers, and conduits will be laid outside the traveled way, so that pavements need never be disturbed and these latter will be so durable that they need never be relaid. There will be wide shoulders and rights of way, and the roadside will be beautifully landscaped.

In 1937, a speaker was reported by the Associated Press to have told the National Planning Conference in Detroit, Mich., that, "The American street and highway system must be scrapped and rebuilt unless the automobile is to become a malignant growth." "We cannot," he said "look with tolerance upon shackles which fetter this newest servant of mankind"; and then he also blamed the highway structure for the great toll of accidents on it.

Apparently, it is to be taken for granted that in this Utopia, the motor vehicles themselves will be of supreme design and construction, built of materials that cannot fail, that will have no mechanical defects, that will, perhaps, take their fuel out of the air so as to avoid stopping, and will be driven by supermen from Mars. The latter is the most essential because the frail humanity of this day and age has apparently not cultivated the skill and stamina to take advantage of these transcendental highways and vehicles, and as one reviews the slow progress in the development of the human machine it scarcely seems likely that succeeding generations will attain the ability and skill to operate these super-motor vehicles about which so much is being written.

The writer is entirely serious in attempting to create this vision because it must be given consideration. It is being preached in many quarters, not by laymen alone but by engineers—engineers who claim that most of their fellow craftsmen have no thought for the morrow, no vision of the future. These statements must be given consideration, but consideration based on some sanity.

The writer is not unmindful of the developments in both cars and highways of the past thirty years, since the time that he bought his first car in 1908 and thought a 100-mile drive in a day was a feat, a perilous adventure, and a difficult, grueling task. Without effort, he can compare that car with the car of to-day, which will go the 100 miles in a few hours with almost no apparent effort either on the part of the car or of the driver; and he has no doubt that similar or even greater progress will continue.

[15] Cons. Engr., New York, N. Y.

After looking at these visions, however, engineers should look at the realities of this long-distance planning and attempted provision for the future and visualize the real status of their attitude toward the highway of the future (which is being built to-day), and think about these problems with sense and with their "feet on the ground."

It may be fairly claimed that highway engineers and highway authorities, without having indulged in any extravagant visions of the future, have contributed their share to this advance, and their progress to date has fully kept pace with that of the automotive engineer. There is no reason why they may not be expected to continue going along together.

The writer is not opposed to planning. For many years, while engaged in the planning and design of railroads, his work has been nothing but a long attempt to forecast the future properly and reasonably, and to build for the future, but always with the brake on his enthusiasm of having to "make a dollar earn the most interest." It seems to be a most desirable training for engineers to have been connected with commercial enterprises. Engineers building highways with public funds would do well to think, for some years to come, of the need of making public dollars earn the most interest rather than of providing special facilities for the few or of building highways for excessively high speeds.

It is trite to state that one should do the greatest good to the greatest number; but trite or not, it is one of the great duties of the engineer who spends public monies, and perhaps particularly that of the engineer who directs the spending of them for highways. This does not gainsay the fact that returns from the expenditures of public monies may reach the dollar stage, through health and happiness from recreation; but engineers should be reasonably certain that there is a real return some way or other, and that this return should be a return to the people at large and not to a special few.

Writers on highway subjects during the past year or two have very generally stressed two things: (1) The great number of highway accidents; and (2) the need of "building safety into highways." Strangely enough, many who have deplored the accidents and urged engineers to "do something about it," talk about designing highways for speeds of 100 miles per hr, or even more. They point to the fact that the motor vehicle is being improved every year and that when a highway is built it must remain unchanged for a long time. Consequently, one must build to-day the highway that will meet the requirements of 10, 15, 20, or 25 yr hence, and that, at first thought (and maybe on second thought) seems a very valid argument, particularly if the human element behind the wheel of the car is ignored.

The highest types of modern pavements may be expected to have a life of 20 or 25 yr, even under heavy traffic. There is no possible reason, therefore, for denying the responsibility of the engineer in laying them out so that the most use may be obtained from them during their life.

Accidents and accident prevention are primary topics of consideration to-day, and accidents on highways are a growing menace to the entire body politic. Furthermore, the prevalence of accidents is now tending to be greater in the

open country, in the rural districts, than in cities and congested areas. British experience in this respect, coincides with that of the United States, and a reasonable inference from this information is that excessive speeds are a predominant cause.

It has been quite generally stated that 85% of all accidents are caused by the failure of the human element, the driver of the car. On the other hand, it is claimed that accident reports do not show the extent or the occasions in which the highway structure itself is the cause. Admitting that this may be true, to some extent, and that, in some cases, faults of the highway structure may contribute to, or aggravate, accidents and possibly increase their severity, it still remains a fact that highway accidents are very largely the result of incompetent and careless driving and excessive speed. Here, again, British statistics and British observers are in accord with those in the United States. A New York State report[16] published in 1937 states: "So long as the motor vehicle is employed as a means of transportation the driver will remain the chief factor in the accident problem."

When writers refer so glibly, therefore, to designing highways for speeds of 100 miles per hr, they not only ignore this very definite fact of human fallibility but they probably are definitely increasing the accident risk. The writer does not believe that design for high speed provides a margin of safety for drivers at lower speeds. Few drivers are capable of driving faster than 40 to 50 miles per hr, with safety to themselves and to the other users of the highways.

This question of speed as it affects the design of highways and their cost is a most important one. Designs based on speeds greater than 50 to 60 miles per hr are not warranted to-day, or by any reasonable consideration of the future.

Most engineers visualize the highway of the future as something in the nature of the trunk-line military "autobahen" created in Germany, the so-called "freeways," or the parkways near New York City, N. Y., in Westchester County, and on Long Island. These are typical of high-capacity highways in open country. There are also the great arterial highways through congested areas such as New Jersey Route 25, from the Holland Tunnel to Elizabeth, of which the Pulaski Skyway is a part, the great West Side Highway in New York City, and others of a similar type.

In general, such highways have good alignment, gradients that do not require trucks to reduce speed rates, say, of less than 5%, and four to six traffic lanes with traffic in opposing directions definitely separated by a raised curbed strip, perhaps 3 to 5 ft wide.

All these very expensive roads, however, have been built to meet heavy traffic demands, and they carry large numbers of vehicles. It is well known, of course, that maximum traffic capacity is attained at comparatively low speeds, probably less than 30 to 35 miles per hr. There seems to be little reason, therefore, for assuming speeds much greater than this, certainly not greater than 50 to 60 miles per hr, in designing such roads.

[16] Annual Rept., New York State Bureau of Taxation and Finance, New York *Herald-Tribune*, July 18, 1937.

Probably the most important task that confronts highway authorities and highway engineers to-day is the provision of sufficient highway capacity to meet traffic demands. This means that new highways, built to-day, should have capacity for meeting the traffic demands of some years to come. Ability to estimate such demands with reasonable accuracy is a necessary qualification for all responsible highway engineers.

Such engineers also should have some reasonable appreciation of the economic relation of expenditures to highway capacity and highway use. Expenditures in this case mean total annual cost—that is, interest on investment, plus annual cost of upkeep. These factors should have a definite relation to traffic volume and operating costs. Of course, highway engineering cannot be entirely evaluated in dollars and cents but the nearer highway engineers can come to such evaluation, the nearer they will approach reasonable economic justification for the large expenditures they make.

The writer is inclined to believe that where there are legitimate criticisms of highway design and highway structures this is due to incompetent engineering rather than to any lack of engineering knowledge by those who keep abreast of the developments of the times. This, however, is not a failing confined to highway engineering alone.

Because of the general nature of highway work as part of a public works program, by which the appointment of engineers and the methods of their functioning may, in some cases, is dictated by political needs and exigencies, there is probably some incompetence in road design and construction and this is especially true in the smaller governmental units and rural districts. Such defects as result from this source cannot be enumerated or specified herein but the writer suspects that these are the defects that cause writers and commentators to refer to certain roads as obsolete before they are completed and to place the blame for accidents on such defects. The remedy is better engineering by properly qualified engineers.

Most important highway officials and engineers are fully alive to the necessity of meeting future needs, and know how to do it; but they evaluate these needs with some sanity and common sense. The writer, however, would like to mention, very briefly, some of the features of modern road construction that should receive general attention.

Most of the States to-day have reasonably well conceived plans of main and secondary highways and are fully alive to the need of adequate surveys both of terrain and traffic. The importance of securing ample rights of way is fairly generally recognized, but there should be a reasonable balance between providing for the future and the permanent alienation of taxable values. It is probably difficult to evolve any formulas that will guide the engineer in adjusting alignment and gradients to the topography. The old-time railroad locating engineer had his Wellington and values for curvature, distance, rise and fall, and rates of gradient. The highway locating engineer of to-day has little to guide him, but experience and judgment. It is here that communities and governments would be wise and well advised in procuring the widest experience

and best judgment. Those responsible for highway location should probably err (if they err at all) in laying out the best alignment and gradients they can, to fit the topography and terrain reasonably well. It is suggested that sight-distance diagrams should be developed, at least in all cases of doubt.

The present practice of separating the traffic on four-lane roads by a center strip may well be extended. There is some tendency to build traffic lanes wider than 10 ft. This is a question that should receive careful consideration as to its economic justification. Probably one of the most serious defects of some modern roads is their obstruction by stopped vehicles. Roadside filling stations and eating places probably serve a public need and help taxable property, but provision should be made for stopping vehicles off the main traveled way instead of on it. It is undoubtedly desirable that consideration be given to the provision of sidewalks, at least on some highways.

The provision of reasonably wide hard shoulders and proper forms of side ditches is now generally recognized both as a necessary safety measure and as an aid to increased capacity. It would seem advisable to have all roadside structures set back a reasonable distance from the pavement or traveled way.

It should not be necessary to refer to narrow bridges, except for the fact that so many exist as interruptions to the free flow of traffic on otherwise good roads. It should be a recognized necessary attribute of road improvement that the general newly established character of such roads should be maintained throughout the length of the improvement.

It seems generally desirable that new roads should be designed so that they maintain certain general characteristics of alignment, gradients, width of pavement, etc., for considerable distances; but there seems to be no valid reason, why if proper signs and signals are displayed, changes in these characteristics may not be made if adequate considerations exist to warrant them and drivers are properly notified. A certain standardization of warning signs and the method of their display is most desirable.

All these features are well within the purview of the competent, informed highway engineer of to-day. In view of the needs of the vast network of roads all over the United States, it is doubtful whether highway planners can afford to be too visionary. Grade crossings with other highways and with railways can only be eliminated in special cases. The construction of expensive "freeways" to facilitate certain traffic must be weighed against the needs of the entire highway net and particularly their effect on taxable values of adjacent lands.

Perhaps the time has come when the construction of toll highways for trucks may be considered, but this involves consideration of the economic effect of maintaining the railway system, which seems to be gradually drifting toward Government control and possibly support by the taxpayers. Both railways and highways are tending to become part of one general network of land transportation.

Viewing the entire problem as a whole, it seems that engineers cannot go much further to-day than to adopt the best current practice and to continue improving it as the need arises. What is really needed is to make certain that

highway problems are placed and kept in the hands of engineers competent to solve them.

No one expects to stand still, because standing still is really going backward; but, on the other hand, highway engineers are not to be stampeded into attempting to build highways for super-cars, driven by super-men who do not exist.

Engineers (that is, competent engineers) have always been as forward looking and alert as other people—perhaps more so. They should continue to justify that tradition, but should continue trying to make their dollars earn the most interest.

EDGAR DOW GILMAN,[17] M. AM. SOC. C. E. (by letter).—The Symposium entitled "Increasing the Traffic Capacity and Safety of Thoroughfares"[18] raised many of the same questions that the present Symposium now raises.

First, one wonders if, in giving consideration to traffic problems, the word, "traffic," does not mean the movement of all people and not just the movement of motor vehicles. Sidney J. Williams, M. Am. Soc. C. E., in his comment[19] on the Symposium, stated that "much attention has been given to the time lost by automobilists on account of pedestrians, but little attention has been paid to the time lost by pedestrians on account of automobilists." This is a "ray of light" that should be brightened. Traffic regulation should be for masses of people and not for individuals.

Second, although the writer's natural instinct would be to emphasize the importance of the Engineering Profession in traffic problems, studies of hundreds of accidents prove quite conclusively that only a small proportion of accidents are traceable to conditions in which pure engineering is a factor. In fact, there are data to indicate that as engineering improves conditions at certain points, the accidents increase rather than decrease. Some of the points in the city that are obviously the most dangerous have the fewest accidents. The obviousness of the danger seems to be one of the best deterrents to accidents that has been found. As roads are straightened, automobile drivers take more chances and are not as attentive. As a matter of fact, the situation can be summed up in this statement: "If people drove as they should drive, they could drive perfectly safely even in unsafe places."

Studies of events leading to an accident show that the vast majority of accidents are caused by influences that no act of engineering, short of complete separation and isolation of traffic lanes, could avoid. They are caused primarily by foolishness and carelessness, selfishness, lack of courtesy, and lack of consideration on the part of drivers of cars. No mechanical devices or physical rearrangement of streets can be substituted for the manner (or lack of manners) in which people handle automobiles.

The full question of engineering, although important, has been emphasized to the point where automobile drivers use the theory as an alibi for their own actions. This does not mean that the engineering should not be made as

[17] Director, Dept. of Public Utilities, Cincinnati, Ohio.
[18] Transactions, Am. Soc. C. E., Vol. 104 (1939), p. 440.
[19] *Loc. cit.*, p. 504.

beneficial as possible, but engineers are leading themselves into "the hole" of building up a point of view on the part of the public that accidents are the result of something they have done wrong or something they have failed to do, and that drivers themselves cannot be held responsible unless and until the engineering is something highly idealistic and hypothetical and beyond all practical means of attainment. The engineering should go ahead, but the emphasis should be placed on the drivers and not on the engineering.

Mr. Kettering states (see heading, 'Lighting—Road or Vehicle?"), "authorities agree on one fact: Night-driving conditions are far behind day-time conditions, and for one reason—lack of adequate lighting and glaring headlights." Many data have been published showing that accidents at night are more numerous than accidents in the day time and in many of the papers including such data the definite conclusion is drawn that this is due to the absence of light, without any consideration of the many other factors in night driving. Of late, a few writers have attempted to proportion these factors properly. Certainly there are enough other factors to justify some question as to whether lack of adequate light on streets and highways is the one reason for a greater number of accidents at night than in the day time.

Nearly all day-time driving is done by people who are soberly intent on the particular accomplishment of a business in hand. It is after the day's work is done that social functions and parties are held. Practically all the driving under the influence of liquor is done at night. Accident records show that this is a big factor. The element of fatigue enters into night driving to a considerably greater extent that it does in day-time driving. Many police records of accidents at night have the notation "Driver fell asleep." All the young men working, and in most cases those not working, use the evening to drive with their "best girls," and their attention is not always on their driving under these conditions.

A mere tabulation of the time of day that accidents occur does not present a justification for the conclusion that night-driving hazards can be reduced at least to day-time driving hazards by lighting the highways. Furthermore, some serious thought should be given to the question as to what would be the effect of illuminating certain highways and not others. It is admitted that it would be impracticable to light all. What will be the effect of lighting some to an extent that will make it safe to go at certain speeds, upon the speed of drivers on other highways where it would not be safe to go at anywhere near those speeds?

If the mental attitude of the mass of drivers could be "built up" to a point where good judgment could be counted upon, this would not be a problem; but in view of records of the immediate past is one justified in assuming that the drivers of cars in mass will exercise good judgment in the manner in which they drive? It is a strange commentary on the entire situation to say that if the streets were studded with cast-iron posts set in the road, requiring automobiles to be driven a tortuous and difficult path, there would probably be no accidents and no traffic deaths. Of course, there would be no speed and no mass movement in short times, and this is not desirable.

It is good engineering to pull out these cast-iron posts from the middle of highways so that automobiles can travel in straight lines, and engineers, very properly, study and eliminate these physical obstructions to movement; but it is a fair question to ask whether they are not improperly designating such things by saying that they are eliminating "hazards" when actually, due to the psychology of the situation, they may many times be adding an intangible type of hazard when they are removing a physical obstacle.

Sometimes, it seems that the public has placed the engineer in a very unfavorable position, that in which engineers are taking the responsibility even where it is not an engineering problem. Coincident with the study of engineering in traffic, engineers should constantly emphasize the fact that the effect of engineering can be but minor on accident records and that deaths and injuries and accidents are largely a result of the action of the people themselves. Although engineers will work to try to get greater utilization of motor vehicles, there is a responsibility on the part of the people who use motor vehicles over which the engineer can have no control.

This feeling that the engineer is responsible for the accidents has progressed to such an extent that there is a one-page article in a popular magazine of recent date rather strongly setting forth the claim that it is the duty of the engineer to separate roadways and crossings and make it impossible for children and pedestrians to get in the path of automobiles. It is a strange mind that can take such a position that this is the sole duty of the engineer. The engineering involved would present no great difficulties. The big problem in the accomplishment of such plans is that of financing, and this means taxes. Engineers can submit billions of dollars worth of plans for eliminating intersectional highway crossings in high-sounding terms of medial and other frictions. The plans will involve a multitude of details, but none that presents insurmountable engineering obstacles. The obstacle to such plans is in the financing and the payment by the public for such idealistic construction. The public has not been able to provide the necessary money with which to eliminate the relatively few railroad grade crossings, and yet in the article referred to the statement is made that it is "up to the engineer" to provide road separations and other tremendously expensive structures.

Engineers should not complacently permit themselves to be thrust into a false position in the traffic situation. They can do much to facilitate traffic movement if people will use their plans as they are supposed to be used. They can do something to add to traffic safety. They cannot do anything that will be a substitute for good judgment, common sense, and decency on the part of the man who has his hands on the wheel and his foot on the accelerator. The attitude of the public itself is the major problem in the safety angle of traffic. The public says it wants safety, but it resents enforcement and there has actually grown up a predominating belief that the problem of traffic safety is a contest in which the police and other enforcement agencies are on one side and the public itself is on the opposite side, fighting against each other. The problem of traffic safety is a problem of mass psychology—the establishment in the minds of the masses of people of the true factors that cause accidents. Engineers are too readily letting this fact sink into oblivion.

GEORGE HARTLEY,[20] ESQ. (by letter).—In the group of papers comprising this Symposium a valuable contribution to the art of planning future highways is ably presented. In his interesting résumé, Mr. Kettering has illustrated, splendidly, the possible future of highway travel. The entire Symposium would have been rendered more complete by the inclusion of a few additional details.

The major part of Mr. Kettering's paper evidently represents careful editing of replies to the questionnaire (Items (1) to (18) under "Introduction"), by the various contributors listed under "Acknowledgments." It would have been of interest had it been possible to include typical replies or edited replies, to show the range of opinion expressed by the various contributors. Views not directly in accord with those of the authors might have been discarded or considered insignificant.

Each of the authors attacks the problem from a theoretical engineering standpoint with only a slight reference to the importance of motor vehicle laws and their relation to engineering design. What good will a highway or motor vehicle, designed for, say, 80 miles per hr, be if some provision is not made to bring the law into such form as to allow speeds approaching this value. Engineers are constantly thinking in terms of increasing speed but, to-day, even on well traveled secondary highways, posted speed limits of 15 and 20 miles per hr are not uncommon and the main express highways, rigorously patrolled, keep travel at a speed representing only a fraction of that for which the highway was designed. Safety proponents are always demanding slower speeds and these bodies are constantly increasing in number and importance. Any serious attempt to revise present highway laws so as to allow increased speeds will surely meet organized opposition.

Some mention should also have been made in regard to some form of standardized financing. Funds for any one structure may come from a number of sources with the subsequent duplication of services. Surely, in a properly planned highway, the financing should be arranged in such form as to permit steady growth and permanence.

Messrs. Smith and Kettering discuss the parking problem in terms of a future Utopia without referring to the parking-meter system. Intended originally as an added tax-gathering system these meters are being installed at a rapid rate in crowded business districts. They create convenient short-time parking in shopping districts where once it was practically impossible to park.

Mr. MacDonald condemns the design practice of the past without due consideration of the fact that these highways were built along single standards, because a certain minimum of width and construction were required regardless of service requirements. That many of these structures are still in service after a score or more years is truly a tribute to their designers. The older bridges in the United States (some of them more than fifty years old) also carry modern traffic. Fifty years ago when the horse and buggy represented the acme of transportation on the highways, who might have forecast or planned future traffic requirements? With their planned programs and im-

[20] With Robinson & Steinman, New York, N. Y.

proved materials, can engineers to-day design structures that will serve throughout the life of a planned program? May not the entire viewpoint be completely revised in only a few years by new inventions or even the technique of planning itself? If so, the present generation of engineers must, in turn, await the criticism of its successors. The development of express highways to by-pass crowded centers of population may be one of the major factors in causing a revision of planning methods in Germany where the express highway, established on a larger scale than in the United States, is already attracting commercial establishments with the attendant growth of adjacent residential districts.

ROBERT KINGERY,[21] ESQ. (by letter).—As Mr. Smith states (see heading, "Introduction") no identical pattern or design of a road facility can be transplanted directly from one metropolitan area to another. However, the good designs and successful operation of a given type of highway facility may be adapted to conditions in most metropolitan centers. Without question the original boulevard system in Chicago, Ill., laid out and acquired in 1869 and 1870, has been imitated in many parts of the world. Perhaps the original was an imitation of some other system. Members of the Regional Planning Association of Chicago have profited not only from the Wayne County Highway, and the Detroit Rapid Transit policies, but have studied and have incorporated, in major thoroughfares and super-highway designs, some of the parkway features from Westchester County, New York, and from the Mount Vernon Parkway, near Washington, D. C.

In the ten years since, in 1928, the Chicago Regional Planning Association originally laid out a program of major highways, super-highways, boulevards, or parkways, almost exactly one-fifth of that program has been completed. It is now (1938) advancing at a much more rapid rate. Of the 603-mile system in the 15-county area, 127 miles of right of way from 160 ft to 240 ft in width have been acquired, and 114 miles of pavement have been built, all outside the City of Chicago itself.

Within the city about 14 miles of major trunk traffic artery of the parkway type have been completed along the lake shore from a point 6.5 miles north of the center of the city to a point 7.5 miles south. Entrance to the city from other directions is more difficult, there being no existing broad rights of way. Many studies have been made by the Chicago Plan Commission and by other official and unofficial bodies and now it seems more hopeful than ever before that a decision upon a comprehensive plan will soon be agreed upon, and construction begun by the co-operation of several highway building agencies.

However, one note of caution might be injected into the subject of Mr. Smith's paper. At many meetings of city planners and in many papers about metropolitan highway planning and about zoning one will hear or read of the conception of the dreamer who pictures cities with buildings and towers a thousand feet high, with miles of two-decked, three-decked, and multi-decked highways in centers of population concentration. To some planners this type of thinking is in the wrong direction. There is adequate evidence of the result

[21] Secy., Chicago Regional Planning Assoc., Chicago, Ill.

of excess concentration of population and of commerce in small centers. One example among many is the fact that closely surrounding such an intensive concentration of high buildings is almost always a broad belt in which disintegration is far advanced. The City of Chicago has such a belt, which is 10 miles long and more than 3 miles wide. It covers 36 sq miles, or one-sixth the area of the city; and more than 260 000 people have moved from it during the past twenty years. Many of the tax delinquencies are in this area; and it includes a substantial number of both juvenile and adult delinquencies which form the principal police problem; as well as a substantial majority of fire-protection problems. Tax receipts from this area do not nearly support the governmental services to it. In slightly modified form, the same can be said of every large metropolitan area.

Although high buildings with multi-decked highways—with masts for the anchorage of dirigibles, with landing fields for the clouds of aeroplanes that are seen in photographs of the "City-of-the-Future"—are all stirring to the imagination, by no means do they involve solvency of the municipal pocket-book.

Construction of highway facilities, of course, will not solve all these problems, but it can come nearer to it. Penetrating the centers of these large cities and surrounding the business centers of them in the so-called blighted areas, the development of exceptionally broad rights of way or parkways with adequate space for pavements—on the ground level, elevated, or depressed—with adequate space for grass and trees will, in the judgment of many, do more to reconstruct the city at its core than almost any other single influence. With the construction of such radial or belt line boulevards (or both), and with the addition of adequate parks and playgrounds in such a zone, and with courageous and intelligent zoning or re-zoning of the neighborhood, property values will be restored for residential occupancy of much of that area.

For some decades too much attention has been given to the construction of buildings in the development of cities in the United States, and too little to their setting and their surroundings. The introduction of more open space in the form of boulevards and parkways is one of the greatest services that the highway officials in metropolitan areas can perform, not only toward facilitating traffic movement, but toward salvaging and even enhancing the value of the metropolitan area as a whole. There would follow the further introduction, by park authorities, of the parks and playgrounds with their trees and grass, and the intelligent, unselfish and courageous zoning or re-zoning of large units of the metropolis. The result will be a better rounded community and sounder and safer distribution of traffic volumes.

R. L. Morrison,[22] M. Am. Soc. C. E. (by letter).—One of the most outstanding items in Mr. Kettering's interesting paper is the constantly increasing maximum speed of automobiles from about 58 miles per hr in 1926 to about 87 miles per hr in 1937. This is an increase of 50% in 11 yr, and the curve is almost a straight line, with practically no indication that a top limit is even being approached.

[22] Prof. of Highway Eng. and Highway Transport, Univ. of Michigan, Ann Arbor, Mich.

Mr. Kettering states that "people, on the average, do not want to travel much faster than 60 miles per hr," and perhaps that is a reasonably safe speed on a good clear road in the daytime. Investigations made by the Michigan State Highway Department in 1936 showed average speeds of less than 50 miles per hr, but the fastest 15% of vehicles were driven more than 65 miles per hr and, on one route, 70 miles per hr.[23] This means that many of the drivers must have been using the entire speed capacity of their cars. Darkness slowed down this fastest 15% only 2 or 3 miles per hr although, even with good brakes and lights, they could not possibly stop before hitting a dark object on the road.

While the maximum speed of vehicles was increasing 50% between 1930 and 1937, the fatalities on rural roads (the only ones on which maximum speeds can be used) increased about 37%, and the rural night accidents increased 60 per cent.[24] The increase in automobile registrations during the same period was less than 5 per cent. A close relationship between increased speed capacity of cars and increased rural night fatalities is evident.

Mr. Kettering states that the roads "where it is necessary should be above or below the ground. * * * Crossings should be eliminated * * *," and other safety features, which he lists, should be provided. Such roads would certainly cost at least $300 000 per mile. If 10% of all motor taxes could be spent entirely on the construction of these superhighways (which is very unlikely), it would be possible to build about 300 miles per yr. Therefore, at the present rate of revenues, it would take nearly 200 yr to build the 50 000 or 60 000 miles of superhighways which are assumed to be needed. It is impossible for the writer to see how superhighways can ever make more than "a small dent" in the accident rate, assuming that they do reduce accidents where they are built.

The paper discusses two items, the vehicle and the road, both of which are constantly being improved. The cars go faster each year and the roads are gradually being changed to facilitate fast driving; but, unfortunately, there is a third factor, and a very important one. It is very doubtful whether this third factor—the driver—had any more inherent ability to handle cars at high speeds in 1937 than he had in 1926. He doubtless developed a little additional skill during that time, but most accidents are caused by lack of judgment rather than by lack of skill, and certainly there is little evidence that the judgment of the average driver has improved. In fact, the less judgment he has the faster he goes. In other words, the automotive engineers and civil engineers are constantly producing cars and roads with speed capacities more and more beyond the ability of average drivers to use them safely. Of course, this is done to meet the desires of the motorists whom they both serve.

To state the problem is much easier than to offer a solution. It can be said, however, that regardless of the responsibilities of the automotive and civil engineers, public officials have a very definite responsibility to use all reasonable methods to reduce accidents, and this is a responsibility that is very far from being met in many localities. For instance, there are scarcely more than 100 traffic engineers in the entire United States, and when a State

[23] "Graduated Speed Regulations," by D. Grant Mickle, *Proceedings*, 1937 Michigan Highway Conference, pp. 14–25.

[24] "Accident Facts," 1938 Edition, pp. 28 and 36.

or city does decide to have one the usual procedure is not to find and appoint an experienced traffic engineer, but to appoint to that office some engineer who has no knowledge of traffic engineering. Residence in the State or city concerned is usually considered of much greater importance than experience in the work which he is expected to do. A number of States still do not require standard driver's licenses, and, in many places, both traffic laws and their enforcement are far below what they should be.

Although Mr. MacDonald does not make the exact statement in his paper, it seems to be his guiding principle, that highways should be built so as to be of maximum service to the motorists who use and pay for them. Maximum service to the motorist through highway improvement includes decreasing his operating costs, saving his time, and increasing his safety, comfort, and general enjoyment of travel. It also includes making new areas available to travel for recreation or for other purposes. Of course, there are many other "benefits of good roads" of a more or less incidental nature. The main problem before highway administrators is to determine how available funds should be expended in order to render maximum service to the greatest number of highway users.

Unfortunately, it is the spectacular that is likely to appeal most to the general public and to politicians in high places. One school bus is struck by a train and immediately almost a billion dollars is appropriated for railway grade separations, although the same sum of money spent for such things as crossing gates, better street-lighting, the flood-lighting of street obstructions, and more efficient policing would probably save a vastly greater number of lives. Other billions are proposed for building four or six-lane roads across the deserts to accommodate a largely imaginary coast-to-coast or border-to-border traffic although millions of dollars are wasted annually by motorists traveling over untreated gravel roads and poor earth roads, and in crawling through congested city streets for the lack of by-passes around the cities.

Broad vision of future needs is required for real progress in any field, but it is possible that sound economics is more needed than dreams and visions in planning highway improvements for the next few years. Perhaps the greatest need of all is a determination of what constitutes sound highway economics. Even in that field there seems to be a great temptation to pile up vast imaginary savings. This is done by taking the difference in operating costs over pavements and over earth roads and assuming that every mile operated on a pavement results in this saving. This involves the assumption, of course, that all the millions of vehicles now using pavements would be traveling on earth roads if the pavements were not there, which seems palpably absurd. If these imaginary savings could be used to finance the super-highways on the desert all would be well.

The very real savings that can be made to present highway users through sound improvements justify the kind of road-building program outlined by Mr. MacDonald.

ROY F. BESSEY,[25] M. AM. SOC. C. E. (by letter).—This Symposium is thought-provoking, timely, and valuable. The flattening out of motor

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vehicle curves shown by Mr. Kettering does not indicate the end of the great national task of modern highway building, but rather the transition from the era of pioneer construction to the era of reconstruction, readjustment, and improvement for greater efficiency, safety, and beauty.

Those responsible for highway design and construction have done an excellent job under difficult conditions, trying to keep pace with very rapidly developing or changing needs—with the growth of population, cities, industry, commerce, distribution, and technics, and, particularly, with the mushroom expansion of the automotive industry in both technics and production. In their thinking, many of those responsible have done much better than keep pace with public opinion in appreciation of many important requirements—and, consequently, have been far ahead of adequate public financial support in meeting conditions.

Although a great national network of good roads has been created, it may be concluded that transition from the pioneer stage of motor highway development is still under way. Advances in technology generally, and particularly in the field of automotive equipment; increasing density, diversity, volume and speed of traffic; and growing needs in safety, convenience, comfort, time-saving, and recreation—all call for further, probably radical, improvements in highway design and construction.

The pressures upon highway design and construction have been so great until recent years that there has been little time and means for refinement; but the present is none too soon to complete a new estimate of the situation—to re-evaluate needs and practices and to overhaul standards and plans. For this work the current nation-wide highway-planning survey is providing the essential data.

A number of desirable changes and adjustments are indicated in the Symposium. More will be disclosed by the analyses of the planning survey. Others will be found in city, metropolitan, county, district, State, regional, and national planning studies. Obviously, highway plans will have to be adjusted: (*a*) To the shifts of population and industries out of the centers of cities; (*b*) to other changes in population and industrial patterns; (*c*) to changing land use; (*d*) to activities relating to the conservation or exploitation of natural and economic resources (including flood and erosion control); (*e*) to other means of transportation (including rapid transit); and (*f*) to various other physical, economic, and social changes.

Obviously, too, it will be desirable to transfer some of the emphasis in highway design and construction from questions, such as line, grade, and pavement, in which the art is relatively far advanced, to others, such as surface, lighting, parking, rights of way, and roadsides, which (perhaps unavoidably) have had less attention in the past. All the latter features are increasingly becoming of importance to highway efficiency and safety. Wide rights of way and suitable roadside control will be particularly important factors in delaying absolescense.

From a regional planning viewpoint, the new highway era seems very definitely to involve three outstanding problems and programs:

(1) Trunk highway systems—modernization;

(2) Secondary road systems—more complete co-ordination with such resources and facilities as forests, recreational areas, mineral areas, present and probable future land use, schools, etc.; and,

(3) Co-ordinated transportation—establishment of more adequate relationships of one means of transportation with another, and with the entire system.

Requirements for trunk highway modernization will vary considerably (with geographical location, density of population, kind of traffic, etc.); but there are many requirements common to various conditions, such, for example, as location, alignment, grade, roadway and pavement standards to permit fast and continuous travel; freedom from the threats to movement, the safety and convenience involved in too-frequent crossings and points of ingress and egress, in roadway or roadside parking, in improper or excessive roadside use and obstruction, in conflicts with city and town congestions; provision for pedestrians; and provision for parking on sites away from the roadway. Fortunately, an outstanding requirement of recreational highways—the control of roadsides from the aesthetic standpoint—harmonizes generally with the requirements of commercial traffic and involves broad economic values as well.

The "freeway" or "limited motorway," with its wide rights of way, separation of opposing traffic lanes, grade separations, rotary intersections, border controls, limited points of access, etc., seems to provide the general solution and to indicate the directions in which the most effective improvements can be made in trunk highways.

A very intimate connection between highway-planning and land-use inventories and plans would seem to be the key to the most rational and efficient development of secondary road systems.

The advantages of co-ordinated transportation need not be elaborated. Not the least is elimination of much of uneconomic or needless duplication and competition. Some of the directions for study and planning of co-ordinating features in the highway field might be exemplified: Feeder lines for railroads, rapid transit lines, waterways, ports; integrated terminal facilities; interchangeable freight bodies or containers; roadside emergency airplane landing fields; and arterial express highways co-ordinated with airport locations.

In passing into the new era of automotive transport, a higher degree of co-operation is essential. Now that some of the urgencies of the pioneer period have diminished, it is to be assumed that close co-operation is more practicable. Of course, this co-operation must be based upon a mutual willingness to strive to keep design in automotive equipment and design in highways in close harmony. A closer co-operation is also required as to highway location, design, construction, and operation between various levels of government, between adjoining governmental jurisdictions, and between those responsible for highways and those concerned with other means of transportation.

Finally, if broad highway planning is to reach maximum practicable rationality and effectiveness, quickly, it should be very closely related to national, regional, State and local planning programs, and to functional

planning in such fields as land use, zoning, industrial location, transportation, resource development, and recreation. Of course, the comprehensive highway planning work will be reciprocally valuable in the general planning programs.

BRUCE D. GREENSHIELDS,[26] ASSOC. M. AM. SOC. C. E. (by letter).—The least understood but perhaps the most important problem of motor transportation is that of harmonizing highway construction and motor-vehicle design with human behavior.

The engineer has been building highways for hundreds of years. He has learned how to deal with inanimate materials and forces that behave in a definite manner under given conditions. Human nature seems perverse and is so uncertain that the engineer, having correctly designed a highway from a mechanical standpoint, is inclined to let the "fools" kill themselves if they insist upon it.

Whatever his inclination, however, the engineer must accept the fact that the people who use the highways pay for them and, therefore, have a right to demand that they be safe. Each driver should be held to account for his own mistakes, but he must be protected from the mistakes of his neighbors on the road.

Mr. Kettering states, in the "Synopsis," that "the vehicle and the road must form a complete transportation system" and that "each one is dependent upon the other for the success of the whole." The writer would add that the whole must include the driver. Not only is highway safety dependent upon the driver's ability, but its utility is limited by his whims and desires. One loitering motorist may hold up a long line of vehicles.

There is ample evidence that drivers are foolhardy. Recently the daily press,[27] quoting from a pamphlet issued by the Board of Railway Commissioners of Canada, asks why so many people risk their lives by trying to beat the train to the crossing:

"The latest safety devices and cautionary signals may be in operation, yet to a strange element of humanity these appear to present only a challenge.

"A summary of the dangerous practices at railway crossings only adds to the wonderment as to why many drivers behave as they do: of all the accidents and near accidents reported (350 drivers and pedestrians in 6 months) 22.3 per cent of offenders ran into lowered gates, 18 per cent crossed in front of approaching trains, 11.7 per cent drove under gates while being lowered, while the remainder resorted to utterly foolish ways of risking their lives."

The people who deliberately commit suicide on the highway are few indeed. The explanation lies in another direction. One reason is that the driver or the pedestrian does not know the risk he is taking. Statistics show that a large percentage of injured pedestrians do not drive cars. They put undue trust in the ability of the driver to see a pedestrian and to bring a car under control. If one's attention is momentarily distracted he may not see something that is otherwise perfectly obvious. Every one has had such an experience.

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[27] *The Kansas City Times*, August 8, 1938.

The driver has had little more than a generation within which to learn to avoid the unnatural hazards of high-speed cars and to adjust himself to the unnatural experience of driving.

Professor Yandell Henderson speaking before the National Academy of Science, at Charlottesville, Va., in November, 1935, stated that:

"'The car went out of control' is a usual explanation of automobile fatalities, but in reality, it is the driver who goes out of control. He acts in the only manner that his nature permits, the manner in which every human being always instinctively acts and always will act under the circumstances."

Any motorist, no matter how experienced, according to Professor Henderson, when suddenly and severely jolted, instinctively re-acts to steady himself in his seat, and in doing so, presses his foot down on the accelerator pedal. The more he bumps along the harder his foot presses and the more rigidly he grasps the wheel. People cannot be changed but motor cars can. Professor Henderson would have a pedal under the left foot which would counteract the effect of the right by shutting off the power.

There are many phases of behavior—physical, mental, and emotional—that need to be considered, but obviously only a few can be considered in a short discussion. One of the natural attributes most discussed in connection with automobile driving is that of "reaction-time." This is the brief interval between the happening of something in one's environment and the time when a certain response is made to it. This interval may be, for example, that between the time a pedestrian steps into the street and the time the brake is applied to avoid hitting him.

In general, the speed of all forms of reaction varies from one person to another and from time to time in the same person. Extreme fatigue decreases the ability to respond. Emotions such as fear or anger interfere with the driver's reactions. The effect of alcohol varies with the individual—it does not necessarily lengthen reaction-time, but an excess amount makes the reaction-time more uncertain. The reaction to hearing is quicker than to sight.[28]

Certain responses are made more quickly than others. The hand is quicker than the foot. Perhaps a hand-operated brake would be better in an emergency.

Although reaction-time has been considered mainly in connection with highway safety, a means for reducing it is probably more important in highway design than in safety work because it has not been demonstrated that reducing reaction-time would lessen accidents. On the other hand, it would speed up traffic and increase highway capacity.

Persons who react more quickly drive at higher speeds. They thus void whatever advantage their quickness gives them and have just as many accidents as slower drivers.[29] The average minimum spacing between vehicles depends upon the reaction-time of the individual drivers. The spacing between vehicles

[28] "Reaction-Time and Traffic Behavior," by Bruce D. Greenshields, *Civil Engineering*, June, 1937, p. 384.

[29] "A Study of Factors Influenced by Automobile Brake-Reaction Time," by Frank R. Olmstead, *Proceedings*, 22d Annual Highway Conference, Ann Arbor, Mich.

fixes the number that can occupy any length of roadway and, hence, is one of the factors determining highway capacity.[30]

Earl Allgaier, Safety and Traffic Engineer of the American Automobile Association, after subjecting approximately 22 000 drivers to a battery of 15 tests, states that driving ability reaches a maximum at about 25 yr of age.[31] The decline begins between 40 and 50 yr and grows rapidly from that point on. The tests included field of vision, eye dominance, excitability, blood pressure, hearing, and steering ability. Mr. Allgaier states that the falling off in the test scores made by drivers more than 40 to 50 yr of age need not necessarily indicate that these drivers are actually poorer or less safe than younger drivers. They are more experienced and likely to be more cautious.

Dr. H. M. Johnson, referring to such tests, states that he has found no published report of a comparison which warrants the conclusion that test performance is closely associated with accident rate.[32]

Dr. A. R. Lauer, of Iowa State College, who has developed many of the tests, states[33] that after having analyzed several sets of data it is his guess that "when our final analysis is made we will find no high validity coefficient." He adds as a reason the fact that "human nature is unstable and highway conditions are highly variable." There is significance for the highway designer in the last statement. Human nature cannot be changed but highway conditions can be made less variable.

To claim that human nature cannot be changed does not mean that one cannot learn to do things better or that natural handicaps cannot be overcome. The quickness with which one can move his foot in a certain way in response to a given stimulus cannot be reduced by practice beyond a certain point; but by simplifying the movement required to control the vehicle the car manufacturer can, in effect, shorten the reaction time. Although there is a natural limitation to one's ability to see, cars can be made easier to see out of and highway signs can be improved by an increase in size or by illumination.

The experienced driver has learned to make the proper responses to a large number of situations. He is less likely to be surprised. Experience enables one to make quicker judgments. Judgment is more complex than perception. For example, in taking a laboratory test of brake reaction-time, a light is flashed and the subject presses the brake pedal. He perceives the signal and acts. No judgment is involved. He has decided what to do beforehand. In the case of passing a vehicle on the road, he first sees the vehicle approaching on the opposite lane. He then decides whether he can pass the car ahead. This deciding is a matter of judgment and is a much more complex process than "sensation." It may take minutes instead of seconds.

The young driver cannot be given experience but experience can be made less necessary by simplifying the highways and by informing the motorist of approaching conditions so that he has time to decide what to do.

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[30] "Studying Traffic Capacity by New Methods," by Bruce D. Greenshields, *Civil Engineering*, May, 1935, p. 301.

[31] *Public Safety*, May, 1938.

[32] "The Detection of Accident-Prone Drivers," *Proceedings*, Highway Research Board, 1937, p. 445.

[33] *Loc. cit.*, p. 452.

Consider highway curves, for example; in most States all curves are heralded by the same type of sign. The driver does not know whether the curve is sharp or flat or whether he can drive it at 50 miles per hr or whether he should slow to 20 miles per hr. Why not give the motorist the information he needs?

Common arguments against such a practice are that the safe speed for one car is not that for another car and that the State would be to blame if a defective or old-model car had an accident while traveling at the announced speed. The curves should be designated by numbers as 1, 2, 3, etc., to indicate riding qualities. The motorist would soon learn at what speed his car would take a No. 1 or a No. 2 curve.

Adequate highway signs might have prevented two fatal accidents that occurred at Fidelity Corner, six miles south of Carthage, Mo., in August, 1938. In the writer's opinion the rather inconspicuous "Slow" sign, followed by another indicating the intersection, should be replaced by (1) a prominent intersection sign, and (2) a danger sign; and, to make sure, a "blinker" should be added. Note that, first, the driver would be informed of what to expect; and, second, would be warned of danger.

Highways must not be deceptive. Many a new highway has failed to reduce accidents. Its deceptive appearance of safety has induced motorists to step up their speed to a point at which they did not have time to react to the road's surprises.

Speaking on the subject of "Highway Design and Safety" at the Highway Safety Conference, Yale University, on April 4, 1938, Guy Kelsey, of the Signal Service Corporation, Elizabeth, N. J., described the surprise hazards confronting drivers operating on 5.4 miles of a "very modern highway" selected at random. Low visibility, head-on-intersection-of-vehicle hazards, as well as several traffic flow inefficiencies were among the deficiencies found in the short stretch.

The statement is made by Mr. A. R. Nichols[a] that even if the safety and utilitarian requirements have been met, the road that does not closely follow the lay of the land results often in glaring artificiality of ugly cuts, high fills, and an increased area of destruction of natural vegetation. Such unnecessary artificiality makes a road more dangerous. Its unnaturalness leads to surprises.

Although the unexpectedness in human nature cannot be removed like the perplexities of the highway there is the gratifying fact that human nature *en masse* is not so variable after all. Insurance companies cannot tell how long any individual will live, but they have built up a thriving business on predicting how long the individuals in a large group will live.

From his studies of behavior on the highway (such as the spacings maintained between vehicles, the distance required for passing, and the point at which drivers slow down because there is a vehicle ahead) the writer has arrived at the definite conclusion that drivers do behave in a definite manner under certain conditions. The curves resulting from the plotting of such data are surprisingly smooth.

The traffic engineer must study human nature as the design engineer has studied soils and concrete and steel. Road intersections that are unsafe

[a] "Highway Design: Its Relation to Landscape Objectives," by A. R. Nichols, *Proceedings*, Highway Research Board, 1937, pp. 269–278.

must be compared with those that are safe to find out how they differ. The "specifics" of driving behavior must be determined by careful analysis. How prominent must a sign be for the driver with poor eyesight to see it? Advertising signs are much more prominent than highway signs. At what distance can one determine whether or not an object is moving? These are the facts the motorist needs to know, and does not.

The highway of the future must expedite traffic and it must do it safely. It must be honest. If it invites speed it must have no dangerous surprises. As sight distances are increased and vehicles are made even more responsive to control, speeds will go up in direct proportion. If 50 miles is a high average speed now it is because drivers feel comfortable and safe at that speed. If average speeds of 100 miles per hour are adopted in the future it will be because the driver feels safe at that speed. When speeds on limited ways go high enough they will be restricted to the best drivers.

It is hoped that these remarks have added something to the excellent papers of the Symposium by emphasizing the importance of studying the highway user.

ROBERT B. BROOKS,[35] M. AM. SOC. C. E. (by letter).—In the final analysis, the place of the express highway in a modern road system must be determined by its economic justification.

The most important economic phase of the paper by Mr. MacDonald is that in relation to the continued construction of super-highways. His idea is that present policies indicate that the location of super-highways will be integrated with population centers and that the layout will not be on the transcontinental basis.

It is undoubtedly true that in Germany and Italy the express highways are built for protection and aggression as well as for peace-time traffic. In the United States express highways are built to satisfy the demand of peace-time traffic, as well as to provide highways that can be used for handling men and equipment in time of war. This protection did not exist twenty years ago, as was shown definitely, time after time, by the wrecking of highways by even limited troop movements during the World War. There can be no doubt that there is a definite place for the express highway in a modern road system.

In January, 1932, the United States had a total of 3 790 miles of extra-wide highways in its State systems and not included in the mileage of city streets and parkways.[36] By extra-wide highways are meant those having more than two lanes. There were 2 230 miles of three-lane width, 1 385 miles of four-lane width, and 175 miles of five-lane width and greater.

Five years later, and bringing this date up to July 1, 1937, there is a total of 7 999 miles of important highways exceeding two-lane width, of which 4 703 are three-lane, 3 096 miles are four lane, and 201 miles are five and six-lane.[37] This increase in width is significant of the trend in highway construction. Within that same time the genuine planning of modern highway

[35] Cons. Engr., St. Louis, Mo.
[36] *Public Roads*, November, 1932.
[37] *American Highways*, July, 1937.

systems has been given exhaustive study, under the basic assumption that they should be planned to do the greatest good for the greatest number.

State traffic surveys should reveal not only the traffic volumes, and other physical information, but should include a description of financial status and explanations of how the citizens are to pay for highways in the future. Consider Missouri, for example. The total mileage of all the roads in the State is 104 850. The State highway system, as now designated, contains a total of 17 193 miles. Of this total there are 1 651 miles in the primary system, 5 877 miles in the secondary system, and the remainder in the supplementary system with its traffic relief, park connections, etc. In other words, the State highway system in Missouri specifically consists of 16.4% of the total road mileage in the State which, however, does carry more than three-fourths of all the traffic when measured in vehicle-miles per year. Carrying this computation a step further, the several systems of highways in Missouri, in the survey report of 1934, showed the following percentages of traffic:

System	Highway mileage	Vehicle mileage
United States highways	3.6	48.1
State highways	4.6	18.5
Supplementary	4.1	8.0
County roads	87.7	25.4
Total	100.0	100.0

Although proper consideration must be given to the farm-to-market roads and to the secondary road system, it is readily apparent that the main highways carry by far the greater volumes of traffic. This is as true in other States as it is in Missouri.

The era of toll roads in the United States is passed. Although individual experiences may warrant the impression that the user would be willing to pay an extra sum for using express highways between centers of population, the cold facts are that there are not enough motorists to amortize the cost of building an express highway in the United States. This is proved by the fact that most motorists will drive many miles out of their way to avoid paying even a small toll on a bridge which might otherwise save them considerable time as well as the price of the bridge fare.

If the cost of the express highway is to come from gasoline tax and vehicle license fees, with added grants from the Federal Government, engineers must "cut the coat to fit the cloth," and in so doing build express highways in such a way that they will handle those traffic volumes in, around, and near metropolitan areas where the expense of construction can be justified, not only from an engineering standpoint but from that of public opinion.

With the proceeds of most of the State bond issues for road purposes already spent, road programs seem to be on a "pay-as-you-go" basis. This means a further economic justification rather than a lavish expenditure to take care of anticipated needs.

Highways are often called traffic arteries through which streams of automobiles flow. The comparison, of course, is to that most perfect system of

veins and arteries which takes care of the circulation of the blood. Comparing traffic flow to the distribution of water, the largest pipes are next to the source of supply, or reservoir. As the water is carried to various sections, the sizes of the pipes are lessened in deference to the demand for water by the consumers. The system of arteries and veins in the human body shows very definitely that the need for the larger arteries and the larger veins is near the heart, and the size of each is smaller and smaller as it gets away from those parts of the body that need circulation least.

It is self-evident that the pressure of traffic is from the centers of congestion in metropolitan areas outwardly, just as water is distributed from a reservoir, and just as blood is circulated in the body of an individual.

"Flow" maps invariably show that traffic demands wider traffic-ways near centers of population. The same maps also show that the two-lane highways are sufficient to take care of traffic needs a reasonable number of miles away.

Although the out-of-State farmer can see no reason why his gas tax money should go for the building of an express highway from Chicago, Ill., to another locality, neither does the urban dweller see any reason why his tax money and that of his neighbors in the large city, which may pay three-fourths of the entire cost of constructing highways in the State, must be used in building farm-to-market roads which he, the urban dweller, may never use.

The opinion has been expressed that large cities must construct express highways in order to exist. The writer believes that various State traffic surveys will supply the factual data which will educate every one, whether urban or rural dwellers, as to the mutuality of traffic needs so that gas taxes and vehicle license fees can be spent on a network of traffic arteries, which will take all classes of roads into consideration.

During the eight years, 1925–1933, a definite system of streets was laid out in the City of St. Louis, Mo. These streets were divided roughly into three classes: 60-ft streets, 80-ft streets, and 100-ft streets. A progressive system of construction each year saw various sections completed, so that to-day with the street plan practically completed, traffic flow maps show, definitely, the value of the various widths of streets. Consider the planned design of what is known as US 40TR, in Missouri, which extends from St. Louis westward about 40 miles to Wentzville, Mo. It is a two-lane highway from Wentzville to the Missouri River; a three-lane highway from that point to Chesterfield; a four-lane contiguous highway from Chesterfield to Bellefontaine; and then 2 two-lane highways divided by a 30-ft parkway to a point close to the City of St. Louis. At this point it is necessary to converge into a subway running three miles inside the city limits to Vandeventer Avenue, where traffic is then poured into two or three streams for distribution.

Through bitter experience highway engineers in Missouri have already learned how costly it is to obtain right of way sufficiently large for an express highway. The longer the acquisition of land is delayed, the more it will cost. Therefore, on express highways they have, and are, securing a 200-ft right of way which will take care of future traffic needs, although the present-day construction of extra-wide highways may not be warranted at the present time.

Although many engineers would like to see the general acceptance of four-lane highways instead of two lanes, it seems self-evident that there is not economic justification for such an expenditure in many cases, and, although there may be some accidents caused by a third lane, the three-lane traffic is a transition from a two-lane highway to the express highway. Any one who doubts this point should note the immediate relief afforded when driving in holiday traffic on a two-lane highway almost at the moment it passes into a three-lane highway.

State traffic surveys now being completed and analyzed will show where express highways should be located and, although there may not be economic justification for the construction of an express highway now, it certainly is good planning to acquire land for the subsequent building of these roads when, if, and as, the need arises.

At its meeting in July, 1937, the members of the Missouri State Highway Commission were sufficiently impressed with this idea on U. S. Route 54, between Jefferson City, Mo., and the Lake of the Ozarks, that they instructed the Engineering Department to arrange for the acquisition of sufficient right of way to provide for the building of an express highway of extra width sometime in the future. At present, only a two-lane highway, leading south from Jefferson City for a few miles, will be constructed. Missouri needs express highways to take care of the outward pressure of traffic from its large cities. The writer cannot agree that there is a need for express highways up and down the land where the traffic itself cannot show an economic justification. He does agree most emphatically that engineers must plan wisely to secure sufficient right of way in order to add more lanes to take care of future traffic demands.

Mr. R. E. Toms, Chief, Division of Design, U. S. Bureau of Public Roads, recently presented data to demonstrate that from 95% to 97% of the State highway mileage in the United States may never progress in improvement beyond a two-lane highway.[38] If it is desirable to improve such a small percentage of the highway system as express highways, then let it be realized from the standpoint of economic justification, that the function of an express highway in a modern road system is to take care of the outward pressure of traffic from metropolitan areas to the extent that this extra pressure exists, and not as a continuous super-highway connecting centers of population.

If any further evidence is needed to show that the location of super-highways should be integrated with respect to population centers and that their layout should not be on a transcontinental basis, it is only necessary to observe the restricted use of the State and Federal highways immediately outside the orbit of metropolitan areas as ably shown by Mr. MacDonald.

H. George Altvater,[39] Assoc. M. Am. Soc. C. E. (by letter).—Referring to "Trunk-Line Highways in Metropolitan Areas," Mr. Smith states that highways must serve the area as trunk lines for public utilities and that inadequacy of right of way will affect the utilities. The practise of laying

[38] *American Highways*, January, 1937, p. 12.
[39] Cons. Engr., Denver, Colo.

pipes beneath the traveled roadways of streets was inaugurated in the days of horse-drawn wagons on dirt roads, and then it caused little inconvenience in digging up the streets. With the carefully designed pavement of to-day, however, there is no reason why each block of it must be repeatedly trenched through and patched numerous times during its life.

At the time of the World War, the United States found itself so thoroughly unprepared to supply munitions that the only experienced engineering organization in the nation that was qualified to build explosives plants could undertake to build only about one-half the necessary capacity, and the remainder was built by entirely new inexperienced organizations. Under these circumstances, the matter of utilities in streets was a serious cause of delay. The main plant transportation, at Nitro, near Charleston, W. Va., where one of the two American smokeless powder plants was constructed, consisted of 45 miles of narrow-gage railroad, which was responsible for the results obtained. In the deep mud the tractors and even horses became bogged down, so that oxen were resorted to for moving heavy machinery. It was not possible to build roads first because the streets were torn up for utilities.

There were untreated industrial water lines, treated domestic water lines, high pressure fire lines, steam lines, industrial sewer lines, domestic sewer lines, storm sewer lines, gas lines, electric power lines, telephone and telegraph lines, sulfuric acid lines, nitric acid lines, caustic soda lines, ether lines, and alcohol lines. Their construction in the streets obstructed the delivery of essential machinery. Time was the only consideration, because in July, 1918, the Allied Armies were using explosives about six times as fast as they could be produced by all plants. The separation of rights of way for utilities would have permitted road construction to be done previously or concurrently. The writer recommends to industrial city planning engineers that an attempt be made to provide separate rights of way for utilities on new developments.

This is in no way a reflection upon the excellent work of those who were responsible for the miraculous speed in the construction of the plant at Nitro, because they produced their $75 000 000 job in about the same time as the slightly larger Nashville (Tenn.) job was done by the explosives specialists.

Although the presence of utilities in streets contributes greatly to the engineering difficulty and cost of subways in the large cities there does not seem to be any feasible way to avoid it; but in new developments where land is relatively cheaper a separation of the utilities in the rights of way should be possible.

W. W. CROSBY,[40] M. AM. SOC. C. E. (by letter).—The conclusion of Mr. Kettering's "salmon" story is good, and his remarks on "where to get the money," should be regarded as fundamental. Although the writer could applaud most, if not all, the remainder of Mr. Kettering's remarks, it is from the ideas just mentioned that he wishes to propose an hypothesis which may account for many of the defects in the highways of the United States as well as suggest an answer to an engineering question that has been widely discussed for years.

[40] Cons. Engr., Coronado, Calif.

Before so doing let the writer note that he has carefully read the paper by Mr. MacDonald, which seems to express, fairly, the attitude of the U. S. Bureau of Public Roads for the past fifteen years. A significant quotation (regardless of the question of fact) in this case is "Highway builders [in the United States] are proceeding on the principle that the utilization of the highways must produce directly the revenues with which to finance their construction" (see heading "Super-Highways").

The third paper of the Symposium, although limited to a narrower field, seems commendably broad in conception. Mr. Smith remarks several times on the fundamental importance of adequate rights of way, which the writer has been emphasizing for years. Mr. MacDonald barely suggests anything on this point although its prompt recognition is even more important in his work outside the cities. In some of its recent publications[41] the writer believes that the Bureau of Public Roads has admitted the need for "elbow room"[42] in the future.

The writer believes with Mr. Kettering that "Sometimes, people calculate entirely too much in dollars," particularly in setting up ideals—that is, in planning. Often it is necessary for the material approach to ideals and standards to be gradual as funds may be found; but to establish standards on the basis of funds in sight only results in regrets.

This brings the writer to the hypothesis mentioned:

May it not be that an answer to the questions discussed for so many years—"What is the matter with engineering?" and "Why does it not rank with the learned professions?"—lies in the fact that too many of its more prominent representatives cling to the definition of an engineer as one who "can make one dollar do the work of two," and are not imbued with the spirit of one familiar to the Society: "An engineer is one who adapts the forces of nature (including Human Nature) to the benefit of mankind," or perhaps the latest one:[43]

"An Engineer is one who, through application of his knowledge of mathematics, the physical and biological sciences and economics and with aid, further, from results obtained through observation, experience, scientific discovery and invention, so utilizes the materials and directs the forces of nature that they are made to operate to the benefit of society. An Engineer differs from the technologist in that he must concern himself with the organizational, economic, and managerial aspects as well as the technical aspects of his work."

THOMAS H. MACDONALD,[44] ESQ. (by letter).—The last paragraph of the paper emphasizes the fact "that the country has completed the pioneer stage of road development and every trend of highway development of the future must be an intelligent meeting of the particular service to be rendered." In order that there may be an intelligent meeting of the particular service to be rendered in the highway development of the future, it is essential that all pertinent factual information be available to highway engineers and adminis-

[41] *Roads and Streets*, February, 1939, p. 53; also *Public Roads*, January, 1939, p. 209.
[42] *Proceedings*, Am. Soc. C. E., May, 1938, p. 973.
[43] *Scientific Monthly*, February, 1939, p. 176.
[44] Chf., U. S. Bureau of Public Roads, Washington, D. C.

trators. In the paper reference was made to the State-wide Highway Planning Surveys. These are now (1939) being conducted co-operatively between the Bureau of Public Roads and 46 States and the Territory of Hawaii. Already these surveys have produced the factual basis for the solution of specific highway problems within a single State. They have also formed the basis for a comprehensive report from the U. S. Bureau of Public Roads, submitted to the Congress of the United States on April 27, 1939, by Special Message from the President of the United States. This report[45] was made in compliance with the specific direction of the Congress and consisted of two parts—Part I covering the "Feasibility of a System of Transcontinental Toll Roads," and Part II covering "Master Plans for Free Highway Development."

From the factual information developed in the State-wide Planning Surveys and other specific studies developed by the Bureau of Public Roads and the State highway departments, the definite conclusion was reached, and the recommendation made to the Congress, that it was not feasible to construct a system of transcontinental toll roads—three east and west, and three north and south—with any expectation of such a system serving the genuine traffic needs of the United States, or of being self-liquidating. The facts and considerations leading up to this conclusion were fully discussed in the report.

Further analysis and study of the Planning Survey data clearly indicate the problems confronting highway engineers and administrators. Some of them are of long standing and have become acute through the tremendous increase in highway traffic. Not only increased numbers but also increase in normal speeds critically affects the various problems.

Much of the yearly obsolescence of the rural highways built in the past has been due to the restrictions imposed upon the design by inadequate rights of way. Another outstanding problem centers around the metropolitan areas and involves the provision of means for getting into, around, and through such areas without the delay that is involved in using present inadequate facilities. Traffic-flow maps indicate the natural flow lines between the various regions of the United States. A limited system of inter-regional highways approximating 1% of the total highway mileage constructed to modern standards is needed to provide adequately for the ever-growing traffic. Further study is needed to determine the location and approximate mileage in each State of such a system.

From a full discussion of these problems, there emerges the general outline of a master highway plan for the entire nation. The prosecution of the plan in all its parts calls for appropriate action by the Federal and State Governments and all county and municipal subdivisions. As desirable joint contributions of the Federal and State Governments, the report lists several undertakings as follows:

(1) The construction of a special, tentatively defined system of direct inter-regional highways, with all necessary connections through and around cities, designed to meet the requirements of the national defense in time of war and the needs of a growing peace-time traffic of longer range;

(2) The modernization of the Federal-aid highway system;

[45] H. R. Doc. No. 272, 76th Cong., 1st Session.

(3) The elimination of hazards at railroad grade crossings;

(4) An improvement of secondary and feeder roads, properly integrated with land-use programs;

(5) The creation of a Federal Land Authority empowered to acquire, hold, sell, and lease lands needed for public purposes and to acquire and sell excess lands for the purpose of recoupment.

The report emphasizes the difficulties encountered in the acquisition of adequate rights of way; and, in view of the fundamental necessity of such rights of way, proposes definite measures by which the United States could aid in the acquisition of suitable rights of way and simultaneously contribute helpfully to the solution of other urgent problems, especially certain problems confronting the larger cities.

LEROY C. SMITH,[46] M. AM. SOC. C. E. (by letter).—With the ever increasing use of the passenger automobile, together with the increased use of motor trucks for industrial transportation, the necessity for adequate highway systems in and about the metropolitan areas is becoming more and more acute. The problem has reached such proportions that the Federal Government has taken definite steps to develop a system of inter-city super-highways, connecting the major metropolitan centers, and are contemplating acquiring such widths of right of way that even the most enthusiastic planners of the past had not ventured to advocate. The Government plans, discussed for connecting major metropolitan centers, provide for right-of-way widths ranging from 200 ft to ½ mile, many of them being parallel to railroad lines. Although these roads will alleviate the condition between the centers, there must be a system of express highways within the metropolitan centers to be connected with the inter-city roads.

Industrial Super-Highway Development in the Detroit Area.—Many of the civic and industrial leaders of Metropolitan Detroit and Wayne County are proposing a system of cross-town highways to permit the free flow, not only of the passenger motor traffic but also the large volume of industrial traffic. Factories of all types and descriptions are scattered over Wayne County and they depend upon co-ordination with one another in the process of their manufacturing operations. This is particularly true of the automobile industry where parts, bodies, etc. must be brought to the assembly plants. Narrow streets and roads not only delay transportation to the plants but create a dangerous situation with respect to other vehicles. These conditions could be eliminated by a system of wide thoroughfares. The "Drive Away" system of transporting new automobiles is another factor that creates congestion on the highways in the metropolitan areas as well as on the inter-city rural highways. Adequate facilities for delivering new automobiles would result in savings in transportation costs, thereby reducing the cost of new vehicles and encouraging new car buying.

Public Reaction.—Public reaction continues to be toward rapid transportation on rubber. A large majority of people are pleased to use their automobiles

[46] Chf. County Highway Engr., Wayne County Road Commrs., Detroit, Mich.

in lieu of buses or street cars in spite of the fact that transportation costs may be a little greater. This fact must be recognized and encouraged by the public agencies—whether local, State, or Federal—who are in charge of highway development. In 1938, the people of the State of Michigan adopted, by the vote of a great majority, a constitutional amendment which specifically provides that highway revenues be used for highway purposes only. This is another indication of public reaction to highways. Wayne County, in which Detroit is situated, has no property tax for highways. The only funds accruing to the County for highway construction and development are from the motor-vehicle gas and weight tax revenues. This is general throughout the State of Michigan. The constitutional amendment, however, guarantees that there shall be no diversion of highway funds for purposes other than highway construction and development.

Huron-Clinton Parkway.—The Legislature of the State of Michigan has enacted a law providing for the incorporation of the Huron-Clinton Metropolitan Authority. The purpose of this act is to permit the planning, development, and construction of parkways and limited access highways through two to five contiguous counties in the valley of the Huron and Clinton rivers. The act is comprehensive and is well worth detailed study.

Conclusion.—All State agencies are in accord with the Federal plans for cross-country highways. As in all cases of development, however, the question of adequate funds for such development always seems to be the chief obstacle. With a program of feasible and economical financing, there is no reason why these plans cannot be effected in the near future. The United States needs highways and, in line with the provisions of the Federal Constitution, there should be free intercourse between the cities and States of the country.