

Narrow overpasses and bridges likewise present some imposing barriers which have a high accident frequency. We, in Texas, have long believed that all structures should be wide enough to accommodate the full width of approach roadway and shoulders. A crown width bridge does, of course, cost more than does a restricted width structure; however, considering the length of time the structure will be in service, it is an exercise in false economy to permit the initial cost to dictate design. Traffic safety and operation are enhanced by the wider roadway. The driver is more comfortable on a wide structure. In the event of an emergency stop, the wide structure can accommodate the parked vehicle without obstructing a traffic lane. Studies have indicated that emergency stops along a conventional facility occur each 10,000 to 12,000 vehicle miles which means approximately eighty million stops per year on the Nation's highways. If we are willing to spend millions of dollars to construct parking shoulders on the highways in between bridges, why should we shrink at spending a little more to extend this refuge area across our structures?

When guardrail is required on the approaches to a structure, it should be continuous across the structure, anchored securely to the bridge and at the end of the rail. The bridge should not have any curbs if there are none on the approaches. In particular, construction of a so called "Safety Walkway" should be avoided. While on the subject, I might offer the observation that altogether too much curbing has been used in the past along our highways. As a general rule, curbs should be used only where required for drainage and, in such cases, should be easily mounted by traffic. An acceptable curb would be a laydown type with a suggested rise of three inches in a width of twelve to eighteen inches. Any higher curb can throw a vehicle out of control or impart a dynamic action that tends to project the vehicle onto or over a protective rail.

Bridge parapets and rails should be designed so as to provide unimpeded sight distances to side roads or ramps beyond the structure. On many of our existing facilities, we have discovered that traffic on an exit ramp or frontage road, stopped at the intersection, cannot see a through vehicle on the crossroad structure until they pull out into the intersection. As a result, a number of collisions, several involving fatalities, have resulted. These existing situations can only be corrected by altering the traffic patterns or, at great expense, modifying the design.

DRAINAGE STRUCTURES

Our highway cross sections are replete with death traps for the unwary or errant driver. Among the most common are our installations for handling surface or cross drainage. Openings in medians and outer separations, between culverts, are prevalent in all areas of the Nation. If the culvert is continuous, any number of drop inlet designs with raised covers are encountered. Such hazards can be rather easily eliminated by extension of the culverts and installation of flush inlets. Admittedly, a flush inlet is a maintenance headache since it is susceptible to being plugged by loose brush, debris or even a newspaper; however, a raised inlet or an open ditch is an even greater headache to anyone unfortunate enough to run into it. The only exception to the use of flush inlets would be where they are located thirty feet or more away from the edge of pavement.

Curb inlets also present a hazard to drivers if they are located adjacent to the travel way. As a general rule, the use of curb inlets should be avoided; however, where they are absolutely necessary, they should be located on the back side of the curb.

The ends of culverts, headwalls and headwall curbs, etc., should be located well beyond the shoulder edge and behind protective guardrail rather than adjacent to or projecting into the roadway. Again, the guardrail should be of sufficient length, with anchored ends, in order to enable it to develop full ribbon strength if it is struck by a vehicle. Too often, a short length of rail, usually 12' 6" is installed at culverts. These short rails cannot contain a vehicle. Thus the only purpose they serve is to delineate the hazard; however, they are a hazard in themselves.

TREES

For the past several years we and the highway industry have been maligned both publicly and privately for our lack of appreciation of nature's beauty. We have been accused of willfully and unfeelingly wreaking havoc on areas of natural beauty by construction of highways which disfigure the landscape.

Unfortunately, there have been cases where overzealous engineers have disregarded the amenities; however, I do not agree that this is the case rather than

the exception. A modern, well designed highway is a thing of beauty. By judicious planting and landscaping it can be adapted to the terrain and natural foliage so that it complements rather than detracts from the scenic grandeur. What we must guard against, however, is becoming too overzealous in our beautification efforts.

Aside from their ability to enhance a highway's appearance, trees are still a deadly menace to high speed traffic. Drivers and their unfortunate passengers are still being daily maimed and killed by trees on our highway system. In Texas, last year alone we recorded 788 accidents on our rural system involving trees and shrubs.

In no case should safety ever be compromised in the interests of beautification. No trees should be planted or permitted to remain within thirty feet of a main-lane shoulder or within twenty feet of a ramp. No trees should be planted or permitted to remain within medians less than seventy-five feet in width. Since over twenty-five per cent of highway fatalities result from vehicles leaving the road, trees should be removed on the outside within the limits of horizontal curves. Inside the curves, they should be removed or set back a sufficient distance so that they do not limit sight distance.

We have developed break-away mounts for our highway signs and illumination standards. Until such time as an artificial break-away tree is developed, they must be considered one of our major roadside hazards.

ABUTMENTS AND RETAINING WALLS

Since abutments and retaining walls must by their very nature be closer than thirty feet to the roadway, they must be continuous with no protruding features subject to collision. Desirably, they should be at least twenty feet from the roadway. If a closer location is required, protective guardrail should be installed. Retaining walls or abutments should not impair sight distance to ramp gores or signs. Retaining walls should, of course, be avoided if at all possible, thus resulting in a much more open, pleasing and safer facility.

UTILITIES

Utility installations are the nemesis of many highway engineers. They contribute nothing to the appearance, operation or maintenance of our system. The tangle of utility lines along many of our highways severely detracts from their appearance and they are a constant headache to our construction and maintenance personnel. Nevertheless, we must live with them, hence we must establish some basic housekeeping rules.

All overhead lines constitute a hazard by virtue of their supporting poles. Due to the massive size of H-frames and towers, they should be kept completely off the right of way except at extremely wide sections where they can be placed beyond any reasonable possibility of danger to traffic. Ideally, overhead lines should span the entire right of way with poles adjacent to or just outside the right of way line; however, if a compromise arrangement must be accepted, utility poles should be no closer than thirty feet to the main lane shoulders or twenty feet to the ramp shoulders. Electrical transmission lines, of course, pose the greatest danger to traffic since any accident resulting in a pole knock-down or damage could drop a "hot line" across the highway. Telephone lines do not pose this danger; however, because telephone lines cannot normally span as great a distance as power lines, their pole placement is a principal consideration.

Railroad signal devices such as gates, flashing lights, crossbuck signs, etc., constitute a menace to traffic due to their usual proximity to the highway at railroad-highway crossings. I might mention that Texas is currently engaged in a cooperative research study involving at-grade railroad crossings. It is our intent to try and develop a hazard rating of different types of crossings as well as determine whether railroad crossing signs and signals should be brought back into the family highway signs.

In municipalities, fire plugs and traffic signals can be quite hazardous. Most street sections are necessarily constructed on very restricted right of way with fire plugs, traffic signals, illumination standards, etc., located between the curb and sidewalk. All such installations should be located as far away from the roadway as possible, preferably beyond the sidewalk area.

SUMMARY

In closing I would like to express my own philosophy with regard to the role of the highway engineer in the general field of safety. A highway accident, we must agree, has to be caused by one or a combination of three circumstances; namely (1) the driver, (2) the motor vehicle, (3) the highway.

Under present laws the ability of the driver can range all the way from a physical or a mental weakling with low IQ, poor eyes, slow reaction time, etc., to a perfect physical specimen with high mentality. Nearly every state permits vehicles on its highways ranging all the way from one with poor steering apparatus, slick tires, etc., to perfectly operating machines. The driver and the automobile cannot, and it is my prediction will not, ever come under the purview or jurisdiction of the highway designer or traffic engineer. However, there is something we can do to improve the design and operational characteristics of all highways. It is believed that such meetings as this can provide the very best forum for an exchange of views among experts in this field. We are obligated to not only be sure that the facilities we are now constructing are designed as safely as possible, but we are further obligated to ceaselessly point out to administrators in our field the need to take corrective measures on the many, many miles of highways now in use which are just as backward as the driver with low mentality or the automobile with poor steering apparatus and slick tires. We should carefully study all accident reports and design features to determine whether they may have been the cause of accidents. Only in this way can we eliminate those highway design features which contribute to our rising accident rate.

Mr. CONSTANDY. Mr. Wilkes.

Mr. WILKES. Some of my remarks will repeat comments made before. The highways we saw would meet the existing design standards, and the bridges could comply with the governing specifications. I think I can make this statement safely.

This would then suggest that either our standards need revising or they need to be expanded to cover the deficiencies that we observed and were so apparent. However, I believe there is a greater need for highway engineers at all levels, the designers, supervisors, construction men, maintenance men, inspectors, to be made aware of the need for their respective responsibilities to produce the highway facility that will provide maximum safety by the elimination of these hazards.

This can only be done by the chief administrative officer of each State. He must impress on all employees the importance and the high priority for producing this total design for highway safety.

We have seen in this presentation evidence of the lack of attention to details of design and construction which are necessary to produce this safest environment for the users of the Interstate Highway System.

In many cases the deficiency could be corrected with little or no increase in construction costs. In other cases, the initial cost may be substantially increased. However, as Mr. Constandy has pointed out, if consideration is given to the total cost, the initial construction, the maintenance, the accidents, the tragic loss of life and limb, the additional expenditure and money may well be justified.

The greatest deterrent to the correction of existing deficiency of bridge width and the inadequate side clearance is the lack of adequate financing. I am confident that future designs will incorporate the several features that have been found to provide the maximum safety to the highway users. The efforts made with the AASHO traffic committee and the expressions of genuine concern at all levels of government, and especially the hearings held by this special subcommittee,

have focused the attention of all responsible highway officials on this national problem.

We do appreciate the time and attention that the members of this House committee have given to this subject, and I feel that you have made a major contribution to the advancement of highway safety by dispelling the apathy among highway organizations throughout the country on this national problem.

Mr. CONSTANDY. Thank you very much, Mr. Wilkes. Very fine statement. Mr. Ricker?

Mr. RICKER. It is of course difficult to be the last one to summarize after five summaries, such as you have just heard.

Perhaps I will be forgiven for going back and being a little more philosophical rather than repeating what has been said.

Our ordinary highways, the older ones in particular, are lined with hazards such as trees, rocks, utility poles, and so on, and in general we seem to drive them fairly safely without too many contacts.

Starting I guess with the construction of the Pennsylvania Turnpike we provided a new driving environment. It has been said that the Pennsylvania Turnpike was the first highway to be designed ahead of the vehicle that would operate on it. Certainly since that time the vehicles have been capable of higher speeds and seemingly the drivers are using higher speeds.

We are in the era now where we are building many new freeways, limited access highways, according to the knowledge available from the older roads. Apparently what is happening is that as we eliminate the hazards of crossroads, railroads, trees, and so on, near the right-of-way, near the pavement, we are moving into a new operating environment where the drivers are perhaps more relaxed, less alert if an animal runs out in front of them or a tire blows or something else. And because they are more relaxed, they are more apt to leave the pavement and go into the adjacent areas.

Therefore, these areas should be, as Mr. Wilson expresses it, more forgiving. I believe what we have seen in the slides these past several days indicate ways that we can improve this environment and make it more forgiving, and I certainly feel that we should all move toward that.

It must be a continuing program. We cannot design safety into the road and then go away and leave it. We have to make maximum use of observations as the traffic uses the road, talking to the police who patrol it, talking to maintenance men who repair the damaged guard rail, talking to the traffic engineers who are out observing the actual operation of the highway. And as Mr. Wilkes says, it will be fairly easy to incorporate these improvements in new products.

To go back and correct the others is quite a bit more difficult, particularly when right-of-way is limited, when the structures are already built.

It has been implied by some of the Congressmen at this series of hearings that maybe we can get some more money to correct the older deficiencies. I am sure that when I go back to Pennsylvania this will be the first question asked me: Are we going to get more money to do it?

Mr. CONSTANDY. Thank you, Mr. Ricker.

Mr. Chairman, I would like to personally thank the members of the panel. I think they have made an important contribution to the effort

we are making, which incidentally is to define a problem. I do not think you need to worry about design standards coming out of the committee. I think that will be left, and properly should be, to the people who are professionally qualified to do it.

I think they can be helped in the attention to the problem the committee will give, the definition of that problem.

I want to thank you very much for your cooperation. It has been a strain, I realize—as an example—Mr. Ricker gave up his vacation to be here with us, and we are most grateful.

Mr. McCARTHY. On behalf of Chairman Blatnik, and the chairman of the full committee, Mr. Fallon, I would like to express the thanks of the committee to Mr. Ricker, who gave up his vacation, and to Mr. Wilson, Mr. Prisk, Mr. Skeels, Mr. Huff, and Mr. Wilson. I think you certainly made a major contribution to the future saving of a lot of American lives.

When we took up the highway safety bill last year, it was brought out—of course we are all concerned about Vietnam—it was brought out that since we have been in Vietnam three times as many American servicemen have been killed on our highways in the United States during that time, as died in battle and we are now killing more than 50,000 people a year. So this is certainly a major problem that affects the vehicle and affects the highway and relates to all aspects of it.

I think that this testimony is going to accomplish a lot, and I think your suggestions are very valuable. We will be poring over them, and nobody has the answers as yet.

We would not be here in this hearing if we had all the answers.

Some of the suggestions made convince me, from my own experience in industry especially, that this should be a top management function. I think it should start with the Governor, and certainly his highway director, and I think that there is value in having a member of the top management team, the first echelon, right under the director of highways, who would be the director of safety. I think there is some value in that.

I know there are also safety review teams that some of the States have; but that is a different sort of responsibility.

If you had one top-level safety engineer who is part of the top management team in the States, I think—at least from my experience with a big company with over 70 plants—it showed that where we had one man in each operation who was in charge of safety, but with the ultimate responsibility falling on top management, this seemed to work.

Also I think it would be a mistake for Washington to try to dream up all the answers and impose them on the States.

The longer I am here, the more I see danger in some people who think, well, they have all the answers. That just it not so.

I think the States could enter into a very healthy competition to determine which would be the most effective in cutting the number of deaths.

Out in the field will be many, many valuable and important answers developed that could then be incorporated by the other States as one of you suggested.

One thing the staff has discovered, and the members of the committee, is that too often these admonitions that have gone out have gone

unheeded, despite the good sense they made from a safety point of view. Many of the suggestions were disregarded by the design people who seem to justify continued error by observing that "we have always done it this way."

Chairman Blatnik is sorry he cannot be here to bring today's session of the hearings to a close. As you know, one of the biggest problems confronting Members of Congress is time. We often do not have enough time to do everything that we want to do, due to conflicting demands and duties. However, I do have his statement and I would like to read it here into the record:

As we bring to a close this discussion by a panel of witnesses, each of whom is distinguished and nationally known in his field, the Chair wishes to thank each of the panel members for the fine service he has rendered to his country, the highway program, and the cause of greater safety to be designed and built into our new roads. You are to be commended for giving of your time and your knowledge as you have done, and I want the record to show that the Chair expresses, in behalf of our entire subcommittee, the gratitude and appreciation that is your due.

During the opening days of our public hearings we heard testimony from early witnesses, documented by scores of photographic slides, that all was not well in the design-safety area of our highways. Roadside and gore areas cluttered with sturdy, overdesigned or unnecessary fixed objects such as heavy-duty steel poles or sign supports, elevated concrete bases and similar roadside hardware unprotected or too close to the traveled way were shown to be commonplace, even on our newer roads. So were other unsafe design features which so abound in the record by now that it would serve no purpose to recite them in full at this point.

To establish whether these conditions were limited geographically, we broadened the scope of our inquiry. This was done by taking a representative sampling of the whole Interstate System, utilizing for the purpose an inspection of the most recently opened Interstate project in each of the nine regions administered by the Bureau of Public Roads. Each region was visited, and the projects inspected by a representative of our staff accompanied by an eminent respected and experienced highway engineer, Mr. Charles W. Prisk, who is currently on loan to us from the Bureau of Public Roads. Mr. Prisk's excellent credentials are well known throughout highway circles and require no further comment.

The results of this sampling are now apparent to us all. They are consistent with the testimony that has been previously incorporated into the record at these public hearings. The evidence has unfolded before our eyes as photograph after photograph has been thrown onto the screen to document with overwhelming persuasion the testimony of the witnesses as to what they found and observed on newly opened Interstate projects all around the country.

As a result, for several days this distinguished panel has seen slide after slide upon our screen, depicting built-in roadside hazards in these newest of projects. The opinions and observations of our panel members have confirmed our own impressions from the evidence to date. There is little question but that the design of these, our newest and most modern highways, has failed to take advantage of the available results of experience and research.

The knowledge is at hand. Safe highway design is advocated and taught by leaders in the highway design and traffic engineering fields such as the gentlemen who have constituted our fine panel at this hearing. It is set forth in bulletins and publications that have issued over a period of years from the Bureau of Public Roads and from AASHO, the American Association of State Highway Officials. But somewhere along the line there has been a failure of communication with those who design and construct the actual roads.

Possibly this situation has come about, in part, by a tendency on the part of State highway departments to regard themselves as "constructing agencies," whose chief function is to press forward as rapidly as possible under our great highway building programs. This attitude too frequently displaces what should be the concept of a highway department, namely that of managing the highway system as an operating physical plant, which is what it actually is. The highway is a live "going concern," which grows and changes with conditions, not a mere stretch of pavement which, once completed and opened to traffic, may then be abandoned except for the necessary maintenance-crew attention.

The Chair expects that out of these hearings will come, among other things, a greater realization that the design and construction of highways should be the beginning, and not the end of sound highway practice and operational efficiency.

With the close of this week's sessions we have achieved a recognition of the scope of the problems we face in the area of safe highway design.

We will try to find the answers to some of the problems that have been identified thus far, when the subcommittee meets again to resume these public hearings on safe highway design and operating efficiency.

Mr. McCARTHY. The committee will stand adjourned until 10 a.m. Tuesday, June 27.

(Whereupon, at 12:30 p.m., the hearing was adjourned, to reconvene at 10 a.m., Tuesday, June 27, 1967.)

HIGHWAY SAFETY, DESIGN AND OPERATIONS

Roadside Hazards

TUESDAY, JUNE 27, 1967

HOUSE OF REPRESENTATIVES,
SPECIAL SUBCOMMITTEE ON THE
FEDERAL-AID HIGHWAY PROGRAM
OF THE COMMITTEE ON PUBLIC WORKS,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10:10 a.m., in room 2167, Rayburn Building, Hon. Robert C. McEwen (acting chairman) presiding.

Present: Messrs. Wright, Clark, McCarthy, Cramer, McEwen, Schadeberg, Zion, and McDonald.

Staff present: Same as previous days.

Mr. McEWEN. The Special Subcommittee on the Federal-Aid Highway Program will come to order.

The subcommittee heard testimony last Friday by a panel of experts in the field of highway design and traffic engineering to analyze and discuss design safety features found in recently opened Interstate projects in all regions of the country.

These gentlemen, after viewing numerous photographic slides depicting design conditions found by our staff and by Mr. Charles W. Prisk of the Bureau of Public Roads at each of the projects visited, were asked for the benefit of their observations and opinions. Their testimony confirmed our own impressions from the evidence received earlier in these hearings. The testimony left little doubt that the design of these, our very newest highways, too often failed to incorporate and put into practical use the results of knowledge available from past experience and research.

The failure appears to be one of communication. Somewhere along the line the people who design and build the roads have failed to receive the knowledge about safety design which is at hand and have gone about the design of new projects without incorporating safety features which research has demonstrated are both practicable and efficient.

Today and tomorrow we will hear testimony from people who are leaders in the field of research and development. These witnesses will describe to us some of the tools that are available in our endeavor to create safer and more efficient highways.

We are pleased this morning to have Mr. Kenneth A. Stonex, Executive Engineer, General Motors Corp., Detroit, Mich.; and Louis C. Lundstrom, Director, Automotive Safety Engineering, General Motors engineering staff.

(1005)

Gentlemen, you will both be sworn at this time.

Do you solemnly swear that the testimony you are about to give before this subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. STONEX. I do.

Mr. LUNDSTROM. I do.

Mr. McEWEN. Gentlemen, you may be seated.

Mr. CONSTANDY. Will you each give your name and address, please?

TESTIMONY OF KENNETH A. STONEX, EXECUTIVE ENGINEER, GENERAL MOTORS CORP., DETROIT, MICH.; AND LOUIS C. LUNDSTROM, DIRECTOR, AUTOMOTIVE SAFETY ENGINEERING, GENERAL MOTORS ENGINEERING STAFF

Mr. LUNDSTROM. I am Louis Lundstrom, Warren, Mich.

Mr. STONEX. I am Kenneth A. Stonex, Executive Engineer, automotive safety engineering, General Motors engineering staff.

Mr. CONSTANDY. Mr. Lundstrom, will you begin by telling us about the General Motors proving ground, please?

Mr. LUNDSTROM. Yes. I would like to tell you a little bit about the history and scope of our proving ground, and to identify some of the safety problems we have found on our roadways and to discuss the solutions as they evolve.

The General Motors proving ground near Milford, Mich., covers some 4,000 acres of rolling countryside. On this proving ground we have some 75 miles of road system that is used for all types of automotive test work. This involves the typical passenger cars, small trucks, large trucks, buses, earthmoving equipment, and military equipment. Would you like me to continue?

Mr. CONSTANDY. Yes, sir, please.

Mr. LUNDSTROM. In the conduct of our work over the years, we have encountered numerous safety problems. These problems include roadside obstacles, such as trees, stones, culvert headwalls, bridge abutments, roadside drainage ditches, the slope of roadside fill sections and the evaluation of theoretical approaches to these problems.

Included in our work was the development of guardrails that were required for roadside obstacles which could not be eliminated.

The problems of roadside signs, sign posts, were with us as they are in the public highway. The problems of light poles and their solution were encountered as well as the problems of bridge rails or parapets.

As solutions to these problems evolved or appeared to evolve, we presented the results of our work in a number of technical papers at formal meetings of professional or technical societies with highway orientation. We will later summarize the highlights of a few of these papers which we think are significant to the formal record of these proceedings.

To provide a graphic demonstration of some of the developments of the General Motors proving ground program and highway safety, we propose to show several motion picture sequences. The first two of these, "Safer Roadsides" and "Guardrail Testing for Safety," are part of the General Motors Public Relations Film Library available to the public. This composite film has been shown to more than 1,200,000

people during the last 2½ years. The other sequences we will show are of our current views of roadsides, performance of breakaway light poles and bridge parapet designs.

Mr. CONSTANDY. You mentioned the film had been shown to 1,200,000 people. What kind of people were these, engineers or what?

Mr. LUNDSTROM. This film is often used, probably most frequently used by service clubs. It is also used frequently by high school groups, by even the Boy Scouts in their programs of safety. It is also frequently shown to highway officials, city officials, anyone who might find reference to this road film library.

Mr. CONSTANDY. Fine. Tell us a little bit more about what use is made of the proving ground?

Mr. LUNDSTROM. The proving ground is used by all of the divisions of our corporation. Mr. Stonex and I represent the engineering staff who operate the proving ground, but it is open for use by every one of our divisions.

The original purpose, obviously, was to have a private road system where testing would not be subject to the traffic encountered on normal public roads.

We have at our proving ground then a total employment of about 1,500 people.

Mr. CONSTANDY. When was this established?

Mr. LUNDSTROM. The proving ground was established in 1924.

Now, the proving ground is utilized very extensively by these operating divisions. We have accumulated 337 million test miles during our operations. The current daily mileage runs between 70,000 and 80,000 miles. This is done on a three-shift basis, typically 6 days per week.

Mr. CONSTANDY. So it is used in all types of weather, too?

Mr. LUNDSTROM. Day and night, year-round; the proving ground actually never closes.

We have typical maintenance equipment, obviously, so that if there be a heavy snowstorm, we would clear our roads as you would on the public highway to conduct the scheduled tests. Nonscheduled tests under adverse conditions would, of course, be run as weather conditions would require.

Mr. CONSTANDY. Yes. We want to make this point, the traffic which you have on your road system is fairly typical of the traffic and the traffic conditions you then find on public highways.

Mr. LUNDSTROM. Very much so. The purpose of the proving ground as far as automotive testing is concerned is to find the problems before the vehicles are released to the customer. So we must have operations on the proving ground that are typical of conditions throughout the country.

Mr. CONSTANDY. Fine. When did you take over the proving ground?

Mr. LUNDSTROM. I came to the proving ground myself in 1939, but I was advanced to director of the proving ground in 1956.

Mr. CONSTANDY. What problems did you have then?

Mr. LUNDSTROM. Well, gentlemen, the director of a proving ground or the manager of any plant in General Motors is responsible for the safety of the people under his jurisdiction. This is a cardinal rule in any of our industrial operations, and so it became my responsibility to have safety foremost in my mind and obviously then we had to be very careful about the safety of the operation on the road system.

We had been drilled over the years in plant safety and the extension of this concept to the road system was natural for us to take.

Mr. CONSTANDY. Yes. I think it is kind of interesting, your efforts along this line were motivated as an industrial safety project, this particular plant being the road system.

Mr. LUNDSTROM. That is correct. We could not tolerate injury on our control road system any more than we could tolerate injury from some careless practice in the plant itself.

Mr. CONSTANDY. Could you continue then?

Mr. LUNDSTROM. All right. In describing the proving ground then, as we saw it in perhaps 1956, the general layout of the road system was somewhat unique in that all of the major operations had been one-way traffic. Let me repeat again, as early as 1924, the men who laid out the proving ground recognized the importance of one-way traffic and all of the major roads from that time until now have been one-way traveled.

Mr. CONSTANDY. That is an important feature in your safety record, is it not?

Mr. LUNDSTROM. I am positive this is perhaps the most important feature that we have had over the operation from 1924 to the present time.

Now in 1956, or thereabouts, we discovered to our dismay that our roads were lacking in roadside safety. They had been built much as were the roads throughout the States and the country road systems; they lacked the wide shoulders that are known today to be important; they did have obstructions along the roadside; they had deep ditches in places that were thought to be necessary to remove surface water; they had steep backslopes or cuts through hills. In general these were the problems confronting us in 1956 and it was quite obvious in studying the accidents, one by one, that our most severe problem was related to these roadside hazards.

Early computations or early studies of accident statistics indicated that approximately 70 percent of our accidents were of this single-car-running-off-the-road type.

The proving ground, as I indicated earlier, is typical rolling country. There is nothing different about it than any State or country road you might see in Michigan—curves, hills, lakes, level country, very ordinary type of operation, very ordinary type of environment.

But we did, again in studying accident records, find that our test drivers, try as we may, would leave the test road about once every 250,000 miles of operation. In other words, this is a vehicle out of control. And then what might happen to this vehicle out of control would depend very importantly on what the condition of the roadside was. And in that year 1956 or thereabouts, we admittedly had these hazards as are so often encountered on the public highway.

Mr. CONSTANDY. At what speeds are the vehicles operated?

Mr. LUNDSTROM. The proving ground system operates over all of the speed ranges encountered on public highways and a considerable number of tests beyond the legal speed limits. This is necessary so that we do go beyond what the customer will demand of his car in normal service.

We also use higher speeds as a way of accelerating the test of a car. So we do run typically many miles at speeds over legal speed limits.

For example, from perhaps the 1940's until this time, all of the durability cars that were run on the proving ground had 90-mile-per-hour tests on the test track as a part of their normal endurance schedule. In other words, a driver every 30 minutes would be driving 90 miles per hour. So we were encountering these speeds that were considerably above normal highway practice, but for the reasons given.

Mr. CONSTANDY. At the same time, though, a good portion of the mileage is at typical highway speeds?

Mr. LUNDSTROM. There are many, many tests at not only highway speeds, but at city speeds. We have stop-and-go traffic in certain areas where the cars never reach more than 30 or 35 miles per hour. Some of the cars stay on the city schedules entirely.

Mr. McDONALD. I would like to say I have had the privilege of going through your facilities there. I have seen cars traveling up to the speed of 130 miles an hour on your big track about 2 years ago when you had a display out there with some super automobile.

I would like to say this is the most modern and well-developed track and test proving ground in America, not only for the safety of the vehicle but for highway safety. I think you are being a bit modest in your description of the proving ground. It is a tremendous thing and General Motors should be commended for the work they have done in the proving ground for vehicular safety as well as driver and highway safety.

Mr. LUNDSTROM. Well, thank you. I hope the continued discussion here this morning will emphasize what you have offered.

Mr. McDONALD. I say that because, as a contractor before entering the Federal service, I was a subcontractor in many of your projects out there, so I feel I have had a hand in developing your facility.

Mr. LUNDSTROM. Thank you.

Mr. CONSTANDY. You will notice, as it became obvious to us, there is a potential for an accident when a high-speed vehicle impacts a solid object. The simple solution is to remove the obstacle. That cannot be overemphasized, can it?

(At this point, Mr. Clark assumed the chair.)

Mr. LUNDSTROM. No. That is a very obvious thing we neglect to say. Many of these obstacles are no match for a car or a car is no match for these obstacles.

A tree of even 6, 8, or 10 inches in diameter can virtually destroy a car.

Mr. CONSTANDY. And the occupants.

Mr. LUNDSTROM. And the occupants. Correct.

Mr. CONSTANDY. So in 1956, did you begin a renovation of the physical plant to enhance the roadside safety?

Mr. LUNDSTROM. Yes. We started developing the new designs, new facilities we were constructing, to higher standards; and in 1958 we started a very intensive effort to redo or modify the existing road system.

I believe the first work of this nature was done in 1958 and it was the result of studies of accidents that had involved personal injury unnecessarily.

When we looked into any case and tried to find why was this man injured, we often came back to the fact, well, his car ran through some roadside obstacle; and I remember very well a rather shallow ditch

that caused some personal injury. They questioned why did the ditch have to be there; and it did not have to be.

Mr. CONSTANDY. You know, this thing ought to concern more people; in this field of highway safety you hear a variety of opinions. Usually the opinion is there was a nut behind the wheel or he was drunk. People seem to be looking for some defect in the driver's behavior. But frequently, in the final analysis, when you look at where the automobile stopped, it stopped suddenly against some object that did not have to be there.

At the scene of the accident more people should be concerned over the signpost or the obstacle that did ultimately stop the vehicle. I think that way we may have more progress toward improvement of the roadway.

Mr. LUNDSTROM. Well, this work that you mention and the removal of these obstacles was continued then, and by 1962 all of the major roads on our proving ground had been regraded and the roadside obstacles removed as necessary.

Mr. CONSTANDY. Before you began this undertaking, did you research the existing design standards and current practices as followed by highway departments and toll roads?

Mr. LUNDSTROM. Yes. We do have at our proving ground a plant engineering department fully responsible for the design of our roadways and we did ask them to review the practices that were being used throughout the country to determine whether or not we could find suggestions for improvements of our road systems.

Now, I remember quite well that they reported to us the construction techniques and the design characteristics that we were using were typical of State roads throughout the country.

In looking at some of the design guidebooks, I do recall seeing the statements made that roads built to minimum standards are not the safest roads. And there was strong evidence that too often roads were built to minimum standards.

Mr. CONSTANDY. And hence not the safest roads?

Mr. LUNDSTROM. Correct. And herein lies part of the problem. So it was simply a matter of the proving ground deciding to build considerably above minimum standards.

Mr. CONSTANDY. Did you survey existing roads and turnpikes in the hope of finding a model safe highway?

Mr. LUNDSTROM. We surveyed many miles of roads, sent men on cross-country trips to look at what practices were being used. I would not say that we were looking for a model, but we were looking for new ideas. And we did not find too much of benefit. We could identify the same problems on the public highway system as we were finding on the proving ground itself.

Mr. CONSTANDY. And were you able to find a single mile of the Interstate System or any toll facilities which did not have obstacles, ditches, which could be potentially lethal if a car should run off the road at legal operating speed?

Mr. LUNDSTROM. No. We had challenged our people to find this, a piece of public road that was free of all roadside hazards 1 mile in length. And to this date my men have never reported to me, and I have never personally found, a road of this type.

Mr. CONSTANDY. Thank you.

Mr. LUNDSTROM. Now, I might continue by saying that in a little bit different way: The object of removing roadside hazards is to provide traversable roadsides, to give a driver time to recover, time to regain control of his car, either stop it or direct it back to the road. This is a rather simple statement, but a very important concept.

Now, we were very enthusiastic about this straightforward approach to this problem. And the early experience on these regraded roads justified this enthusiasm. The early results were good.

The drivers cooperated very well and it was difficult to keep ahead of their suggestions for roadside improvement. This again is perhaps a very significant point, that the drivers, once they understand the problem or once they understand what you are trying to do for them, will offer many suggestions and come in with their own comments, and again let me say it was difficult in those days to provide the improvements as fast as the drivers would ask for them.

They fully recognized it was for their own benefit, their own safety, and it was very encouraging to have their support as well as the support of our engineers who were designing and modifying these road systems.

Now we believed that this same approach could be applied to the public highways with equal effectiveness and we did begin then in 1958 to call attention to these improvements to those responsible for highway engineering throughout the country.

On our proving ground, as well as on public highways, there are some places where it is virtually impossible to remove obstacles. This could be a river or a drainage system. These things cannot be moved. And we do then have construction elements, such as bridge abutments; we must have high roadside fills in places where it is impossible to flatten the slopes, and things of this nature.

It was therefore necessary to develop systems such as guardrails to protect the occupants of cars in the areas where no other protection is feasible. In other words, if you cannot provide a clear, safe roadside, you have to provide a substitute and this is what we typically call highway guardrail.

Mr. CONSTANDY. Yes.

Mr. LUNDSTROM. Now, later in our discussion this morning, we will show motion picture sequences of a project which had the objective of developing adequate guardrail protection.

Back in 1958 we found that the materials currently available could be used to provide adequate control if properly installed and properly built. We did find, though, that the installations typically made on the State highways were rather minimum in strength and we found ways of improving them, ways of strengthening the installations to go beyond the minimum standards.

Probably the most serious problem in standard guardrail installations was that the end of the guardrail was exposed, and I think you have already reviewed some of this work, knowing if the automobile strikes the rail dead center so that the motor mass strikes the guardrail, the deceleration of the car is very high and the guardrail itself becomes a formidable obstacle. If the car strikes off center, the guardrail may and frequently does impale the car.

We have in our files, as I am certain you have in your files, photographs of cases where the guardrail has threaded through the car interior, creating injury and death.

Now the second problem on typical installations of guardrail is that the posts are separated by too large a spacing. Frequently it is found that the guardrail beam is weak enough to deflect so that when a collision is between the posts, the car is trapped and stopped at a high deceleration rate or it simply travels over the rail.

Now in the consideration of roadside obstacles along our highway network, utility poles, and particularly lamp poles for roadway lighting, are prominent. Early in the proving ground program we demonstrated the feasibility of using a tripod lamp pole constructed of thin wall tubing with flush mounted base plates having low shear resistance. By thus distributing the inertia and minimizing resistance at the base, we were able to collide with a prototype breakaway pole, producing only very minor sheet metal damage and almost no possibility of injury to the occupants.

Later in the testimony we will show a record of this early work and demonstrate the current status. This early design was considered to be too expensive and so recently we have gone into additional tests which we will describe later in our program this morning.

Early in the proving ground program we recognized that ordinary traffic signs, mounted then at a height of 42 inches, could be significant hazards. The problem with this installation is that, at normal traffic speeds, collision with the sign support bends it away near ground level; the inertia of the sign is high enough that the mounting bolts are pulled apart or through the sign, and the sign starts to fall. Before it falls far enough, the car runs into it at windshield level. Some of the standard signs weigh as much as 25 pounds and the sign will usually break the windshield and sometimes penetrate it.

The proving ground demonstrated conclusively that if the sign is mounted 60 inches or more above the road, the car will pass below the sign before it falls far enough to be struck by the windshield.

This concept was recognized in the 1961 edition of the Manual on Uniform Traffic Control Devices, where a minimum height of 5 feet, 6 inches on expressways is prescribed.

Now, extensive development of guardrail designs induced a growing feeling that current bridge rail design are inadequate. Reports of increasing numbers of failures in the field as the construction of the Interstate System proceeded substantiated this feeling.

During the planning of access to a new circular test track facility in 1961 and 1962, increasing emphasis was placed on the development of a bridge parapet that would be impenetrable to any type of vehicle, that would produce minimum injury to occupants and minimum damage to the vehicle, and that would redirect the vehicle in the direction of the roadway.

Later in the day we will show some film on this where we are changing from the concept of the flexible beam guardrail on the highway to a rigid beam that is needed on the bridge rail where there can be no possibility of the vehicle penetrating the guardrail.

Mr. CONSTANDY. That parapet is most impressive. I think the movies you have will clearly show it.

Is it not also possible to use that parapet design as a median barrier?

Mr. LUNDSTROM. Yes. There have been some sample installations made, one of them right in Detroit, and we are encouraged by the results, not only on our proving ground. We believe this design will be beneficial as a median barrier.

But the important thing to remember is that this is a rigid barrier, not a flexible barrier, as is used on the open highway.

Mr. CONSTANDY. Yes. I wonder if you could give us some of the accident statistics of the proving ground.

Mr. LUNDSTROM. Yes. I would very quickly like to say that in addition to the elements I have just described this morning, and I would repeat by reminding you that we are talking about a one-way road system, we are talking now about a road system that is used over the entire speed range of automobiles; we are talking about day-night operation, winter-summer; we are talking about improved roadsides. And in addition to this, we are talking about a system where we can be rather selective of who drives on this system. We are talking about a system where we can train the drivers better than you can train the public on the highway system. We are talking about a system that involves vehicle inspection. We are, therefore, talking about control of the roadway, the driver, and the vehicle.

Mr. CONSTANDY. This is about as close as you can get to an optimum situation, is it not?

Mr. LUNDSTROM. Well, this is our attempt, obviously. We are trying to take all possible improvements into account and this can be done on this private road system.

Now, we have no way of breaking out the significance of each one of these elements. All I can tell you in answer to your question is that when you take the total system operating under these conditions, we have an accident record that is 25 times better than the public highway system.

This is 2,500 percent better. It is hard to visualize, because today people are searching for 200 percent improvement, perhaps, in accidents represented on public highways. We are talking today about 2,500 percent improvement.

It is a fact, it is proof that it can be done.

Mr. CONSTANDY. Have you had any fatalities on the proving ground?

Mr. LUNDSTROM. Since 1924 there have been two fatal accidents on the proving ground, each involving two men.

The last fatal accident was in 1942. Since that time we have run 225 million miles without a fatal accident.

Mr. CONSTANDY. It is worth recognizing that the fatalities you have had, as few as they have been—

Mr. LUNDSTROM. I would like to have you understand very clearly the method I am using in comparing proving ground with the public highway. The number of fatalities does not make it possible for us to draw a good comparison with highway practice. So we have to drop to the next level of accident severity. This is in terms then of temporary disabling injury accidents. And it is this basis that I am using in talking about a 25-to-1 improvement.

Mr. CONSTANDY. Yes. I think it is worth keeping in mind that you cannot be concerned only with fatal accidents. The line that separates the two types is sometimes very thin.

The accidents that you did have that were fatal, however, were they run-off-the-road-type accidents?

Mr. LUNDSTROM. Both of them were. One of them involved a special car that ran off the top of our test track through a rather weak barrier and involved the death of two men.

The second accident involved a truck that, again, ran off a curve that was unprotected; it was a rollover accident into a poorly prepared roadside and again there were two fatalities.

Mr. CONSTANDY. Since your roadside improvement program you have had none, both of these happened under the old design?

Mr. LUNDSTROM. Both of them on the old designs, correct.

Since we started working on the roadside improvement program, we have had, I believe, 219 cars off the roadway unintentionally. And there has been one temporarily disabling injury accident in 219 times.

These statistics are significant. I would challenge you to look at the roadways that you drive every day and see if you could drive off the road 219 times without getting injured.

Mr. CONSTANDY. I would like to avoid doing it once.

Earlier you mentioned that the results of your work were given in a series of technical papers before technical groups. I wonder, Mr. Stonex, if you could summarize those papers, at least the more significant ones.

Mr. STONEX. Yes. Our first reference to the roadside as a practical approach to highway safety appeared in a paper which I gave at the Highway Research Board annual meeting in 1954.

Mr. CONSTANDY. In 1954?

Mr. STONEX. Yes, 1954.

Mr. CONSTANDY. Thirteen years ago?

Mr. STONEX. Yes. I would like to quote a part of that.

I said—

Many fatal accidents are a result of a too sudden stop. As highway designers, your concern is with the obstacle that caused the sudden stop and not with the obvious fact that the driver was driving too fast for conditions. As long as obstacles exist, some drivers will hit them. And the safety of a highway design should be in direct proportion to the time the driver has available between making his error and striking the obstacle.

Mr. CONSTANDY. That is your whole basic premise, is it not?

Mr. STONEX. Yes. Then I continued to point out that higher design standards have been adopted for all components of the highway. However, we still have—and this was 1954—

We still have hundreds of thousands of miles of two-lane highways where opposing traffic stream of units with hundreds of thousands of foot-pounds of kinetic energy pass within a few inches of each other. We have shoulders which are narrow, rough, soft when wet, obstructed by culvert headwalls, stones, trees; we have highways where the curves are short and sharp, sight distances so short that almost no opportunity for safe passing is provided, traffic lanes which are very narrow, deep roadside ditches, traffic types mixed from transport vehicles to pedestrians, and far too few roads to carry the traffic volume. It is no wonder the traffic accident record is as bad as it is.

Our next paper discussing roadsides is a fundamental paper given by Mr. Lundstrom at the SAE summer meeting in 1958. And among the things that Mr. Lundstrom stated was—

The importance of the vehicle-road relationship to the utility and safety of the highway system is often overshadowed by the individual problems of the vehicle manufacturer and the highway builder. With the accelerated highway program becoming a reality, a new objective look at the vehicle-road relationship is necessary. * * * Projecting requirements of vehicles and roads ahead nearly 20 years and combining them into an orderly and safe transportation system is an enormous undertaking. This paper can only suggest typical problems for additional study.

He also said—

Of greatest prominence—in a complete study—are the new interstate highways, but of equal importance to the public is the safe use of primary, secondary, and urban roads.

And in this paper, he called our attention to the fact that Mr. Harlow H. Curtice, who was then chairman of the President's Committee for Highway Safety, had stated that the—

Nation's highway traffic toll could be cut in half within a relatively short time if present knowledge of highway safety problems were effectively applied on a nationwide basis. Our fundamental problem is not ignorance of what to do; it is failure to get it done on a sustained nationwide basis. We should concentrate more intensively on putting our knowledge to work instead of casting about for revolutionary, new approaches in a mistaken belief that present measures are futile.

Mr. CONSTANDY. There is not much that can be said which would be more pertinent than that.

Your own experience shows that you people have proved there are ways to improve highway safety, to improve design. You have been able to show the results of it. The knowledge is available; it is a matter of implementing it.

Mr. STONEX. Right.

Mr. CONSTANDY. The paper you mentioned is dated 1954, which was 13 years ago, 2 years before the Interstate System was provided for by law. Again 2 years after it was begun, and in the years since, you have been proclaiming the things that you have found in your own efforts at the proving ground. Yet we have seen examples too frequently here of that knowledge not having been applied, the result being that the roadside is not as safe as it might have been.

Mr. STONEX. This is right.

Mr. CONSTANDY. Will you continue?

Mr. STONEX. Mr. Lundstrom also referred to a cooperative project conducted by the proving ground and the Pennsylvania Turnpike and reported in 1940 in the proceedings of the Highway Research Board, which was done by myself and Mr. C. N. Noble. This paper had an interesting item in that we reported the details of some tests conducted on the Pennsylvania Turnpike, before it was opened, at speeds in excess of 100 miles an hour using a production 1940 car with production 1940 tires.

Now this, I think, is relevant because of the possible current interest in what has been spoken of as a "Century Highway" in the northeast corridor.

Mr. CONSTANDY. Century Highway is a road that would be designed to accommodate traffic at speeds of 100 miles an hour.

Mr. STONEX. One hundred or higher, depending on who is discussing the proposal.

Mr. CONSTANDY. Or higher. This research was done in 1940?

Mr. STONEX. Yes.

Mr. CONSTANDY. Continue, please.

Mr. STONEX. By the time of the 39th annual meeting of the Highway Research Board in January of 1960, we had advanced the development of the roadsides at the proving ground to the point where we could report a theoretical analysis and validation by experiments, which makes it possible to predict the severity of operation through ditch cross sections. We also related the characteristics of the automobile, such as tread width and center of gravity height, to the effect of increasing the steepness of the slope on fill sections toward inducing car rollover.

Now, we recognize that it would not be possible to submit these points of view and concepts to the highway engineering profession without an engineering approach. And this paper does develop this. It appears in the paper and we won't proceed to discuss it at the moment.

However, another thing we felt would be necessary would be to get some practical estimate of the width of the traversable roadside which would be required.

I have a slide which summarized the distribution of the distances from the edge of the pavement that we have found on our proving ground roadside system.

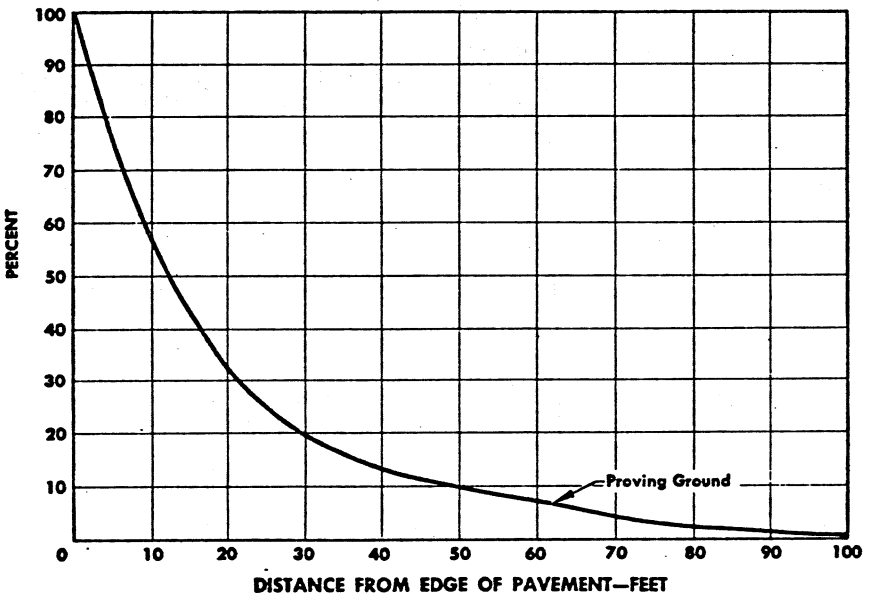
If I may go over, Mr. Chairman, I can describe it a little more accurately.

This covers 211 cases where drivers had left our roads from 1958 to the conclusion of 1966.

This curvature shows 10-mile distribution, distance from the edge of the road. You will note at about 100 feet we had probably about one incident of the driver going as far as 100 feet from the edge of the road. And as we go back closer to the road, we accumulate just a few more, two or three more cases probably.

HAZARD CURVE 211 GM PROVING GROUND ACCIDENTS

211 CASES



Finally we go back, we find that at 30 feet we had 20 percent of the drivers who had gone more than 30 feet. Actually about 28 feet. And so we conclude that if in our modern highway designs we had a traversable corridor beside the road 30 feet or so, that at least 80 percent of the accidents would be eliminated.

Mr. CONSTANDY. Mr. Stonex, these people did not hit anything, did they?

Mr. STONEX. No. This is traversable roadside.

Mr. CONSTANDY. Frequently you hear a comment that the man who hit the tree at 20 feet off the road would have hit something else if the tree had not been there.

Mr. STONEX. On our roadside, no.

Now I would like to show the distribution on several highways where they did hit things.

Mr. CONSTANDY. Before you leave that, that 30 feet is the distance from the edge of the pavement?

Mr. STONEX. This is the distance from the edge of the pavement.

Mr. CONSTANDY. When you say "pavement," is that the traveled way or the shoulder?

Mr. STONEX. This is the traveled way. In some cases this is the traveled road, but it is the edge of the traveled way. Pavement on a paved road; on the gravel road it is the portion on which the man is supposed to ride.

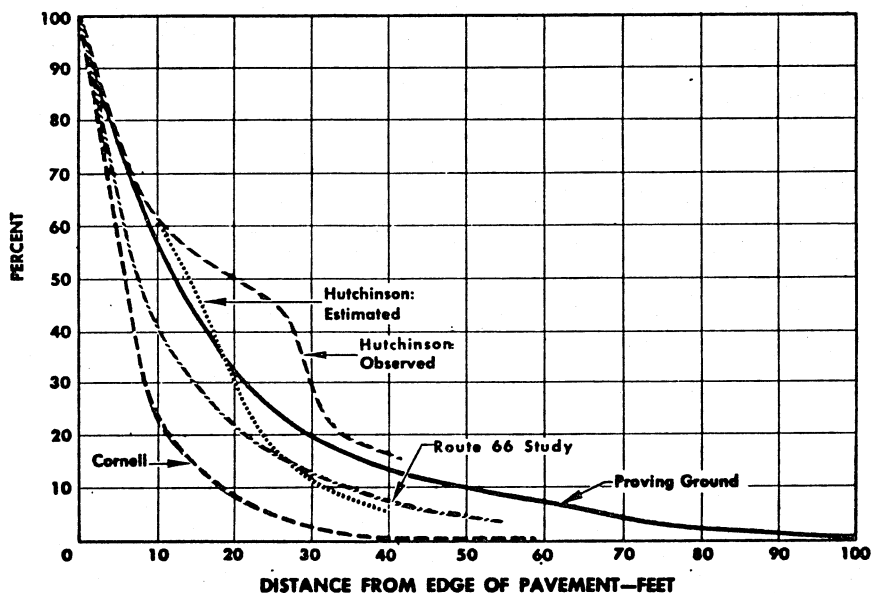
Mr. CONSTANDY. Eighty percent of the cars did not go more than 20 feet from the edge of the shoulder?

Mr. STONEX. This is right.

The next slide repeats the proving ground history. We have here an example of a small number of cases from the Cornell automotive en-

COMPARISON OF PROVING GROUND HUTCHINSON, CORNELL, AND ROUTE 66 "HAZARD" CURVES

211 CASES



gineering research program, showing distance where the cars left the road where people were injured or killed. We have recently reported a study on Route 66, a seven-State study of injury and fatal accidents, and this curve shows the distance where these people went off the existing highways. And we have another 70—we have this dashed line which was recorded, a study by Hutchinson, on median encroachment. A particular type of divided highway, the number of instances where the people have gone into the median, leaving the road on the left side, and we found distribution like this.

Now there was no record as to whether there were injuries. There were cases where a number of these vehicles did strike obstacles in the median. Fifteen percent of the cases went over on the opposite concrete line, across the median line.

In all cases, on the proving ground, it was where obstacles were in the road.

Mr. CONSTANDY. Could you make some conclusions from that, Mr. Stonex?

Mr. STONEX. We conclude that if there had been no obstacles along any of these other roadsides, that probably these people would have followed a distribution somewhat like our proving ground drivers did.

Mr. CONSTANDY. Would this suggest clear roadsides of at least 30 feet?

Mr. STONEX. We think 30 feet is a very practical measurement; it would be safe for a very great proportion of the accidents and the cost is reasonable.

Mr. CONSTANDY. You would not object to more than 30 feet?

Mr. STONEX. Not at all. The more the better.

Mr. CONSTANDY. As a matter of fact, you relate back to something Mr. Lundstrom said, that if we are speaking of 30 feet, might we not be speaking in terms of minimums?

Mr. STONEX. Yes, certainly.

Mr. CONSTANDY. Minimum values from design standards, but relatively safe highways.

Mr. STONEX. Yes. That is right.

Mr. CONSTANDY. Do you want to add something, Mr. Lundstrom, at this point?

Mr. LUNDSTROM. Well, typically I would say use the right-of-way, at least if available. And on the Interstate System, we do have, generally speaking, enough right-of-way to go beyond the 30-foot figure. And obviously it is on these roads where we have a higher speed traffic and the need for greater roadway width.

On lower speed roads, where the traffic might be 35 miles per hour, proportionately narrower escape routes would have been adequate. But the thing that the designer needs to look at is what is available to him to work with to make maximum use of his resources.

Mr. CONSTANDY. Yes. And we may even question the level of service which is desirable. We may desire greater right-of-way widths within which to work.

Do you want to continue, Mr. Stonex?

Mr. STONEX. We have reported additional development of this concept from time to time which I will not go into in the interest of time this morning. However, I would like to discuss a paper which I pre-

sented at the Society of Automotive Engineers national meeting in January 1964. In this paper, the particular significance is that we showed and developed the dynamic energy considerations of collision between an automobile and a solid object. We show, for example, that in these solid and direct impacts at suburban and urban traffic speeds, peak horsepower from 5,000 to 6,000 will be developed. We ran a higher speed test, collision test, on a public highway outside of the proving ground, 64 miles per hour, and we developed a peak of almost 14,000 horsepower.

And the purpose of this analysis was to make it clear that it is the collision horsepower that injures and kills people and the analysis then puts the consideration of the rated horsepower of the engine into proper perspective.

Now, this will be the opening scene of one of the pictures we are going to show you in a few minutes.

Mr. CONSTANDY. What was the title of that?

Mr. STONEX. "Single-Car Accident Problem."

Mr. CONSTANDY. That was in 1964?

Mr. STONEX. In 1964, yes. We have had the opportunity to discuss these concepts with a great many people and a great many audiences.

For example, we have been invited to present the material at the highway division or highway department conferences on 43 separate occasions, from 1958 until and including the current year.

Mr. Lundstrom showed it to the executive committee of the American Association of State Highway Officials in November of 1958.

We have made similar presentations to regional design committee meetings, that is the AASHO Design Committee meetings. For example, in Boise, Boston, Madison, and Tampa. Mr. Lundstrom has shown it at at least two staff meetings of the Bureau of Public Roads, the first time in October 1958.

We have also presented the material before meetings of the Canadian Good Roads Association and the Canadian Highway Traffic Association, and at staff meetings of the National Safety Council and the Automotive Safety Foundation.

We have shown it to the staffs of the Indiana, Ohio, and New Jersey Turnpike Commissions; The Port of New York Authority; and at meetings of the American Bridge, Tunnel, & Turnpike Association.

We have also appeared on programs of many technical and professional associations and we have a total of 91 listings in our records. In this visit, Mr. Lundstrom, for example, has gone from San Francisco to Boston to Atlanta. I have gone from Winnipeg to Miami or Quebec City to Tucson, with intermediate places.

And we have also made this available for many civic organizations, such as service clubs, church groups, and the communities around Milford and Detroit. We have a listing of 105 presentations to these groups.

Our colleague, Mr. Meyer, who is with us, has kept a record of the people to whom he has talked, and it numbers more than 4,000 people.

Mr. CONSTANDY. You made a very sincere effort to try to bring before the people the knowledge that you have gained from the efforts you made at the proving ground.

Mr. STONEX. Yes.

Mr. CONSTANDY. You have not tried to keep it a secret, I know.

Mr. STONEX. We have done the best we could to make it available. We thought that it was a very good investment to get it as broadly understood as possible.

Mr. CONSTANDY. I would assume, or at least hope, that the lessons learned by you people might be incorporated in the design and construction of our public highways.

Mr. STONEX. We would sincerely hope so.

Mr. CONSTANDY. Before we get to the movie, you have a paper which you gave, if I can find it, entitled "Roadside Design for Safety." What was the date of that paper?

Mr. STONEX. That was 1960.

Mr. CONSTANDY. Mr. Chairman, that was an award-winning paper and we have a copy of it here. I would like to ask that it be made exhibit No. 10 and, if space permits, it be printed in the transcript; if not, to be retained in the files.

I would further like to ask that the slides be made exhibits 11 and 12.

Mr. CLARK. Without objection, so ordered.

(Exhibits Nos. 10, 11, and 12 were marked and are retained in subcommittee files.)

Mr. SCHADEBERG. Mr. Chairman, going back to the last few slides, I am not clear in my mind as to what the situation was when you talked about the number of feet off of the highway which would be safe.

Now, these cars that went off the highway; did these hit an object or did they not hit an object?

Mr. STONEX. In each of the distributions, these are the distances that the cars departed from the pavement. In other words, the maximum excursion.

On our proving ground road system, this is where the driver regained control and either stopped the car or turned back. In the other cases, in most cases, also in the Cornell and Route 66 studies, these were injury accidents and this is the distance they went out before striking an obstacle, before causing an injury or fatality.

Mr. SCHADEBERG. Was there any evidence as to why they went off the road, was it because they fell asleep or because they lost control of the car? Why did they leave the road?

Mr. STONEX. There is very, very little evidence. In the case of our drivers, where the accidents are investigated, occasionally it was pure carelessness. We have cases where a man reached over to pick up a package of cigarettes which had fallen off the seat onto the floor. We have another case where a driver reached over to pick up a data clip board which had fallen off the seat. We have numerous cases where they fell asleep and many cases where they do not even know why they left the road.

Mr. SCHADEBERG. Would there have been any help if there had been some sort of rumble in the road that would have awakened them or at least called attention to the fact that they were off the road?

Mr. STONEX. It is quite probable this would help in some cases. On the other hand, we did experiment for nearly 2 years in trying to devise some way of alerting people before they really got off the road, and this we concluded was not successful and would not be effective.

Mr. SCHADEBERG. I see.

Mr. STONEX. We find when people fall asleep, they frequently leave the road before their head even drops.

Mr. LUNDSTROM. I might add to that just a little bit. A rumble strip would hopefully awaken a person who was subject to going off the road for this reason. But this is only one of many reasons that cars leave the roadway. And so we have no way, at the moment, of keeping a driver from suddenly swerving off the roadway to avoid something ahead of him. It might be an animal, it might be a stalled car, or something he comes upon unexpectedly, so he drives off the road to avoid the obstacle. Other times, snow and ice conditions cause people to go off the road, probably for driving too fast, but the fact remains that you and I and the general public do drive too fast on the snow and ice and even on wet roads, so cars will go off the roadway and rumble strips have no effect on these cases.

So it is correct that a rumble strip might pick up a few cases, but I think the other reasons are so important that they overshadow the gains to be obtained from a rumble strip.

Mr. SCHADEBERG. Thank you very much.

Mr. MCCARTHY. Mr. Chairman.

Mr. CLARK. Yes, Mr. McCarthy.

Mr. MCCARTHY. I wonder if we could underline this particular point. The other day we heard about the Bureau of Public Roads study of the last 6 months of last year showing that 65 percent of the accidents on the Interstate System were where the vehicle left the right-of-way.

Now, we hear from General Motors where they have trained drivers, 70 percent of the accidents are where the vehicle leaves the right-of-way, the traveled way.

Now, I think what we can conclude from this, no matter what the reason—fatigue, alcohol, swerving, animal, falling asleep—whatever it is, and these are all causes I think should be explored, but I think the statistics point out that no matter what, drivers are going to leave the traveled way.

I think that these statistics show that no matter what, there are going to be cars leaving the right-of-way.

Now, before, I think there was sort of the attitude we picked up in these hearings, well, if they leave the right-of-way, that is their problem. And we put these signs in and put them in steel and concrete and protect the sign rather than the driver.

Now, what I would hope we would see is a change of attitude here to realize that whether it was the driver's fault or not, a certain percentage of the cars are going to go off. And this idea that you are proposing of a 30-foot traversable corridor cutting 80 percent of the accidents. I think, is an excellent idea. And I just would like to underline that point right here in the record.

Mr. STONEX. We have felt that falling asleep and leaving the highway really should not merit capital punishment.

Mr. CONSTANDY. As someone remarked earlier here at the hearing, there has to be some forgiveness built into the highway. I think it is very appropriate.

I think it might be worth mentioning, since we discussed 30 feet, that you would not advocate a fixed figure, would you, Mr. Lundstrom.

Mr. LUNDSTROM. No. As I mentioned earlier, the necessary traversable roadside depends, importantly, upon the operating characteristics. For example, you need a wider right-of-way along the outside

of a curve than inside. You need wider traversable roadsides for higher speed operation, and so forth. So you are correct that the 30 feet is a nominal figure, but it is not one to be fixed for every road in the country.

Mr. CONSTANDY. You have to be very careful with minimum values, apparently. The sign manual suggests that signs should be placed at the minimum of 2 feet from the shoulder, and throughout the country they are placed just 2 feet. They could just as well, very frequently, be placed at some greater distance than 2 feet.

If the people who set standards were to adopt the minimum and it were blindly followed, you may have another problem later to overcome.

We have seen situations where States have adopted some figure for a clear roadside, say 20 feet, and at 21 feet there would be a row of very heavy trees. Depending upon the circumstances, judgment must be exercised as to what would be appropriate for that highway for that speed limit at that particular place; what is the clear road width that you used on the proving ground?

(At this point Mr. McCarthy assumed the chair.)

Mr. LUNDSTROM. We use as much as 100 feet, if possible.

Mr. CONSTANDY. Yes, building safe highway and using 100 feet, you minimize the problem of the single-car-run-off-the-road type of situation.

Mr. LUNDSTROM. Yes.

Mr. CONSTANDY. I think it is worth pointing out, too, you count every vehicle which leaves the traveled roadway as an accident, do you not?

Mr. STONEX. That is right.

Mr. CONSTANDY. Whether it hits anything or not?

Mr. STONEX. Right.

Mr. CONSTANDY. The driver is obliged to report back to you each instance when he leaves the highway?

Mr. STONEX. Yes.

Mr. CONSTANDY. Before we get on to the movie, is there something, Mr. Stonex, you would say relative to slopes and the condition causing rollover?

Mr. STONEX. It is described, Mr. Chairman, in the film. I could say that we have concluded that the 6-to-1 slope ought to be about the steepest which should be used on a road. We have no slopes steeper than that.

Mr. CONSTANDY. That would be what you would consider a minimum?

Mr. STONEX. That is a minimum, yes.

Mr. CONSTANDY. In those circumstances where drainage permits a slope that flat?

Mr. STONEX. We would not permit one steeper than 6 to 1, and where possible we would like to have them flatter.

Mr. CONSTANDY. 8 to 1?

Mr. STONEX. 8 to 1, 10 to 1, again depending on circumstances.

The flatter it is, the less problem you have with erosion, the easier it is to mow it; so all is in favor of the flattest slope possible.

Mr. CONSTANDY. Yes. I suggested that at times you may find it necessary to have something less than 6 to 1, say 4 to 1; if it were

mountainous terrain, physically impossible, going along a river edge or other topographical situation which may force you to adopt something less desirable than that. But when feasible, a lot can be said about what is feasible, 6 to 1 should be a minimum?

Mr. STONEX. This is right. We should be very careful about anything steeper than that. And we should know what is being done. Consciously.

Mr. CONSTANDY. Yes. I think that there are studies that have been made which would indicate that frequently obtaining a 6-to-1 or even 8-to-1 slope, with the price of dirt being what it is on that project, is cheaper than installation of a guardrail.

Mr. STONEX. This is right. Yes.

Mr. CONSTANDY. A preliminary study exploring that possibility could result in flatter slopes and safer roadways.

Mr. STONEX. This is right. Yes.

Mr. CONSTANDY. Do you want to present the film now?

Mr. STONEX. We have the first film, entitled "Safer Roadsides," which is self-explanatory, I think.

Mr. CONSTANDY. Mr. Chairman, the gentleman has been kind enough to furnish us with a script of the film and I would like to ask that the script of this film, "Safer Roadsides" be made exhibit No. 13 and printed in the record at this time.

Mr. McCARTHY. So ordered.

(Script of film, "Safer Roadsides," follow as exhibit 13.)

NARRATOR.—Each year, off-road accidents claim the lives of more than 13,000 people, and account for approximately one-third of the national highway death toll. In severity and frequency, these accidents are second only to car-to-car collisions as virtually every mile of roadside in the nation is studded with obstacles that can cause serious or fatal accidents.

While many of these accidents occur on secondary and rural roads, residential streets and even our newest freeways contribute to the grim statistics, for virtually every obstacle at the roadside is a hazard that can cause a serious or fatal accident.

But perhaps the most alarming fact is that most of these accidents, and most of the more than 13,000 deaths that result, could be prevented! The validity of this statement has been proved by actual experience at the General Motors Proving Ground, where driving hazards have been systematically eliminated over the years.

Here, more than 60,000 miles are driven daily to test the performance, durability, comfort, and safety of GM cars on 75 miles of specially engineered roads that comprise a cross-section of American highways. The tests are severe, the speeds often high and the maneuvers extreme . . . yet records prove that the General Motors Proving Ground is probably the safest place in the world to drive—more than twenty-five times safer than public highways!

The principal reason is the fundamental concern for driver safety that has guided the Proving Ground since its origination in 1924—the application of one-way traffic, median dividers, grade-separated intersections, and limited access high-speed roads.

Then there's the drivers themselves. Each applicant is carefully screened, then he must pass a thorough physical examination, safety indoctrination, and several days of on-the-job training with other test drivers before he is allowed on the road system alone.

But—despite well-trained drivers and the application of all known safeguards—accidents occasionally occur. Human fallibility, slippery roads, unexpected traffic situations, and occasionally mechanical troubles are ever-present conditions that cause accidents; even under the most closely controlled conditions.

In the six years between 1952 and 1958—a period covering 65 million miles of test driving—the Proving Ground experienced property damage accidents at the rate of one every 240,000 miles.

Surprisingly, the majority of these accidents—approximately 80%—were one-car off-road accidents, not two-car collisions!

In these accidents the drivers involved lost a total of 64 days due to injuries.

The cause of these statistics became evident in a review of the 1958 road system. While the road surfaces were wide and safe, the immediate roadsides were laden with obstacles as the test roads had been built to the same standards as our public roads. Accordingly, many trees were left at the edges of the roads, and steep banks and grades were left untouched. In addition to these natural obstacles, it became apparent that sign posts, bridge abutments, and other man-made structures also presented severe hazards.

Since emergencies sometimes cause vehicles to leave the road, it was determined that accident-producing hazards should be eliminated to create a wide, safe emergency lane.

Trees are one of the most common obstacles along roads of all types, and while beautiful, they are among the most dangerous, even in residential areas where speeds are low. The extreme danger of tree impacts is further illustrated by this 45-mile per hour test.

(Show a remotely controlled car occupied by life-sized test dummies not restrained by seat belts.)

Thousands of motorists are killed each year in tree impacts such as this, and even speeds as low as 25 miles per hour can easily result in serious passenger injury.

Despite knowledge of their deadly potential, trees are still planted at the sides of many of our newest highways and will soon become hazards.

Along major thoroughfares, the obvious solution is tree removal, and with modern equipment, the cost is moderate. Once the site is regraded and seeded in grass, this section of once-dangerous roadside will be safely traversible and will blend nicely with the surrounding terrain.

The addition of small shrubs and bushes creates a still more pleasing appearance and illustrates that a safe roadside can be attractive without trees. The Proving Ground has hired landscape architects to develop roadside plantings that will provide maximum beauty and safety.

Additional benefits of the clear roadside are a more open appearance and increased visibility at drives and cross streets.

While tree removal is the most practical, the Proving Ground does not advocate the destruction of century-old landmarks such as this. To preserve the tree and yet safeguard the motorist, a section of guardrail is probably the best answer. and this correction has been used in some locations on the Proving Ground.

Although tree-lined streets enhance the beauty and value of any residential area, they are dangerous and some means should be developed to provide the protection necessary without adversely affecting the appearance of the street.

Broken lamp posts are a common sight along our roadways and are mute reminders of the thousands of serious and fatal accidents they cause yearly. Massive light and utility poles should be eliminated or set back from the roadside substantially. On depressed roadways such as this, relocating the posts well up the slope would eliminate the problem.

Another solution possible is to change the design of the poles to a light, tubular construction that will shear-off when impacted. This unit was designed and built by GM engineers to test the practicality of this approach.

By minimizing deceleration at impact, poles of this type could reduce the severity of these accidents.

Large sign posts and similar roadside markers are also very dangerous, and these, like trees, should be eliminated from the roadside.

Signs that are essential on highways should be protected by heavily reinforced guardrail.

Small signs at the roadside are also hazards. Observe the results of a 40-mile-per-hour impact into the common 42-inch high sign.

At 40 mph, the sign pierces the windshield and showers the front seat occupants with glass! At higher speeds, the danger may be greater.

Increasing the sign height to 60 inches proved safer.

At 40 miles per hour, the car passes safely beneath the sign. As an added margin of safety, all Proving Ground signs are now mounted at a minimum height of 66 inches.

Irregular surfaces beside the road can be nearly as dangerous as projecting obstructions, as skidding into a deep ditch or hitting a steep bank can cause severe damage and injury.

The danger potential of a clear roadside is directly related to the slope of the terrain; the more gentle the slope, the safer the roadside.

The angle of a slope is most commonly expressed as a proportion, two-to-one, six-to-one, and so forth.

For example, this is a two-to-one upslope—quite a steep grade.

This means that in two feet measured horizontally, the height increases one foot.

Accordingly, a four-to-one slope increases one foot in four, and an eight-to-one slope one foot in eight.

Downslopes are described in the same manner, but the heights are, of course, diminishing.

This test illustrates the danger of impacting a two-to-one upslope at 35 mph.

A similar test on a four-to-one slope produced better results, but even this grade could produce injury or damage at higher vehicle speeds.

On the Proving Ground, maximum upslopes of six-to-one are applied, as these are safely traversible, even at 60 miles per hour. This grade produces the needed safety for high-speed roads and could be applied generally on most public highways. If steeper slopes are necessary, they must be well rounded.

The contour of the ditch bottom and road shoulder are as important for safety as the slope itself, for it is obvious that a car can travel over gently rounded contours with far greater safety than thru the sharp angles of the traditional V ditch. This design is not only safer, it is easier to maintain as erosion is reduced and mowing machines can operate without difficulty.

When the roadside slopes downward, the possibility of roll-over increases as shown on this four-to-one grade.

With the downslope reduced to six-to-one, the car tends to spin, rather than roll on firm soil. From these and other tests, it was concluded that the maximum safe grade for any road is six-to-one, but preferably flatter. From the standpoint of safety, the less grade, the better!

A sloped roadside should also be free of surface irregularities to be really safe—eroded surfaces that could upset a vehicle skidding laterally can be smoothed and seeded at a nominal cost and, with proper grading, small parallel ditches could be eliminated in favor of gently rounded depressions a safe distance from the roadway.

Where drainage requirements are such that deep parallel ditches are needed, underground drain systems should be considered because of the extreme hazard presented by these excavations and this same correction must be applied to transverse drainage systems, including small creeks and culverts. This need is absolute to eliminate dangerous headwalls and bridge abutments. While underground drains increase the cost, the end result is well worthwhile as this creates a safe roadside, completely free of obstacles.

While a clear roadside is the ideal, many natural and man-made obstacles cannot be eliminated. In dangerous areas, the only solution is to install some form of guardrail.

Unfortunately, there is no such thing as a perfect guardrail—any guardrail in itself is a hazard as any impact produces some degree of risk and damage. For those reasons, guardrails and barriers should be installed only at those places where hazards cannot be eliminated.

For example, guardrails are absolutely needed on bridge approaches to protect an out-of-control vehicle from the steep embankments, and against the possibility of hitting the bridge abutment.

The guardrail should be firmly attached to the inside of the bridgerail to protect against this possibility.

Lakeshores and other natural obstacles also require guardrail. Guardrails are used only at those locations where roadside hazards cannot be eliminated, and this same practice should be applied on our public roads.

At the Proving Ground, the result of the roadside hazard studies have now been in effect six full years.

Roads that were once lined with trees close to the pavement have now been cleared for a distance of 100 feet on each side, and all other obstacles have been eliminated. In their place, shrubs and bushes are being planted to further enhance the beauty of the site.

Dangerous parallel ditches have been eliminated from the roadside and all side slopes are now as flat as possible, with none steeper than six-to-one. All grade contours and ditch bottoms are gently rounded. Our records and other cost studies show that ditch and grading improvements can be made reasonably, and that this cost is amply justified in accidents prevented.

While the elimination of small bridges and cross drains is more costly, these have now been encased below grade on the Proving Ground for a distance of 100 feet on each side of the road to eliminate dangerous headwalls and bridge abutments wherever possible. And, where it was not possible to eliminate the hazard, carefully constructed guardrails have been installed, built to the exacting specifications derived from the Proving Ground's guardrail test program.

Today a vehicle leaving the road is an incident; six years ago this could have been a serious accident.

Today if a driver loses control he knows that he has room to bring the vehicle under control—without fear of hitting an obstacle or turning over.

And today, statistics prove more vividly than demonstrations that obstacles removed are accidents prevented!

In the six years that the Proving Ground's roadsides have been improved, not a single vehicle has traveled beyond the 100 foot clearance, even though incident speeds ranged as high as 80 mph.

In fact, a large percentage of the vehicles stopped within 25 feet of the roadside!

This leads to the conclusion that any increase in roadside clearance will produce a substantial increase in safety on roads handling 30 to 45 mile-per-hour traffic, 25 foot side clearances would be reasonable safe, but on super highways and other roads where speeds approach 80 miles per hour, a full 100-foot side clearance is needed. Side clearance should be related to speed, but the wider, the better!

However, the most convincing proof that clear roadsides increase safety is provided by a comparison of injury accident statistics, before and after improvement.

Before roadside clearance and improvements, in the six years between 1952 and 1958, the Proving Ground experienced damage accidents at the rate of one every 240,000 miles, and 80% of these occurred off-road. Sixty-four days of injury time were sustained in those accidents.

Between 1958 and 1964, the six years following roadside clearance, the number of off-road accidents was approximately the same—75% of the Proving Ground's total—and the frequency remained about the same—one accident every 258,000 miles!

The important improvement occurred in the area of driver safety. Where 64 days of driver injury had resulted before roadside improvement, in the six years after improvement, there was not a single lost time injury accident on improved roads! Despite 153 off-road incidents, not one day of lost time in the entire six year period! As the record shows, it was still not possible to prevent drivers from leaving the road, but when the roadside is clear the injury possibility is practically eliminated.

These statistics are working proof that roadsides need not be deadly—that roads like these with wide, clear rights-of-way are a practical, effective means of reducing injuries and saving lives—a means of accident prevention that can be applied today—not only on the Proving Ground—but on all roads throughout the Nation.

Mr. CONSTANDY. That film was revised in 1964, was it not?

Mr. LUNDSTROM. This is the 1964 version and we have not had a major revision since that time.

Mr. CONSTANDY. I was curious as to when you made the first film of this type.

Mr. LUNDSTROM. 1958 was the first time we had a film very much similar to it.

Mr. CONSTANDY. This film then, has been made available to the public, to highway officials, since 1958?

Mr. LUNDSTROM. Correct. We did show early versions of this film in 1958 and improvements have been made and modifications put into the film as conditions made it possible to do so.

In 1964, we had occasion to produce three films, as indicated in the title to this particular film, one on "Safer Roadsides," one on "Guardrail," and one on safety tests of vehicles themselves. These three films

were put together into a single 30-minute film, that was put in our film library and as indicated, has been shown to some 1,200,000 people.

Now copies of the film that you have just seen and a copy of the "Guardrail" film that we hope to be able to show in a little bit, have been donated to various organizations, among these, the Bureau of Public Roads, in sufficient quantity to send to their district offices.

Mr. CONSTANDY. Yes. The point I want to make is that basically the 1958 film is the same as this 1964 version as far as the points shown. You improved the picture itself; the basic features of the film are the same.

Mr. LUNDSTROM. Correct. I believe all of the elements were identified in the 1958 film; right.

Mr. CONSTANDY. So for 9 years this has been shown and has been available to be exhibited, showing suggested improvements in the areas that you have covered and with which this hearing has been concerned?

Mr. LUNDSTROM. Yes, correct.

Mr. CONSTANDY. The second film you have, can you explain that briefly?

Mr. LUNDSTROM. Yes. Gentlemen, obviously, one of the major problems that we have is the landscaping of a road system. We have many groups in the country rightfully concerned about the beauty of our roads. And we, too, are very conscious of this, and whenever we come to a meeting such as this, and propose removal of trees close to the roadway, we immediately have many people much against this procedure.

I have property myself, where we have tree-lined roads and so I would object to a highway department cutting trees in my front yard. The film, though, was careful to explain that we have the option of protecting the driver by use of guardrail, treating the tree hazard much the same as you would treat a deep-fill section or some other hazard that you did not see fit to remove.

But I would like to show a short film and while doing so, comment particularly on landscaping, because safe roads are really beautiful roads. I would call your attention—and many of you have driven the New Jersey Garden State Parkway—this is a road that I believe was built as a parkway, I hope that they had safety in mind, but I believe that the landscape people had an important part in the design characteristics of the roadside itself. So I believe they started with the goal of having a beautiful road and in so doing, they have a very safe road. I believe accident statistics show that that is one of the safest highways in the country.

So I would now like to show some brief recent views of the proving ground, showing how we are attempting to bring back the shrubbery and the elements that do make a beautiful road out of a safe road.

Could we have the film, please. There is no commentary on this. I will identify the scenes as they appear.

[Narrating film:] This is an overview of the proving ground. This is 4,000 acres of property, some 75 miles of road. Now this is simply to show the removal of the trees through wooded area so we do have this 100 feet of green belt along each side of the roadway.

Each of these views will show—well in this particular case, the attempt to produce irregular cut lines. There is no need to cut a straight slash through a wooded area. This is more pleasing and architects will

certainly tell you to make irregular lines. I think you can see rather clearly that the green belt does persist along the side of each of the roads.

The other elements that I could call attention to at the appropriate time, you see a ribbon of guardrail on one side; that is the width of the underground culvert, and it shows that there is no need for a wall adjoining the road itself.

Now, here are irregular tree lines, shrubs have been planted back on the right side.

Here we had to have a minor drain structure to eliminate erosion. This is an 18-percent grade that you just do not have on a public highway but these elements have been moved back far enough to eliminate the hazard.

Here we are bringing in the small shrubs and trees back away from the roadway, where they are out of the escape route of the cars. Cars have gone off this curve summer and winter with no injury.

Now among other elements, here again is an extension of a culvert. There is no headwall. The guardrail simply indicates the extreme edge of the drainage system.

Along here we have some shrubbery planted in front of the guardrail. Some people say guardrails are not pleasant. Now there are multi-flora roses hiding the guardrail. Just an experiment to see what can be done in the interest of beauty.

Here is the edge of the lake, which has an irregular shoreline, very beautiful. Here is a wooden section with the trees removed in an irregular pattern, again in the interest of beauty.

Notice the clean, uninterrupted slopes that can be had. There is no erosion. Actually in much of this area we have installed underground drainage systems. It is unnecessary to have exposed ditches in all cases.

This is one of the older roads, perhaps built back in 1924. We had to move the trees back, we had to remove the ditches, flatten them out.

Here is new shrubbery going in, a safe distance back from the road.

Generally speaking, the safe road is a beautiful road. These are young trees now but in 2 years they will be up and greatly enhance the appearance.

Proper landscaping of the slopes make for a park-like appearance.

These roads are perfectly safe. As we indicate, we have many, many cars that accidentally go off the roads at all speeds for all reasons and we have had only one temporarily disabling injury accident in some 219 cases.

There are no local distractions. It is actually the safest place in the world to drive.

(End of film.)

Mr. McCARTHY. Do you have any billboards there?

Mr. LUNDSTROM. No; I know your problem. I know your interest. I would simply say that fortunately we do not have any.

Mr. CONSTANDY. Mr. Stonex, will you tell us what you have done with the guardrail, the development of it as a safety system.

Mr. STONEX. Mr. Chairman, as Mr. Lundstrom has indicated, we did have places on the proving ground where it was impossible or not feasible at least to eliminate the obstacles. In fact, in 1958 we had something like 18 miles of guardrail. We didn't know how good it was. We searched the literature to see if we could find anything about the

dynamic testing of guardrails. This was done in 1958. We found that there had been no effective dynamic tests conducted or reported for more than 25 years, and that there was no really good research literature which would demonstrate what an effective guardrail installation is.

Accordingly, we began some dynamic tests, and we found very rapidly that our existing guardrail structures were not adequate. The posts were rotted, the guardrail section itself was found to have insufficient beaming strength. During the course of this, we consulted with the Highway Research Board Committee on Guardrails and Guideposts. We took advantage of the research which Mr. Beaton of California had conducted and we have reported progress to the committee throughout the course of this development, and have given to the committee all of the film footage of the tests which were conducted.

Mr. Lundstrom and Mr. Skeels made a report, a preliminary report, to the Highway Research Board in January of 1959, a paper entitled "Full-Scale Appraisals of Guardrail Installations by Car Impact Tests," and demonstrated certain conclusions. One, that good beaming strength is essential and that the 12-gage W-section steel rail mounted on posts spaced at 6 feet does provide adequate strength.

The end of the rail must be anchored securely. At that time we concluded that a mounting height of 18 inches at the center of the rail appeared to be satisfactory. Later research, I believe, suggested that 21 inches to the center is probably a better minimal value.

We found that 6 by 8 pressure-treated wood posts gave a very satisfactory performance. We found that the guardrail ends present a dangerous obstacle and we developed means to control that.

The second and more comprehensive report was made at the 40th annual meeting of the Highway Research Board in January 1961. This is entitled "Guardrail Installations—Appraisal by Proving Ground Car Impact and Laboratory Tests."

It was written by W. G. Cichowski, P. C. Skeels, and W. R. Hawkins. This shows the results of more than 60 tests at speeds from 30 to nearly 70 miles per hour and at angles of impact ranging from zero to 33 degrees. We had some additional conclusions, in addition to those that were presented before, that 1,000 pounds per inch spring brackets with 4-inch travel could be used as a mounting bracket to space the rail out from the post and reduce impact intensity at lower speeds.

We found, very importantly, that reinforcing washers are required on the beam mounting bolts to prevent the bolt head from pulling through; and that reinforcing sections are required under the beam-center mounting to the post. The ends must be ramped to avoid the end obstacle and they must be anchored.

Now, we found that the reduction in the spacing of the posts from the standard 12½ feet to 6¼ feet approximately doubled the beaming strength and that the use of the reinforcing washer increased the strength of the attachment to the post by three times.

So we have made results of this test available to many of the State highway departments in the 43 conferences we have attended, which I reported just a few minutes ago.

Now, we have a motion picture which summarizes this and I would like to show that now.

Mr. CONSTANDY. Mr. Chairman, I would like to ask that the script from the movie entitled "Guardrail Crash Tests—for Safety," dated July 1964, be made exhibit No. 14, and printed in the record at this point.

Mr. McCARTHY. Without objection, so ordered.

(Script of film, "Guardrail Crash Tests—for Safety," follows as exhibit 14:

NARRATOR: "Guardrails . . . and bridgerails used throughout the country vary widely in appearance and design, and yet each has the same basic function—to demark areas of roadside hazards, and to deflect an out-of-control vehicle away from those areas, with minimum damage and the least possible injury to the occupants.

"But how safe are guardrails? Will they re-direct a straying vehicle or collapse under the impact? Are common design criteria needed for all installations, or are variations needed for different highway conditions?

"To answer these and a wealth of other questions, the General Motors Proving Ground has conducted an extensive program. In the interest of highway safety, this film presents 'Guardrail Crash Tests—For Safety!'

"The investigation of guardrail and bridgerail designs at the General Motors Proving Ground was initiated in 1958 for several reasons. First, several guardrail failures had been experienced during the preceding months, and it was mandatory that the causes for these failures be determined and corrected for driver safety. Second, the Proving Ground was being enlarged and existing roads improved. This construction and renovation would require miles of new guardrail, built to the safest possible specifications. And third, the 'W' section, beam-type rail had recently been introduced and was being suggested for national use. While laboratory tests had been made, no actual impact performance data were available regarding this new material.

"The guardrail situation was reviewed in detail, and proving ground management endorsed a study of current guardrail installations, with full-scale crash tests on those designs that appeared to provide the greatest safety potential. The results of this program would dictate the improvements to be made on the proving ground, and would provide valuable information to state and national highway planners.

"The following criteria were established for evaluating the various guardrail and bridgerail designs:

"(1) The rail must prevent the vehicle from leaving the roadway and going into a roadside hazard.

"(2) It must be flexible enough or of such design that it will deflect a vehicle at a rate of deceleration tolerable by its occupants.

"(3) It should deflect the vehicle parallel to the rail—not back onto the roadway so as to become a hazard to other traffic.

"(4) Finally, the guardrail should inflict a minimum amount of damage to the vehicle.

"It was further agreed that initial crash tests would be made at 35 mph at angles up to 20 degrees as this severity would reveal the better designs to be tested at higher speeds.

"With the parameters of the test program established, the work of gathering, evaluating, and testing began.

"Following physical tests four types of guardrail were selected for full-scale impacts and these would be tested with different mountings, on different post materials, spaced at various intervals.

"One of the earliest tests was made in June of 1958, on a section of convex ribbon guardrail, mounted to 6 by 8 inch wood posts spaced at 10-foot intervals. The car speed was 35 mph, and the impact angle was 18 degrees.

"A subsequent 35 mile-per-hour, 20-degree test with the same rail mounted on posts spaced at 5 feet produced almost the same results. The installation failed to turn the car properly, and both the rail and the car were damaged considerably. This and other tests indicated that the convex ribbon had insufficient beam strength even with five-foot post spacing.

"The 'W' section steel beam rail proved more satisfactory. Even with 12½-foot post intervals, the beam ribbon deflected this 37-mile-per-hour, 20-degree impact with only moderate lateral deceleration and some deflection back onto the pavement.

"The car was only slightly damaged, and deceleration records indicated that its occupants would have experienced nothing worse than minor injuries and, while sprung slightly, the rail and wood posts would be repaired inexpensively.

"Similar successful tests from the standpoint of passenger safety were run with the "W" section beam ribbon mounted on steel and reinforced concrete posts. These tests were also made at 35 miles per hour and 20 degrees.

"Ribbon mounted on steel 'I' beam posts remained intact, with only slight deformation and post damage and the reinforced concrete post installation fared almost as well, with the major post and ribbon damage occurring at the point of impact.

"The next installation tested was a standard four steel cable design mounted on steel 'I' beams spaced at 12½-foot intervals. This test is a 20-degree impact at 41 miles per hour.

"The passenger hazard on any guardrail impact is well illustrated by this slow-motion sequence. Observe the reactions of the unrestrained dummies during impact. The cable installations tend to snare the car, but in so doing, create extensive vehicle damage.

"The next test of 4-cable guardrail was from 60 mph and 20-degree angle. Two of the four cables failed completely, allowing excessive penetration by the test vehicle. Because of the initial success with the 'W'-beam rail, tests were made at higher speeds to evaluate post materials and spacing.

"These are 40-mile-per-hour, 20-degree impacts into 'W'-section, beam rail, mounted directly to reinforced concrete posts, spaced at 12½ feet. Under these conditions, the reinforced concrete posts failed almost completely, and the damage inflicted on the vehicles is mute testimony of the deceleration and passenger danger that results because of post characteristics. Further tests at higher speeds were run with other types of reinforced concrete posts, but none provided the strength and shock resistance needed.

"This is a test of steel 'I' beam posts at 12½-foot intervals. While the impact is from 30 degrees, at 45 miles per hour, this and other tests produced similar results, moderately severe pocketing, with substantial vehicle damage and presumed passenger danger, despite the fact that deceleration effects were reduced by the vehicle climbing onto the rail.

"Tests with 6 by 8 inch wood posts continued to produce good results. The addition of spring brackets between post and rail improved over-all performance. Ribbon and post damage was minor, and vehicle damage was slight, considering the 19-degree impact angle, and 45 mph speed. Further tests would now be made at higher speeds.

"This test proved that post material alone was not the answer at higher speeds.

"At 65 miles per hour and 20 degrees, wood posts spaced at 12½ feet deflected the cars, but produced severe pocketing and high decelerations. The resulting damage was clear evidence that greater structural strength was needed to deflect a car safely at turnpike speeds. By reducing the post interval to 6¼ feet, pocketing is virtually eliminated and deceleration is reduced to a reasonable level, even at impact speeds of 65 miles per hour and 20 degree impact angle.

"Notice the minor damage to the guardrail and moderate vehicle damage sustained from the high speed impact. This test is proof that the installation can deflect almost any vehicle at highway speed.

"The full impact of this 50-mile-per hour, 20-degree test is better illustrated by this black-and-white high speed sequence. Considering the angle, velocity and 16,000 pound weight of the vehicle, damage to the guardrail and truck are slight. This test is vivid testimony that W-beam rail and 6¼-foot post intervals will safely deflect almost any vehicle.

"Even with concrete posts, this installation satisfactorily restrained and deflected this heavy bus from 15 degrees and 40 miles per hour. With the problem of glancing impacts resolved, other tests were conducted to explore the problem of end impacts.

"The extreme danger of the common end treatment is vividly illustrated by these results. Actually, this 30-mile-per-hour test was mild when compared to some of the serious accidents that have resulted on the public highways. To eliminate these hazards and to improve the uniformity and strength of the structure, a variety of sloped end treatments were tried. While these tests verified that it was considerably safer to impact a modified end treatment due to the lower deceleration and lessened damage, GM engineers determined that the safest treatment was to anchor the guardrail in this manner so as to absolutely prevent

any possibility of end impact. The concrete anchor also provides full strength in the end section. Tests have proved this to be the least hazardous, although in any ramped-end impact, there is always the possibility of vaulting.

"This 60-mile-per-hour test was made on the proving ground's oval test track to provide baseline information on the existing guardrail. Failure was principally in the flat steel brackets used to mount the rail over the track.

"The violent nature of this test re-emphasized the absolute need to upgrade rail and post designs to meet present day conditions. Later, a complete section of the track was equipped with W-beam rail, spring-mounted on specially developed brackets spaced at 6-foot intervals. This test and others with heavy cars illustrate the success of the new installation under a 60-mile-per-hour impact. Both the guardrail and the car were virtually undamaged by this 16-degree impact.

"Another high speed guardrail tested was this combination chain-link cable design developed and used in California as a median barrier on high volume freeways. The 36-inch fencing and double steel cable are supported by 'H' section steel posts spaced at 8-foot intervals. Turnbuckles are used at frequent intervals to maintain cable tension.

"This lightweight barrier is purposely designed to ensnare any impacting vehicle, to prevent its deflection back into a high density traffic stream. The installation was tested at 65 miles per hour and 7½ degrees.

"The severity of the deceleration, measured at a peak of 34 G's, is indicated by the extreme damage to the vehicle, and the 4-foot square concrete anchor that was jerked from the ground. However, reviewing the slow-motion footage and instrument recordings of this test, it was noted that the deceleration was very moderate to this point (indicating). Here, the car was snagged by a cable-turnbuckle, and the deceleration increased tremendously. Later designs eliminate the turnbuckle between anchor points.

"This 65-mile-per-hour, 17-degree impact shows how the installation responds with the relocated turnbuckles. Again, the dummies are unbelted. As shown from this car-mounted camera, deceleration during impact is moderate. But because of the possibility of extensive damage to prototype vehicles—this design was not adopted by the proving ground; however, the installation would appear to have application on high volume highways as the maximum deceleration recorded was 5 G's and the mean was a low 1.6 G's.

"Attention shifted to the subject of bridgerails in 1962 as construction began on two new overpasses. Since no commercially available bridgerails embodied the safety and strength deemed essential, proving ground engineers designed and built this bridgerail to prevent any possibility of vehicle penetration. The base is reinforced concrete, angled to present a sloping surface. The top rail is heavy-gauge galvanized steel pipe, mounted on cast steel brackets.

"During low speed, low angle impacts, the sloped surface deflects most passenger cars with no sheet metal contact or driver injury, but the success of the design is best illustrated by this 50-mile-per-hour, 12-degree impact. The wheel rides up the sloped surface banking the car as it is turned back along the roadway. Sheet metal contact is minor and deceleration values are moderate.

"The bridgerail also proved capable of deflecting a 16,000-pound truck at 50 miles per hour and 20 degrees. The impact is best observed in slow motion . . . note how the contact between the front fender and the steel rail helps deflect the truck with its higher center of gravity.

"Summarizing the results of the more than 60 guardrail crash tests already conducted, the following points became apparent:

"While no one guardrail design fully meets all objectives, 12-gauge W-beam rail spring-mounted on 6"x8" wood posts proved the best of those tested.

"The ribbon should be mounted a minimum of 5 inches away from the post to prevent snagging, and ideally on a spring bracket to cushion low angle or moderate speed impacts. Heavy washers should also be added to prevent bolt pull-through on impact.

"Because uniform strength is required to deflect a vehicle safely, the ends of the ribbons should be sloped and anchored in concrete. This need is especially critical on short installations. The anchored end treatment prevents pocketing and dangerous end-impacts.

"On roads where speeds are kept below 50 mph, post intervals of 12½ feet appear adequate.

"On freeways and other roads where speeds above 50 mph are permissible, the interval should be reduced to 6¾ feet. At the added posts, short sections of ribbon

should be used to provide the same double thickness strength that results where the ribbon is overlapped.

"A test conducted on a duplication of this typical signpost barrier illustrates these needs beyond question.

"The boxes in this test set-up simulate the concrete sign bases. As on the freeway, the test speed is 65 mph and the impact angle is 25 degrees. These results are graphic proof that many of our present sign barriers are inadequate for present conditions.

"Bridgerails of this or similar design should be considered wherever possible in new construction, as their smooth surface prevents snagging, and their strength with the steel upper rail will safely deflect even large trucks.

"And finally, the approach sections of W-beam guardrail should be firmly attached to a flaired abutment at the end of the bridgerail. This provides a continuity of support and prevents the possibility of impacting the bridge-end.

"Highway safety tests are a continuing program at the General Motors Proving Ground, and their results to date prove that substantial improvements in guardrail safety can be made on existing and future installations using currently available materials and knowledge.

"Details of the Proving Ground tests and guardrail installations are available. For published materials, write to the Director of the General Motors Proving Ground, Milford, Michigan."

Mr. CONSTANDY. Some of the things which you have shown here were commented on during the slide presentation last week. There was some discussion relative to the merits, or the necessity, of blocking out the guardrail from the post. I have noticed here you used a spring mount. I wonder whether you had any thoughts relative to it versus a wooden blackout section or steel blackout section.

Mr. LUNDSTROM. We have put our emphasis on the spring bracket, actually. We drive these tests now, we find that the shallow angle impacts are very easy on the occupants of the car, very little sheet metal damage. So we believe this additional cushioning is the proper benefit to be obtained from the spring bracket that you cannot get from the simple wood blackout. So we prefer it. It probably costs a little bit more.

Mr. MCCARTHY. Mr. Lundstrom, do you know of any States that have adopted the results of your research?

Mr. LUNDSTROM. Yes; we have obviously worked most closely with our own Michigan Highway Department. In the past few years they have been running their own experiments based on the suggestions we have given them. They have been to our proving ground several times to see for themselves what can be done and I know that they have done very good experiments on roadside slopes. They have been experimenting with improved guardrail, with burying the ends of the guardrail now and most recently we have conducted a series of experiments in cooperation with them on lampposts.

Now, the turnpike authorities have visited us. The median guardrail installed on the Pennsylvania Turnpike utilizes some of the findings that we have developed at the proving ground. We have had this bridge parapet installed in sample section on one of the Detroit freeways. We have had other States. Ohio has perhaps been another leader in the utilization of the clean roadsides and extended guardrail programs. And please believe me, we are not the only ones who have done research. California has done a very considerable amount of research in guardrail and in roadsides and they have applied many of these suggestions.

So while it has seemed to us to be slow in developing, we are very much encouraged by the approach of the States, in more recent years,

to picking up various elements of these programs, finding out for themselves how to incorporate these features into their own design requirements.

Mr. McCARTHY. Why would you say they were slow in recognizing the value of what you are doing?

Mr. LUNDSTROM. I am not able to answer your question in any amount of detail. I would simply throw out one comment, that has come to me repeatedly. The State designer and men in charge must decide how to spend the dollars that are available to them. And in many cases, they have chosen to build more miles of roads to a mere minimum standard rather than building a lesser mileage of roads at some higher standard that is going to be somewhat more expensive.

Now, I am not here to criticize them in their judgment, but this is one of the items that has come to my attention and it is debatable but a real issue. I am sorry that I can't go beyond that point.

Mr. CONSTANDY. Would you agree many of the features about which one could be critical in design and construction of our new highways, wouldn't cost any more money? You showed a picture of the transition of the guardrail to the bridge rail section, and I have to say that it is the only time I have seen one which would appear to be appropriate. We had pictures of the installations in nine States last week and in all of them there were guardrails which were installed up to the bridge parapet, and then ended with no overlap at all.

There were attempts in two places, Utah and Oklahoma, to carry the guardrail on to the bridge parapet and I take it from what was said, that the conclusion was reached by the panel that it was inadequate. However, none of them were doing what would be suggested by your testimony and your film.

There are other features similar to that where the cost would be no more, or at times be only slightly more. I make reference to the washer. The price that has been quoted to us for washers installed on a section of guardrail is 12 to 25 cents, varying in different locations, and I think that in a mile of guardrail the cost would be minimal when we consider the cost of guardrail itself.

I mention the washer, not because it is the most significant element in the design of the guardrail, but simply because it is one of the cheapest elements, and it is one that can be corrected and installed very late during the construction had it been omitted earlier in the design.

Mr. LUNDSTROM. Correct.

Mr. McCARTHY. Too, Mr. Lundstrom, the States have an incentive to adopt the results of your research and those of other institutions, since they get 90 percent of the cost of the construction of these facilities, but they have to pay 100 percent of the cost of the maintenance. And your research certainly shows that by building it with the guardrail properly installed, setting the signs back, and so forth, the maintenance costs are sharply reduced.

So that from their point of view, I think it is clear that they are better off to build the better facility from the beginning, and they are going to cut their maintenance costs, of which they pay 100 percent.

Mr. LUNDSTROM. I believe their own studies and experience with these suggestions will bring out the point that you speak of. I believe it is a real good suggestion that they will come to that conclusion correctly.

Mr. STONEX. May I offer a comment. The problems between the connection of the guardrail and the bridge structure sometimes occur because the responsibility for design lies in two different groups. The bridge engineer is responsible for the bridge and the bridge rail and some other design group is responsible for the guardrail and they don't communicate as well as they might.

Mr. CONSTANDY. I think it is very true. We had a picture last week of a bridge under construction. The guardrail was already installed up to the point where the parapet would exist after it is built, but the bridge has not yet been finished. The design of the bridge seems to be an area in which no one else but a bridge engineer can offer constructive criticism about the operation of the vehicle upon it, or approaching it.

These things are changing. I think that we would be quick to agree to that. It is a question of time and how long we can tolerate the death toll in this country at the rate it is. It reminds me of the Aunt Jemima commercial—"What took you so long?" These things have been known for some years and many major improvements could be brought about at either no cost or slight additional cost, sometimes even at a substantial saving. As example, the installation of sign bridges when the sign can frequently be placed on a structure for little money. It isn't always a matter of cost. That is one of the first things people bring up when you talk in terms of improved safety design.

You have another film, do you not?

Mr. LUNDSTROM. I think I would like to just add this conclusion to your remarks, sir, if I could. It is cost benefit that we are looking at actually, and there are times when the designer must take into account the expected performance to be obtained from some change of design.

For example, it is possible to eliminate piers on overpasses, at some additional cost. And statistics do show you how often these piers are likely to be contacted on any particular roadway. So you should be able to figure out in advance whether or not it is feasible to remove or to change the design to eliminate the piers.

In the bridges that we talked about in this film, we did have to make a decision like this. For \$20,000 we could put more money into the bridge span and eliminate a center pier. We decided that this cost was nominal and would be less than one accident in the next hundred years, perhaps, from striking that bridge pier. So we elected then to put the additional money into the span and eliminate the pier and possibility of accidents for all times.

So it is a decision of cost benefits which must be made.

We have one final film. Mr. Stonex will comment on this and it does give a little more up-to-date information on lamp posts. Are you ready?

Mr. STONEX. I am ready.

Mr. CONSTANDY. We had testimony last week to the effect that in some instances in the construction of a bridge, eliminating the shoulder piers, if begun early enough in design, added nothing to the cost.

Mr. LUNDSTROM. That is possible also; yes, sir.

Mr. CONSTANDY. We also had the problem portrayed last week involving twin structures with the narrow median. We saw examples of twin bridges, where the space between them was about 6 to 10 feet and there again, at no additional cost, perhaps a saving, hazards

could have been eliminated by paving the spaces between the structure.

Mr. STONEX. [Narrating film:] At General Motors, we think that our circular track is one of the safest high speed roads in the world. One of the problems involved was the illumination of the track entrance and the exit. The commercially available lamp poles were rigid and would have been hazardous. These scenes of impacted lamp poles were obtained on a day's drive through the city of Detroit. The city officials indicate that there are about 300 of these poles knocked down during a year's time, or about one a day. Here is a scene that you have seen before.

Here is the tripod-type lamp pole which is not practical particularly; however, it was very effective, damage to the car very slight.

This will be a test of a standard steel lamp pole of standard installation. You get some impression of the severity of the impact and the damage to the vehicle which is caused by this pole.

Through our mutual interest in highway safety, Texas A. & M. University disclosed to us a design of a breakaway slip base for sign posts that they were testing in conjunction with the Texas Highway Department and the Bureau of Public Roads. Taking the lead from them, they had a bidirectional slip base and we arrived at this one which is omnidirectional. The top of the mounting plate is attached to the base of the pole. This is attached to the ground anchor by four bolts and spacers.

And this will be a test of the pole of the omnidirectional breakaway.

This is an aluminum pole. The State of Michigan requested that we evaluate steel posts with the omnidirectional breakaway because of some difference in the initial cost. This is a steel pole with the rigid base, the standard installation at the moment throughout much of the country. They figure in serious and costly accidents, as you can see.

Here is an installation with the breakaway base, slip base. The damage to the pole and to the automobile are minimal.

I might say that this standard is approved by the Michigan State Highway Department presently.

On our test track, we elected to keep the poles 30 feet from the edge of the pavement, so that we get the double safety of remoteness from the edge of the pavement and the slipaway bases.

Mr. CONSTANDY. We have approximately 5 more minutes. I think you have one more film, do you not?

Mr. LUNDSTROM. No; we would like to not show the other film of the bridge parapet. I would like to call your attention to the rigid parapet though, that was shown in the guardrail film.

There are many features that are not obvious to you on initial viewing. First of all, vehicles that strike this new bridge parapet, vehicles that strike at rather flat angles, are redirected by tire contact and there is no sheet metal damage at all. For sharper angles of impact or for higher speeds, the tire climbs the bridge rail and the car banks into a turn. It is this fine turn and bank that gives this quadrail advantages over other structures. This performs so well that we now are driving these tests, rather than running the cars by remote control.

If your committee is able to come to Detroit at any time, you can personally ride in cars being driven into these bridge rails about 40

miles an hour with 10 degrees and you will have no difficulty surviving this experience. All you will be required to use is a seat belt. I believe you have experienced this, sir.

Mr. CONSTANDY. That is a good word; yes, I have experienced this. It was an exhilarating experience and very satisfying.

Incidentally, I believe we went at 45 miles an hour at the time.

Mr. LUNDSTROM. Yes. The only thing I would like to say in closing our part of your investigation, is that we have had an unusual capability of being able to test new designs in dynamic experiments and we fully appreciate this advantage that we have had. The highway departments have not had this kind of an opportunity. There has been nothing set up for them to run this kind of experiment. Because of our unique ability to do this kind of work, I would urge that they be supported in their need for facilities to run dynamic tests, to determine what actually happens on the highway at highway speeds with commercially available cars, trucks, buses, and so forth. It is only through this kind of experimentation that you can have safe highways and safe highway structures developed.

We have appreciated very much the opportunity of being with you this morning. If you are able to come to Detroit and look at our facilities firsthand, we would be most pleased to have you. Thank you.

Mr. McCARTHY. Before you finish, Mr. Lundstrom, have you made any computations on the number of the 13,000 deaths in off-the-roadside accidents that could be reduced by the utilization of the improvements that you have shown us here today?

Mr. LUNDSTROM. I am not one to try to predict with too little information; the number of cases seems very important to us and it would seem very important gains could be made. I am not able to predict percentage-wise what this would do on a public highway. It would be very significant but I would not like to put it in any percentage points.

Mr. McCARTHY. I believe you did say that 80 percent of the accidents could be eliminated by the 30-foot removal of fixed objects off the traffic way.

Mr. LUNDSTROM. This appears to be correct, that the experience we have had on the proving ground would indicate that 75 to 80 percent of the accidents would be eliminated by clearing 30 feet of roadway.

Mr. STONEX. I think we could probably express that as a potential for saving lives. And in this sense, we could save all 13,000 if everybody did a 100 percent job on every mile of roadside in the country. Then there would be some accidental accidents, which we would miss a little, but I mean there is a potential of this number.

Mr. CONSTANDY. I think it is agreed it would be an appreciable reduction if some of the basic principles which you have shown today were incorporated into our highways.

I want to thank you, Mr. Lundstrom and Mr. Stonex. You have been very helpful and cooperative. We appreciate that.

Mr. McCARTHY. Thank you very much, gentlemen. I think it should be pointed out that General Motors has been getting somewhat unfavorable publicity lately. However, they have been devoting many years to this effort to save lives and I hope that this will get exposure, too. I doubt if it will because—and I speak as a former newspaper

reporter—the unfavorable gets a wider circulation. But I think that General Motors has made a great contribution to the country by having this facility and making the results available.

The committee will adjourn now until 10 a.m. tomorrow.

(Whereupon, at 12:40 p.m., the committee was recessed, to reconvene Wednesday morning, June 28, 1967, at 10 a.m.)

HIGHWAY SAFETY, DESIGN AND OPERATIONS

Roadside Hazards

WEDNESDAY, JUNE 28, 1967

HOUSE OF REPRESENTATIVES,
SPECIAL SUBCOMMITTEE ON THE
FEDERAL-AID HIGHWAY PROGRAM OF THE
COMMITTEE ON PUBLIC WORKS,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10:08 a.m., in room 2167, Rayburn Building, Hon. John A. Blatnik (chairman) presiding.

Present: Messrs. Blatnik, Wright, Everett, McCarthy, Cleveland, McDonald, and Duncan.

Staff present: Same as previous days.

Mr. BLATNIK. The Special Subcommittee on the Federal-Aid Highway Program of the Committee on Public Works will please come to order.

Today we will continue to hear testimony from witnesses who are knowledgeable in the field of highway engineering research and development.

Our first witnesses will be a group of gentlemen who are affiliated with Texas A. & M. University College of Engineering and the Texas Transportation Institute, of College Station, Tex. They and the outstanding work they have been doing in the work of highway related engineering research will be further identified by counsel.

Our panel for this morning are Dr. Fred J. Benson, dean of the College of Engineering and director of Texas Engineering Experiment Station, Texas A. & M. University; Dr. Charles J. Keese, executive officer, Texas Transportation Institute, Texas A. & M. University; Dr. Neilon Rowan, project supervisor, Texas Transportation Institute, College Station, Tex.; and Dr. T. J. Hirsch, head of the Structural Research Department, Texas Transportation Institute.

We would like to welcome you gentlemen on behalf of the committee and express our true appreciation for the cooperation and special assistance you have given our staff in what we consider will turn out to be most helpful and significant hearings to further advance the cause of protecting the motorists on the highway system.

Gentlemen, as is customary, we administer the oath to all witnesses. I would like to ask you four to stand and raise your right hands. Do you solemnly swear the testimony you will give before the subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God.

Messrs. BENSON, KEESE, HIRSCH, and ROWAN. I do.

Mr. BLATNIK. Gentlemen, please be seated. All right, Mr. May.

Mr. W. MAY. Mr. Chairman, the staff of the institute prepared a detailed report concerning research objectives and accomplishments of the institute. I ask that that be marked "Exhibit 15."

Mr. BLATNIK. Without objection, so ordered.

(Exhibit 15 is retained in subcommittee files.)

Mr. W. MAY. Dean Benson, perhaps for the benefit of the committee, you can begin by describing the institute and its objectives.

TESTIMONY OF DR. FRED J. BENSON, DEAN, COLLEGE OF ENGINEERING, DIRECTOR, TEXAS ENGINEERING EXPERIMENT STATION, TEXAS A. & M. UNIVERSITY; DR. CHARLES J. KEESE, EXECUTIVE OFFICER, TEXAS TRANSPORTATION INSTITUTE, TEXAS A. & M. UNIVERSITY; DR. NEILON J. ROWAN, PROJECT SUPERVISOR, TEXAS TRANSPORTATION INSTITUTE; AND DR. T. J. HIRSCH, HEAD, STRUCTURAL RESEARCH DEPARTMENT, TEXAS TRANSPORTATION INSTITUTE, COLLEGE STATION, TEX.

Dr. BENSON. Thank you.

Mr. Chairman and Congressmen of the subcommittee, it is a very distinct pleasure for us to be here today, to appear before the Special Subcommittee on the Federal-Aid Highway Program.

Since the mid-1910's, Texas A. & M. University has been active in the training of highway engineers and in research dedicated to a better system of highways for our State and Nation.

Following World War II, Mr. Gibb Gilchrist, chancellor of the Texas A. & M. University; Mr. Thomas H. McDonald, chief and later commissioner of the Bureau of Public Roads; and Mr. D. C. Greer, State highway engineer of Texas, conceived and brought into being the Texas Transportation Institute dedicated to research important to all forms of transportation. In 1953, Chief McDonald came to Texas A. & M. to head the program and bring the institute to fruition.

A major portion of the Transportation Institute program has been the cooperative program with the Texas Highway Department and in more recent years including also the U.S. Bureau of Public Roads. This portion of our program has been dedicated to the solution of long-range problems involving the transportation system on the highways.

In the period 1948-52, Prof. C. J. Keese and I started a modest effort in safety research, beginning first with the idea that major achievements could be had through improvement in driver attitude and driver skills. We found this to be rather discouraging, probably because neither of us was well-qualified for work in this area. In 1956-57, under my direction, Mr. Robert Schleider, a graduate student, made a study of the accidents on Texas Highway No. 6 between College Station, Tex., and Navasota, Tex., a distance of 22 miles. This study indicated that most of the fatal accidents and serious injury accidents involved cars leaving the highway and striking trees or culvert headwalls in the right-of-way and at some distance from the shoulder line. Actually, we were astonished at the number of accidents which involved striking off-the-road obstacles.

This particular section of the highway, was built in the mid-1930's and incorporated many of the features advocated by the General Motors engineering staff.

Mr. BLATNIK. Mr. Cleveland.

Mr. CLEVELAND. I just want to ask, did you have any breakdown as to how many accidents were caused by trees and how many other obstacles off the highway?

Dr. BENSON. Mr. Congressman, it is in the report. I do not have it with me. We could send it to you.

Mr. CLEVELAND. Thank you.

Dr. BENSON. This particular section of highway was built in the 1930's, and incorporated many of the features advocated by the General Motors engineering staff at the hearing of yesterday, June 27. The roadway had high shoulders, flat ditch slopes, and wide flat ditch. Drivers leaving the roadway had an excellent opportunity to regain control of the vehicle when an obstruction was not encountered. Texas has been using the flat slopes and wide rounded ditches advocated by the General Motors staff for some 30 years.

Mr. Gilchrist inaugurated these practices during his term as State highway engineer prior to 1937. Many of the trees involved in the accidents were more—and I repeat, “more”—than 30 feet from the pavement edge.

A later study, which was supported by the Automotive Safety Foundation, and covering the years 1954–58, was made of approximately 10,000 accidents on 54 miles of freeway in the cities of Dallas, Houston, Fort Worth, San Antonio, and Austin. Prof. C. J. Keese and B. F. K. Mullins were the investigators. This study also showed that collisions with fixed objects along the roadway, particularly at night, were responsible for many of the fatalities and serious injuries. Whereas only 12 percent of the accidents studied were of this type, they caused 38 percent of the injuries and 65 percent of the fatalities. This study was completed in 1960.

It seemed evident to us that studies were needed of ways and means of avoiding such accidents or of reducing their severity. The general principle was obvious—the edges of the roadway should be kept as free as possible of fixed objects. Because of the severity of the accidents involving vehicles striking heavy sign supports, the idea was advanced that such supports could be built to fail under vehicle impact. The first formal proposal was developed in 1960 but lacked external support, so the work was carried on until 1963, with limited funds provided by the university and the institute.

In 1963, the program became a part of our cooperative research effort with the Texas Highway Department. The first field installation of “breakaway” signs was made beginning in September 1965 in Orange, Jefferson, and Chambers Counties of the Beaumont district. The first sign was struck on November 4, 1965, without injury to the driver and with only minor damage to the vehicle.

After 1963, the program was extended to include breakaway design for lighting standards and this problem we think has been successfully solved. Currently we are working on procedures for providing impact attenuation devices of fixed objects for which the breakaway principle cannot be used.

All of this work that I have discussed has been carried on under the direction of C. J. Keese with Dr. T. J. Hirsch, Dr. R. M. Olson, and Dr. N. J. Rowan as the principal investigators. Professors Keese, Hirsch, and Rowan will discuss these programs in detail when I conclude.

One matter which we would like to bring to the attention of the committee with regard to highway research in general is the tendency developing over the past 2 years to ask research organizations to perform large dollar research programs in short-time intervals. We seriously doubt the wisdom of this approach since it has been our experience crash programs are wasteful in time and money and often unrewarding in useful results. Most effective research rests on "trial and error" procedures and it is difficult to speed such processes up.

We have one of the larger research organizations in universities in this country and, frankly, several of the projects which we have been asked to quote on recently we do not have the staff to do.

It is now my pleasure to turn the microphone over to Prof. C. J. Keese, who with his colleagues, will provide a more detailed report of our highway safety research in the areas of breakaway signs, breakaway lighting standards, new concepts for highway lighting, and impact attenuation systems. But before I do, I would like to state in summary that it is our opinion that the two principles involved in reducing the number and severity of accidents involving collision with roadside obstructions are these:

First, limitation of the number of fixed objects in the right-of-way to the minimum. I think this should be from right-of-way line to right-of-way line;

Second, provide protection for the driver of the vehicle at those fixed objects that are necessary.

Thank you, Mr. Chairman.

Mr. BLATNIK. Thank you, Dean Benson. Professor Keese, would you proceed?

Dr. KEESE. Mr. Chairman, since about 1956, the Texas Transportation Institute has conducted and reported or now has underway some 29 major studies in the field of traffic and highway safety. These have been in the general areas of traffic accidents, including the breakaway sign and attenuation studies, illumination or highway lighting including the breakaway light poles, channelization and delineation, signing, speeds, freeway design operation and safety, general highway design operation and safety including city street medians.

A partial list of these studies furnished to the staff of the subcommittee will be available to you.

Gentlemen, probably because of the results of our cooperative research program with the Texas Highway Department, the institute has a long-established philosophy that research has little or no inventory value, that it should be put to work as rapidly as possible if we are going to catch up with the demands of transportation today.

We have a philosophy throughout most of our research programs which is based on developing a theory, evaluating that theory through experimentation, and further evaluating it through practical application.

This brings together on each project an advisory committee composed of highly qualified engineers and others from the sponsoring

agencies, from the research staff, and appropriate disciplines wherever we can find this advice.

The institute research team usually works as an interdisciplinary group. This interdisciplinary research has during the years provided successful solutions to many transportation problems.

Our philosophy with regard to safety is that safety is a byproduct of efficiency; that anything we can do to increase the efficiency of any element of the road-driver-vehicle system will result in safer highway transportation.

Now, this philosophy is based in part upon the philosophy of Chief McDonald, and if I might paraphrase his quotation back in 1948, he felt that we had reached the point in our knowledge of the way people use the highways to be able to coordinate highway design and traffic operation. He said that the degree to which this philosophy is accepted and applied would determine the safety and efficiency of our future highways.

For many years in freeway design and operation and parallel studies in freeway accidents we have substantiated this philosophy that design and operational improvements that create more efficient traffic operation result in a reduction of freeway traffic operation, or traffic accidents.

Now, for several years, as Dean Benson mentioned, we have been conducting or had conducted traffic accident studies in the conventional manner. These post mortem studies were disappointing and discouraging.

Our present philosophy, present approach, is to use accident frequency as a symptom of inefficiency and then to apply the diagnostic approach to improve the efficiency and thus improve the safety.

As Dean Benson mentioned, we learned quite early that roadside hazards were a problem. And as more and more miles of freeways were completed, and more signs installed, it was recognized that the large signs that required these massive supports would constitute a hazard to vehicles leaving the roadway. The personnel of the Texas Highway Department and the Texas Transportation Institute became concerned with this problem and began developing a research study aimed at minimizing these hazards. But accident experience was more serious than anticipated and we found a need for more immediate solutions and that this was a matter of urgency.

So we changed our normal research approach and developed the approach of finding through experimentation an acceptable answer, then applying these solutions experimentally along the roadways, and finally going back and doing a more extensive study to find the best answer to the problem.

I might just add, before turning it over here to Dr. Hirsch, the importance of bringing together the research staff and the operating engineers. This has the advantage of stimulating a broad view of the problem which exposes the impractical divisions of responsibility and brings back about a closer understanding, a mutual understanding and respect for each other. And this I think more than any other thing has caused the implementation of this research as rapidly as it has.

I would like to turn this over to Dr. Hirsch now to describe to you our work in the breakaway sign research project.

Dr. HIRSCH. Thank you, Mr. Keese. I will speak principally on the breakaway sign and the research that we have done in this area. To start first, we need a little feel of why this problem of rigid sign supports only came to our attention in recent years. We started our first research in this area in September 1963. I think to give you a little background on our modern freeway and Interstate Highway Systems, they are multilane and the speed limit has been increased up to about 70 miles an hour, and that a vehicle operator traveling on these modern facilities at legal speeds now must make more decisions as to changing lanes, what entrance ramp to select, what exit ramp, and so forth. Consequently, the number of these roadside signs has increased.

Also, with the higher speeds, 60 and 70 miles an hour, the size of the signs required has increased in recent years—they are up to very large size, on the order of 8 feet by 16 feet—the messages are larger; larger letters are used so the operator can see it farther down the road and have sufficient response time so that he can make a decision as to what to do.

Consequently, due to this increased size of the sign background these signs are designed by structural engineers. And this refers to the division of responsibility between the geometric designer and structural designer—there is a need to design and hold these signs up with the wind loads on the larger backgrounds. Larger structural supports have resulted, similar to the sample on the table here, where we have 8-inch wide flange beams weighing 20 to 35 pounds per foot. On some of these large signs, the size of these beams is 10 inches, and more.

Because of this, in about 1963, engineers with the Texas Highway Department and the Texas Transportation Institute realized that we had a lethal obstacle in the roadway. In some cases these were as close as 2 feet to the roadway.

We looked into the statistics and found that in Texas alone in 1963, there were 867 vehicular accidents with roadside signs. These accidents resulted in 264 injuries and 15 fatalities.

In 1964, 1 year later, these figures in essence have doubled. There were 1,201 accidents, 400 injuries and 31 fatalities.

Mr. W. MAY. These are sign accidents?

Dr. HIRSCH. These are sign accidents in the State of Texas.

I am sure we do not have the figures for 1965 and 1966, but the numbers have increased, not only in the State of Texas, but in the Nation.

In September 1963, we started on this cooperative project with the Texas Highway Department and the Bureau of Public Roads. On this project the research engineers were working with highway engineers, and one principally, Leon Hawkins, who was in charge of designing structural supports, and we started out with this approach that Mr. Keese mentioned. We were in a hurry and we more or less followed a cut and dried procedure.

We had a hypothesis when we started. We realized the severity of impact to signs was due to probably three things: the massive posts, the stiffness of the posts, and the fixity of the base of the post to a rigid concrete foundation.

As the research proceeded, it turned out that probably the most significant factor here rather than size or stiffness of the post was the

rigidity of the base connection of the steel post to the concrete foundation. Consequently, our breakaway concept was developed. We worked on structural details to accomplish this.

And I must say to arrive at the details, which you can see illustrated here and which will be illustrated in the movie which we will show in just a minute, required very close coordination between researchers and practicing highway engineers familiar with highway design installation and maintenance of these devices. Too frequently researchers in a university operate in an "ivory tower" situation, and while they work experimentally, they are uneconomical or impractical from some practical standpoint. So consequently the design we are about to show has come fourth.

The immediate attention was placed on a means, and the reason we arrived at a sign similar to the one you will see and will first see in the movie, is because there were a large number of these two- and three-post supports, steel I-beams, and what we call cantilever design, in existence.

Our immediate objective was to find a solution which could quickly be applied to go out and modify these existing hazards, as well as look at new concepts and maybe more efficient, more economical solutions to the problem. Consequently, A-frames, signs with timber supports, signs with supports of aluminum, and other concepts were investigated.

I think probably this would be a good time to show the movie.

Mr. W. MAY. Just before we start, another statistic. According to the Bureau of Public Roads, there were 6,163 accidents involving vehicles in collision with fixed objects which occurred on Texas highways in 1964. The 1,201 figure you mentioned represents about 20 percent.

Dr. HIRSCH. Yes. They were signs. Some of the others were light poles which I think Dr. Rowan will comment on later.

Mr. W. MAY. I see.

Dr. HIRSCH. And possibly trees and culvert wall.

Mr. BLATNIK. Mr. Wright.

Mr. WRIGHT. Mr. Chairman, I want to ask one or two questions at this point, if I may. First, let me congratulate Dr. Benson and his colleagues for the fine work in Texas they have been doing. It is forward-looking work.

One figure he has mentioned that was particularly interesting to me—your studies seem to coincide with others that have been made. We had some yesterday relating to the incidence of accidents and fatalities resulting from a car going off the highway and striking a fixed object along the right-of-way. I believe you said 65 percent of the fatalities in the group of accidents studied by your institute resulted from this type of obstacle.

Do you have any figures that would tell us relatively how many of those resulted from cars veering off to the right and, how many might have resulted in cars veering into a median strip to the left?

Dr. KEESE. Mr. Wright, quite early in our studies, one of the things involved was a study of highway medians, and the encroachment of vehicles onto that median and the development of the median guard-rail to prevent the vehicle from going into the opposing traffic lanes.

I do not have the report with me that indicates the number of these that did cross the roadway, but since these were urban studies, I would

say that relatively few were able to cross the roadway and hit a fixed object. Generally those that cross the median and go into the opposing lanes would be in conflict enough that they would be involved in a collision with other vehicles.

Mr. WRIGHT. Well, we have in Fort Worth a highway that goes from east to west with which all of you, I think, may be familiar. The highway department has erected various types of guardrail from time to time between the westbound and eastbound traffic. And yet frequently when I am down there I will discover a place where a car has plunged right into this protective device and seemed headed for the oncoming traffic, though it is a divided highway.

This brings up one other question. Last year, when we had our hearings, Mr. Chairman, you will recall that there was quite a bit of discussion—I viewed it very hopefully—to the effect that we could reduce the incidence of accidents on our highways by planting in the median strip either trees or shrubs, or something of this type, to take up some of the brightness of the lights from the oncoming vehicles.

I thought this was a great development. It sounded fine to me. I am wondering now if this is good or if it is bad. I would like to think it is good, but are we inadvertently creating hazards in the median area, for example, when we plant trees and things of this type, with the very best intention?

Dr. KEESE. California has done a considerable amount of study in this and Mr. John Beaton, I believe, will testify before this group later and can probably furnish a great deal more information on this than I.

We are still quite interested in the median planting, the planting of shrubs at various hazard points for attenuation of the vehicle, plus the elimination of glare, and esthetics. But certainly not those things that would constitute a hazard if struck.

Mr. WRIGHT. So some type of vegetation that would reduce the glare but not be as sturdy in its trunk as a tree might be a solution. A shrub or some type of growing thing that would absorb the impact of the car and have the tendency to slow it down and stop it without shattering it with a sudden impact. Do you think that is probably the direction in which we should be moving?

Dr. KEESE. I think that is the direction in which we should do further investigation, very definitely.

Mr. WRIGHT. About glare, have you done any research on the incidence of fatalities resulting from glare from oncoming headlights?

Dr. KEESE. We have attempted to do some. But this, because of the complexity of these situations, is almost impossible, as I mentioned earlier. It is almost impossible to do these accident studies from post mortems of the accident and to isolate any particular variable.

Now, we realize that glare of opposing headlights is a problem and the Texas Highway Department has done a considerable amount of work using wire screen and other devices to eliminate the glare from opposing headlights very effectively. There is additional work going on at the present time around the country on this particular problem.

Mr. WRIGHT. I suppose it would be very difficult to identify that as the cause, if a driver tragically loses his life in an accident. You can identify the fact he ran into a fixed object, but you cannot identify that he was caused to do it from the glare of oncoming headlights or necessarily from any other problem that bothered him.

Dr. KEESE. Right.

Mr. WRIGHT. Thank you, Mr. Chairman.

Mr. BLATNIK. Do you have a film to show now, Professor?

Dr. HIRSCH. Yes, I do. Before I start, I might make one comment on this film.

Initially our research on the breakaway sign was sponsored by the Texas Highway Department and the Bureau of Public Roads and this research was conducted from September 1963 to August 1965. And before this, the first signs that were developed, the breakaway concept, were being installed on Texas highways, beginning in August 1965. At present there are something like 1,500 breakaway signs installed in the State of Texas, and 69 collisions with these have resulted. Mr. Keese will comment on this later.

At the present time, we are working on a project sponsored by 13 States and the District of Columbia, and this film has resulted from this further study of this problem, which is a study in depth to determine more specific design criteria. The theory has been developed through mathematical simulation, so that we can extrapolate this to different sizes of signs, different materials, aluminum or wood, and different concepts. I just wanted to clear this up because this film will indicate the 13 States to which I have referred. Unfortunately the District of Columbia has been omitted from this filmstrip.

Mr. BLATNIK. May we have the lights out?

(The subcommittee requested the text of the film be transcribed, as follows:)

FILM ENTITLED "SAFE ROADSIDE SIGNS," PRODUCED BY THE TEXAS TRANSPORTATION INSTITUTE IN COOPERATION WITH THE U.S. DEPARTMENT OF COMMERCE, BUREAU OF PUBLIC ROADS, SPONSORED BY ALABAMA, CALIFORNIA, ILLINOIS, KANSAS, LOUISIANA, MINNESOTA, MISSISSIPPI, NEBRASKA, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TENNESSEE, AND TEXAS

(The opinions, findings and conclusions expressed in this film are not necessarily those of the Bureau of Public Roads.)

VOICE. This is a roadside sign typical of those used along our Interstate highways. Many factors have been considered in the design of the sign and its supports.

The supports generally consist of two vertical wide flange beams which are strong and stable when subjected to wind forces.

The posts have aesthetic quality, support a readable sign, are easily maintained, and are located adjacent to the roadway.

In short, the sign supports are excellent—(crash)—but lethal.

It is this last characteristic that has motivated research engineers to develop safer sign support designs.

There is no doubt that rigid nonyielding sign supports constitute a safety hazard.

Pictorial evidence is readily available from accident files. In Texas, two dead. In Louisiana, one dead.

In Kansas, one dead.

Highway sign accidents have increased significantly as Interstate highways have been completed. Recognizing this problem as early as 1963, The Texas Highway Department sponsored research conducted by the Texas Transportation Institute to develop safer sign supports.

The Texas breakaway design evolved from that research. In 1965, the research effort was increased and several state highway departments joined in sponsoring the research in cooperation with the Bureau of Public Roads.

As a result of the research conducted by the Texas Transportation Institute, the Project Policy Committee has recommended that certain roadside sign support design concepts be considered for use in providing a safer roadside environment.

The Texas breakaway design utilizes a wide flange or I-beam section as the cantilevered support post. The safety features incorporated in the design are a slip base and a hinge joint.

The sign can be attached to the post in several ways. This sign employs a plywood background with aluminum wind beams bolted to the plywood and clamped to the posts.

The slip base is designed in such a manner that a shear plane is created at the base of the post. The base connection is fabricated by bolting the base of the post to the foundation stub and thus providing resistance to overturning from wind forces. The shear plane consists of slots rather than holes in the base of the post and the foundation stub.

The hinge joint is a weakened plane, approximately 7 feet above the base. Its purpose is to permit upward rotation of the post after impact.

To form the hinge joint, the front flange and the web of the post are severed and reconnected with a bolted fuseplate that slips or fractures to permit rotation of the post to clear the colliding vehicle.

The Texas breakaway design functions as follows:

As impact occurs, energy is absorbed by the post and the automobile until the impact force is sufficient to cause the base to slip. After the base slips, the fuse breaks. Energy that was stored in the vehicle and the post results in the post being thrown clear of the automobile. Acceleration of the lower portion of the post causes it to continue in its upward swing and the automobile passes through safely.

Now, observe this behavior in one of the slow motion crash test films taken at 1,000 pictures per second.

Dr. HIRSCH (interpolating). The change in velocity of the vehicle is on the order of 1 to 2 miles an hour.

Mr. BLATNIK. Would you repeat that?

Dr. HIRSCH. The change in velocity of the vehicle is on the order of 1 to 2 miles an hour.

Mr. BLATNIK. The deceleration?

Dr. HIRSCH. Yes.

VOICE (continuing). Note how little damage was done to the vehicle.

Another design recommended by the Policy Committee is the Minnesota deforming post, A-frame design. The post braces and wind beams are all made of U-section rail steel prepunched for easy assembly.

The posts can be driven in the ground, usually to a depth of four feet or more, or they may be set in concrete, dependent upon the soil conditions.

The Minnesota deforming post. A-frame design, functions as follows:

As impact occurs, energy is absorbed by the vehicle and the post until the force is sufficient to shear the post below the bumper level. The impact energy results in bending of the slender post member and twisting the sign.

As the collision progresses, the vehicle collides with the brace member, deforming it, and causing shear failure in the bolted connection.

A secondary collision may normally be expected as the vertical post member strikes the vehicle above the windshield.

Now observe this behavior in a continuous run of the slow-motion crash test film.

In crash testings of this design, the vehicles have sustained only minor property damage.

Another design recommended by the Policy Committee is the joint failure. A-frame design. The sign support is an A-frame structure with features of a truss. The joints of the various members are made of a frangible material which will fracture upon impact. The individual members are tubular in shape and deform upon impact.

Extruded aluminum panels are used for the sign background. The panels clamp directly to the vertical post member.

The joint failure A-frame design functions as follows:

As the colliding vehicle strikes the upright member, the member deforms and the frangible foundation fitting breaks. As the collision progresses, the member is bent, causing a plane of failure near the sign face.

As the vehicle strikes the two brace members, deformation occurs in the first member, and the frangible foundation connection breaks.

As the connection breaks, members are rotated upward by the impact force, the sign background is twisted, and the upper connections break.

The vehicle passes on through the support safely but the tortional effects on the sign cause failure of the other support and the sign collapses.

Now observe this behavior without interruption.

Again note that damage to the vehicle was minor.

Dr. HIRSCH (interpolating). Obviously the maintenance of that sign would be quite high.

VOICE (continuing). Has been adopted as design standards in the State of Texas.

The first signs of this type were installed in 1965. Since that time they have been installed on several hundred miles of the Interstate System.

Not only have lives been saved by adopting the breakaway sign, but this has been accomplished without additional cost to the public.

These sign supports cost no more than fixed base supports.

Modification of an existing sign in Texas costs something about \$150.

VOICE (continuing). The deforming A-frame design is now being used in Minnesota. It is very economical and accident experience has indicated satisfactory performance.

The joint failure A-design is commercially available.

As a result of this research, the Policy Committee of the highway sign support research project recommends that the sign support designs presented in this film be considered for use as a means of making our highways safer.

(Printed:) This film was produced from the Highway Sign Support Research Project HPR-2(104) sponsored by Alabama, California, Illinois, Kansas, Louisiana, Minnesota, Mississippi, Nebraska, North Dakota, Oklahoma, South Dakota, Tennessee, and Texas, in cooperation with the U.S. Department of Commerce, Bureau of Public Roads.

(End of film.)

Dr. HIRSCH. Just as a few comments, this principle is also used on smaller signs, such single-post signs, or where the two posts are very close together and the vehicle can strike both posts at the same time.

And I mentioned before, one of the desirable things, we think, about the cantilever post is that it can easily be applied to modify existing sign supports.

Mr. BLATNIK. Would you repeat that, Professor? You say this technique, shear-type or breakaway supports, can easily be applied to existing installations.

Dr. HIRSCH. The existing signs, that is right.

This has been done in Texas and the cost experience data to modify one of these roadside signs is approximately \$150. It depends on the size of the sign, whether it is a small one or big one, but it is in this neighborhood.

Mr. W. MAY. Do I understand, Doctor, the Texas Highway Department has underway a program of going back and modifying some of the existing rigid supports?

Dr. HIRSCH. Yes. A number of the districts are going back and modifying them. Some of them had modified all the existing signs in several stretches of the Interstate System. On Interstate 10 between Houston and Beaumont, all of the existing signs have been modified, and of course all the new signs are the breakaway concept. They also have a policy, where any of the existing signs with rigid supports are struck by a vehicle, when they go out and maintain it or repair it, they install the breakaway concept.

Mr. W. MAY. Would the Northern States have to worry about freezing conditions or rusting?

Dr. HIRSCH. This question has been brought up by the policy committee from States like Minnesota. We feel that the corrosion problem,

if there is any increased resistance, is so minor that the breakaway action will still be had.

One other comment in this project, and it was not covered in the film, is that we had a study in depth to develop this mathematical model so that it could easily be extended to other types of materials and other types of sign configuration. I will not go into that at this time because it is a little bit too detailed.

I might point out, as far as the deceleration levels I commented on with the breakaway concept, with the Minnesota deforming A-frame cantilever post, the change in velocity of the vehicle is 1 to 2 miles an hour, more usually 1 mile per hour. The *g.* forces on the vehicle are on the order of 7 to 8 *g.* for a short period of time, something like 0.03 second.

As far as the driver himself is concerned, the *g.* levels on our simulations and model studies indicate that he would only get one-quarter to one-half the *g.*, something like one or two *g.*, for a very short period of time. And according to existing impact and survival data developed by people at Holloman Air Force Base, this is well below surviving or accidents that should create any injuries.

Mr. BLATNIK. Professor, your testimony is truly most enlightening; Dean, all of you witnesses have provided most enlightening information. What really disturbs me—am I not correct that all the information we have seen as to deceleration, the dissipation of impact forces and energy, has been long known? It is quite common knowledge in the engineering field, is it not?

Dr. HIRSCH. Essentially, yes.

Mr. BLATNIK. What puzzles me is that the Interstate program itself is the most modern highway system in the history of mankind. It is 11 years old. I find it absolutely incredible if not appalling, for 11 long years we have put in literally millions of signs that were known and should have been known to be lethal all the time, and only within the last 2 years are those in charge of the construction of the roads utilizing information that is standard and simple as far as engineering knowledge is concerned. Is that not true?

Do you want to comment?

Dr. BENSON. Well, Mr. Chairman—

Mr. BLATNIK. Those who should have been utilizing information, our engineers and professors and researchers such as yourself have long known of it and it was available had anyone sought the information.

Dr. BENSON. The profession did not think it was as simple as that. I think I pointed out in my testimony that we actually started, Professor Keese and I, with this concept in 1960. It took us 3 years to get it funded. The reason we could not get it funded, I think, was that most people believed we could not do it. They did not think it was possible for us to build, particularly the cantilever type support, that would carry the windloads and which could be made to fail under the impact of traffic.

So we had to prove to the profession that this could be done; that this was a practical possibility.

Mr. BLATNIK. Someone is living in the age of darkness then. I am talking about those who should be utilizing scientific knowledge. We can decelerate a human being from 15,000 miles in outer space and

bring him alive back to earth, with all gravitational forces and tremendous velocities. To say they did not think it was possible to provide for absorbing forces for vehicles traveling 65 or 75 miles an hour—it is absolutely incredible. But that is a problem we will have to wrestle out with others who will appear later on.

I want to commend you for your most impressive presentation. I well know the methods of painstaking, detailed work and effort that had to go into the production of such findings. It looks simple on the surface. How many months did the whole project take, Dean Benson?

Dr. BENSON. Well, the actual project, the real work on this began in September of 1963, so we have been about $3\frac{1}{2}$ years at it now, I guess. It was about 2 years from the time we started the project until the first signs were installed on the Texas highway system, which from past experience is a very short time.

Ordinarily you cannot go from an idea to practice in that period of time. So really in some respects this idea has been picked up faster than lots of other ideas.

Mr. BLATNIK. You say "picked up," Dean. Is that the State of Texas? Have all the other States who participated in this research—are they utilizing the findings?

Dr. BENSON. Mr. Chairman, I do not know what the situation is in the rest of the country.

Mr. BLATNIK. Counsel, do you have information later on, Bureau of Public Roads?

Mr. W. MAY. It is of interest, Mr. Chairman, Texas installed their first breakaway sign support in September of 1965. Last week we had an analysis of nine brand new State projects from various regions of the country and on only one project did John Constandy and Mr. Prisk find a breakaway sign. So on eight of the projects in various regions of the country, brand new, no breakaway sign.

Mr. BLATNIK. Brand new—you are talking of the time span of a year to 8 months.

Mr. W. MAY. Opened in the last part of 1966 and some in 1967, representing the latest thinking. It is just not being used. We rode over 700 miles from here before we found a breakaway sign support.

Dr. KEESE. Mr. Chairman, it might be appropriate to comment at this time, and I would like to dwell on it in more detail later, that today's traffic facilities are becoming so complex that it is necessary to bring together disciplines of technology that were formerly not associated with the highway development program.

The implementation of research, I feel, depends a great deal on the mutual respect and understanding of the people and the disciplines involved, and I feel that the success in this project, both with the Texas work done with the other 13 States and the District of Columbia, was due to bringing together the operating engineers and the research team, to bring about this mutual respect and understanding between the various discipline groups involved in seeking out the solution.

Mr. W. MAY. What discipline group?

Dr. KEESE. Structures, and traffic, and maintenance, and computers, and scientists, and mathematicians, and economists, I do not know whether I can list the whole array of them. There are quite a number of different disciplines involved, and there is specialization within the disciplines.

Mr. W. MAY. How are we working toward that end right now?

Dr. KEESE. We are working on this cooperative research with the Texas Highway Department and with this other group through these advisory committees, which bring together these representatives of these discipline groups, from the highway profession along with the research group. Through their advice and counsel, by keeping our heads out of the clouds and our feet on the ground, and through our exchange of conversation and technology with them, I think both parties benefit a great deal.

Now they pick these up, and implement them quite often; in the 29 projects that I mentioned we have done, I would say that practically everyone of those have been implemented before we were able to write a research report.

Mr. W. MAY. You must be disappointed when you leave Texas and ride some of the new highways around the country, especially on the Interstate System, and find rigid sign supports close by the shoulder of the road.

Dr. KEESE. I just wish we could find a way to disseminate this technology.

Mr. BLATNIK. You must be disappointed, you must be alarmed—your level of anxiety must be quite high as you flash by this lethal situation at 60 miles an hour.

Dr. KEESE. I think rather than disappointment, sir, you would call it challenge, challenge to find an answer.

Mr. BLATNIK. Mr. May.

Mr. W. MAY. What do we have next?

Dr. HIRSCH. Mr. Keese will come back a little later and give a little experience report from Texas on the breakaway signs.

At this time, I would like to turn the presentation over to Dr. Rowan, who is associate research engineer, associate professor of the driving research department.

Mr. BLATNIK. Dr. Rowan.

Dr. ROWAN. Thank you. Mr. Chairman, I would like to talk this morning on a specific research project dealing with highway illumination and lighting.

This research has been conducted in three specific areas. The first is concerned with the impact behavior of lighting poles.

This project was begun in 1964 as a cooperative project with the Texas Highway Department and the Bureau of Public Roads. And at this time I would like to restate or reemphasize something that Mr. Keese mentioned; that is, that research is most beneficial whenever it is conducted in a cooperative effort. In other words, an equally cooperative effort between the researcher and the people who will put the research to work in application.

In 1965, I suppose it was, the highway department was very much concerned about the hazards of lighting poles along our Interstate highways. At that time they were beginning to install lighting in the urban areas along these Interstate highways, and some very serious accidents had occurred and they were very much concerned over this. We included at that time—it was not an objective of the research, but there was included at that time a study of the state of the art of lighting poles.

In other words, what is the impact behavior of the poles that we can buy and put along our highways?

Following that, we did some—or we are currently engaged in some experimental research with a slip base lighting pole which is a take-off or a continuation from our breakaway sign support.

Now, we have a film this morning which is a series of excerpts from some of our test films. It is not narrated. I will provide the narration myself. But it will be developed further into a narrated film, with its purpose being to disseminate information concerning the impact behavior of lighting poles.

If I can have that film now, we will proceed.

(An untitled film was shown with Dr. Rowan providing the narration.)

This first scene is an installation which caused real concern. This is a steel transformer base, the red object under the pole is a steel transformer base weighing something on the order of 150 pounds. On top of it is a 40-foot steel pole which meets the current design standards of the Texas Highway Department. This is indeed a lethal object. It is nonyielding, is the best way to describe it.

When we get over these long scenes, we will see exactly what it can do to an automobile. I might mention, these are no longer installed in Texas on the State highways.

The penetration of the front of the automobile in this scene was approximately 3 feet. This pushed the engine back up into the driver's lap or within the front seat. The seat mountings were broken, the steering wheel was pushed up near the top of the automobile.

This is a high-speed film shot at 1,000 pictures per second. The clock is turning at 30 revolutions per second. That will give you some idea of the speed. The speed of the vehicle was between 35 and 40 miles per hour.

This would indicate falsity of the normal assumption that speeds on an urban street are safe. At 35 miles per hour, I think this is a good indication that there is considerable hazard in fixed objects in urban areas where your speeds are lower.

I would like to emphasize that point, that we have problems in urban areas the same as we do on highways where our speed limits are on the order of 60 to 70. It is not an isolated problems by any means.

This, gentlemen, is a light base that is now included as a standard design in the State of Texas on Interstate highways. This is a cast aluminum base. It weighs approximately 50 pounds.

We have the same steel pole atop this base. Here you will see a compact vehicle weighing 2,100 pounds striking the pole at 45 miles per hour, and with good results.

This vehicle traveled some 300 to 400 feet beyond the pole and finally became entangled in a fence.

The speed reduction was something on the order of 1 to 3 miles per hour. Now, note whenever the vehicle strikes, you will see the base break diagonally. It functions in two ways. You get, on one side, a breakage due to the frangible nature of this cast aluminum. Then on the other side of the base you get the slip action which we have in our sign supports.

When the pole comes down, you will note that the top of the pole lands approximately at the foundation. The pole itself goes in the direction of the automobile.

Now, this should allay fears that I have heard expressed by highway engineers that this pole may fall in the traffic stream and create another hazard.

But our experience has been that the pole stays in the same region and goes in the same direction as the automobile.

So the only time that you would have a pole falling back into the roadway is when a vehicle has left the roadway and is coming back on and strikes the lighting pole.

Another thing that I would like to point out, Which is the lesser of two evils, when you have a pole tumbling about that a vehicle can strike or have a vehicle strike a fixed object? If it strikes a fixed object, there is no doubt as to what is going to happen. When a pole is loose, there may not even be a vehicle there. If there is, at least he is hitting an object that is movable.

Now, this is a test of remedial design. I guess that is the best way to describe it. This is the steel transformer base we saw earlier. And the highway department was interested in something that would improve the safety aspects of this design.

They designed a cast aluminum insert to go under this steel base. Now this particular base weight is about 120 pounds. The cast aluminum insert here is 6 inches in height. It is placed under a pole which is 30 feet in height. And as I will show, these have been installed in two installations in Texas.

This is to modify existing installations. Due to the mass of the base, we get more penetration in front of the automobile, but it is not really too serious. We have had three accidents with this design, and all of them have been satisfactory.

(At this point Mr. Wright assumed the chair.)

Dr. ROWAN. Now, this is an aluminum pole and is in what we call a flange mounting. The flange on the bottom of the pole is bolted directly to the concrete foundation.

Now, I would like to express an opinion, my opinion. I was led to believe and many other engineers have been led to believe that an aluminum pole, because of its flexible characteristic, is safe. But I would not personally volunteer to ride in this vehicle that is about to strike the pole. Now, that is my opinion. There is too much rigidity. The action depends on one tearing the pole loose from the flange or breaking the flange. This requires an excessive amount of impact energy and this energy can be transmitted to the driver and in such a case it could be fairly serious.

We have by no means shown all of our tests in this film. We have conducted tests of the steel pole in a flange mounting which is serious. It is not quite as serious as the steel transformer base, yet it does pose a problem, a serious problem.

We have also conducted both the steel pole and the aluminum pole on cast aluminum bases. Both of them perform satisfactorily. The difference in them is merely cost. The aluminum pole will cost more than a steel pole.

That was an aerial shot of the aluminum pole we saw just a moment ago, but back to the comparison of these the most desirable design that we have found is the cast aluminum base, and it is incidental as to whether you put a steel pole on it or aluminum pole on it, from an impact standpoint.

Mr. W. MAX. It is a transformer base, is it?

Dr. ROWAN. It is a transformer base, and I would like to mention this fact that we no longer put transformers for lighting in this base. This is strictly a safety feature. Nowadays a transformer is put in the aluminum housing.

Now this is our experimental design of a slip base. It is similar to the sign support except it is in a triangular shape, a round base, but the bolts create a triangular shape.

The deceleration here was negligible, something on the order of 1 mile per hour. Now the reason for this triangular shape is to make the pole multidirectional in behavior. In other words, you can hit this pole from any direction and it will perform essentially the same.

Now, gentlemen, consider this is a 400-pound pole being put into motion by this vehicle with very little penetration of the energy absorbing portions of the automobile, and with virtually no effect on the driver. If you will notice the date, this test was conducted May 10. This was the second of a series of tests. This has not been put into practice yet. We do expect to prepare a researcher's report on the results of this design, and it will be presented to the sponsoring agencies by September 1 of this year. The reason the trunk lid is up is not the result of a crash but we have our instrumentation devices in the trunk, and they were removing them at the time when this picture was made.

This is a film strip obtained from a television station in San Antonio. A lady was reportedly crowded off the road, went into a skid, and hit a steel transformer base, the first crash that you saw, sideways. It is completely locked, as you can see. They are having to pull it off the pole, force it off in order to get her out. She was killed. This is one of several such instances. No more than 2 months ago, two people were killed in Dallas in a similar accident in which they skidded sideways into a pole on a steel transformer base.

I would like to commend the Texas Highway Department in their efforts to improve the safety as related to lighting poles along their highways. They make every effort to influence design, to establish standards, to make this changeover as rapidly as possible. Two weeks ago I was in the Beaumont district down in southeast Texas. I observed that they were cleaning out several hundred poles from a flange mounting base to the cast aluminum transformer base. This was 2 weeks ago. By now they do not have a pole on a state highway which is not a breakaway type.

Also last September the highway district in the Austin-San Antonio area installed these cast aluminum inserts under steel transformer bases, some 300 of them, in the San Marcos area; and on Ranch Road 1 near Johnson City.

Mr. W. MAY. How long did it take to convert the pole into a breakaway type pole?

Dr. ROWAN. Approximately 20 minutes with a crew of five men.

Mr. W. MAY. How much money?

Dr. ROWAN. Within \$35. The cost of the insert was \$19, I think, and 20 minutes of labor for five men and a lift truck. Now I have some slides on that. I would like to show you their procedure, if I may.

Mr. W. MAY. You were talking about San Marcos?

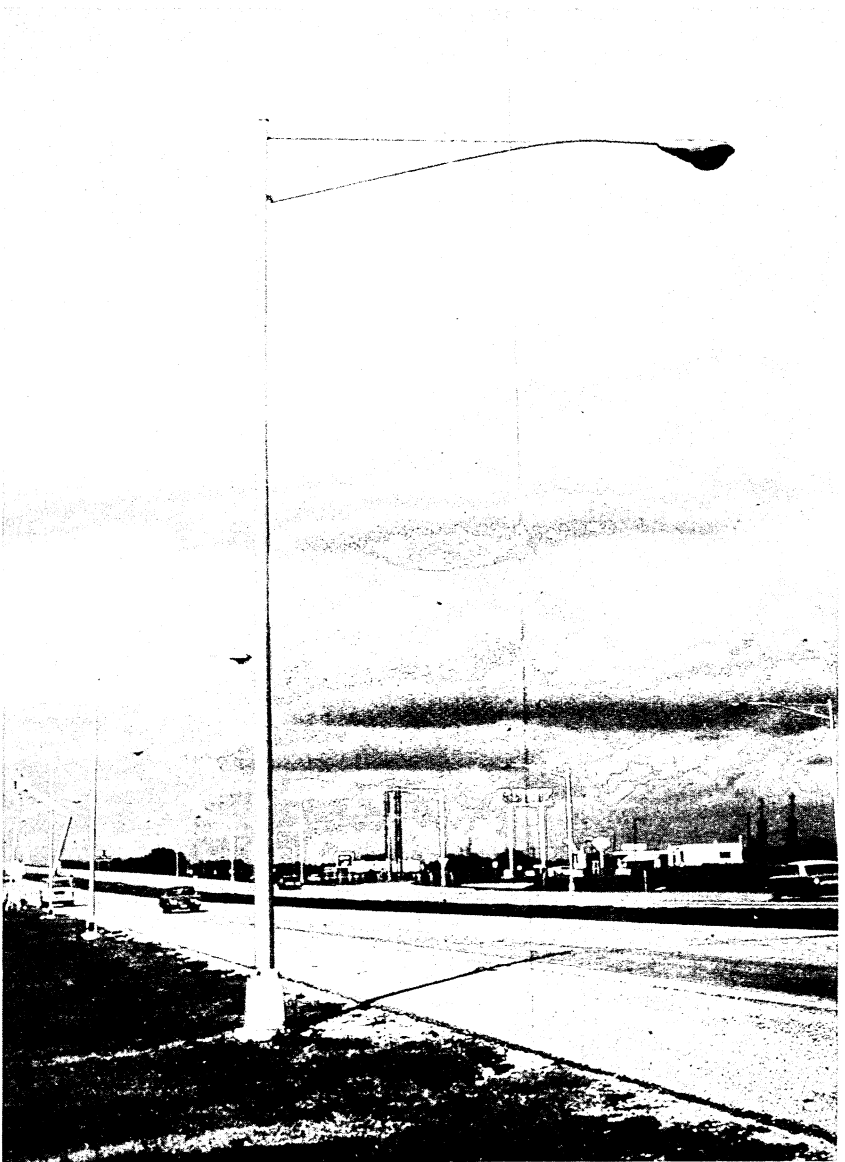
Dr. ROWAN. San Marcos and Ranch Road 1. Now, this is a remedial design, I would like to point that out. It is considered only as a remedial design where you have existing steel transformer bases. This is

not new design. In new design they are using the cast aluminum base which is better.

Mr. MAY. To convert the pole to the steel transformer base of the breakaway type, you pick the pole up with a cherry picker and reset it in the other type base?

Dr. ROWAN. Yes, sir, I have about five or six slides here that will illustrate the procedure and how they did it.

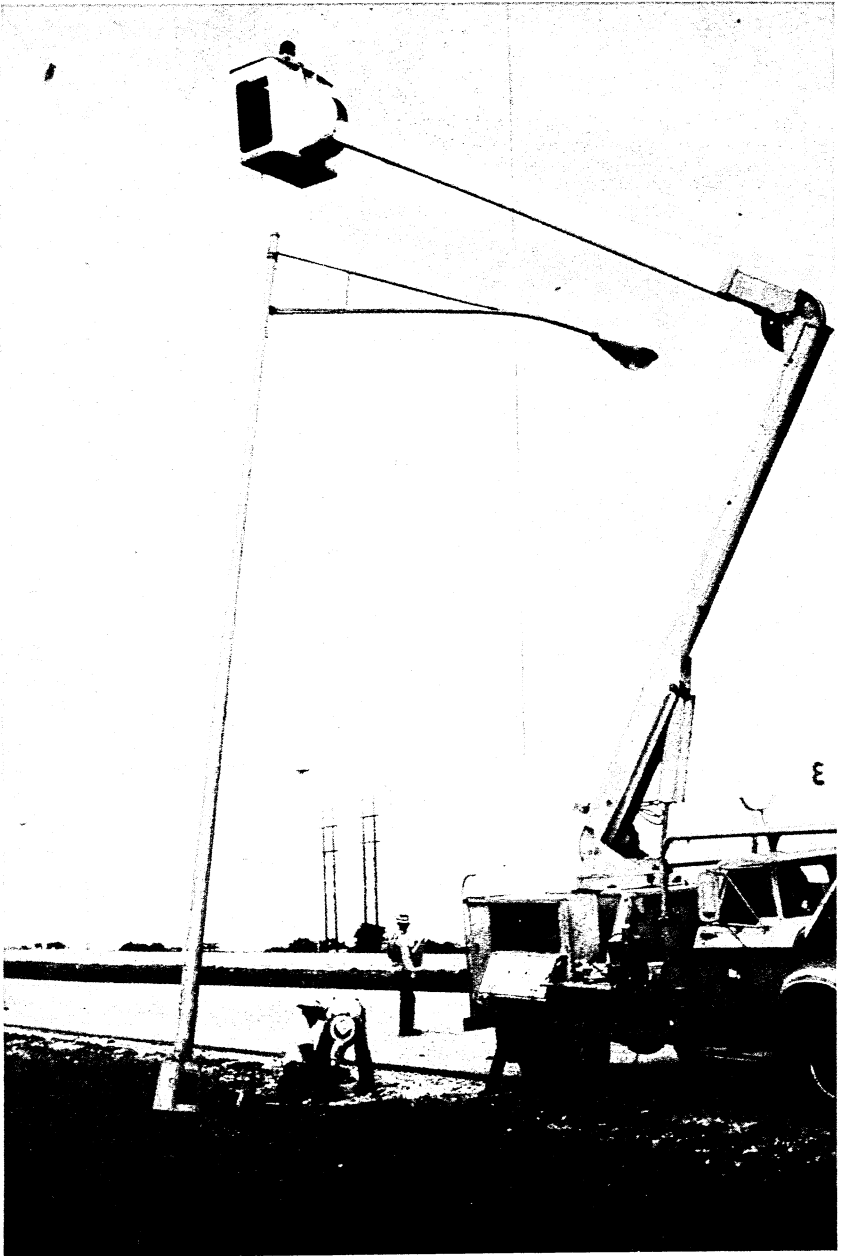
There is the pole before modification, the steel transformer base and a 30-foot pole. They are spaced about 150 feet apart, so you can appreciate the continuous hazard.



Dr. ROWAN. Here is a closer view of it showing the concrete and steel connection.



Dr. ROWAN. Here is the cherry picker lifting the pole from the foundation.



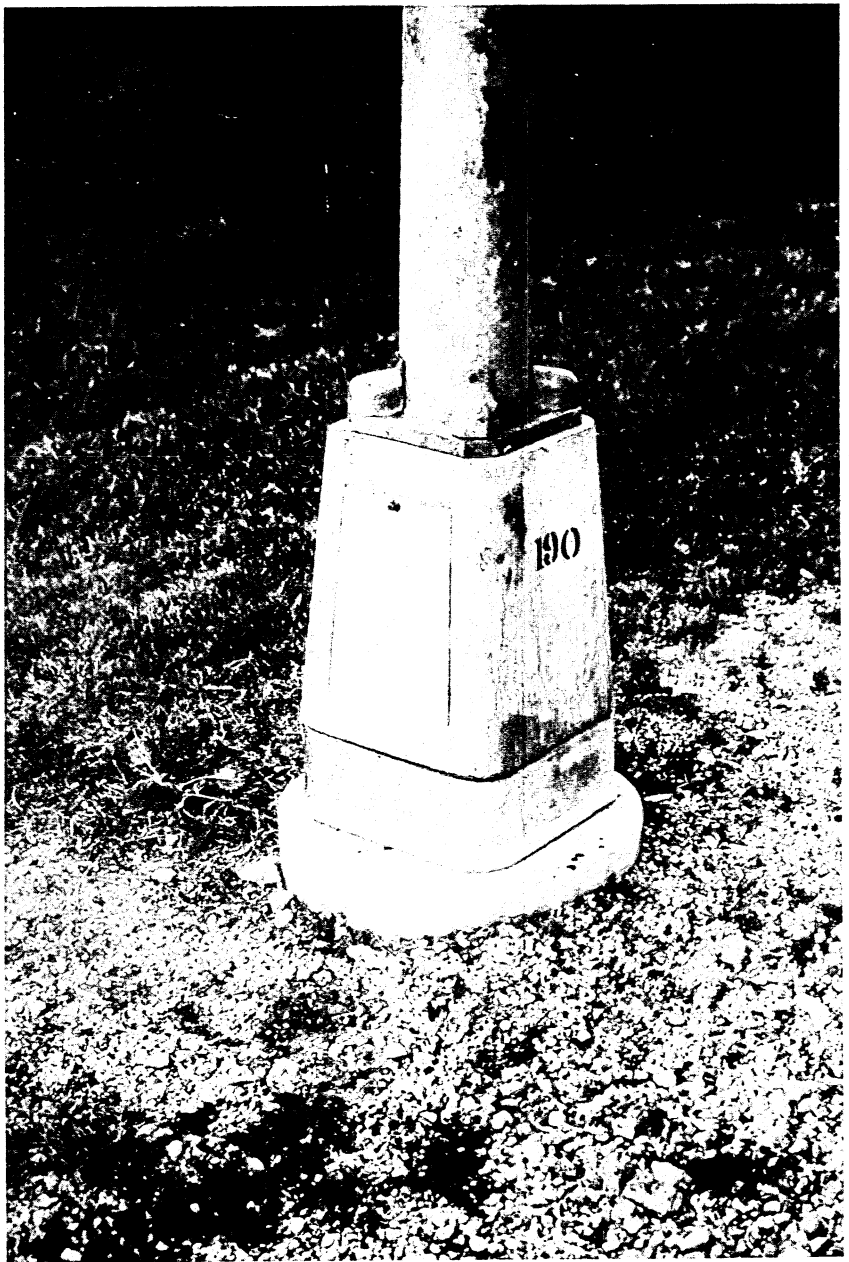
Dr. ROWAN. Here the men are installing the insert, bolting it down to the foundation.



Dr. ROWAN. Here it is being set on top of the insert and the bolts laying at the side will be used to connect the two together.



Dr. ROWAN. Here is the finished product.

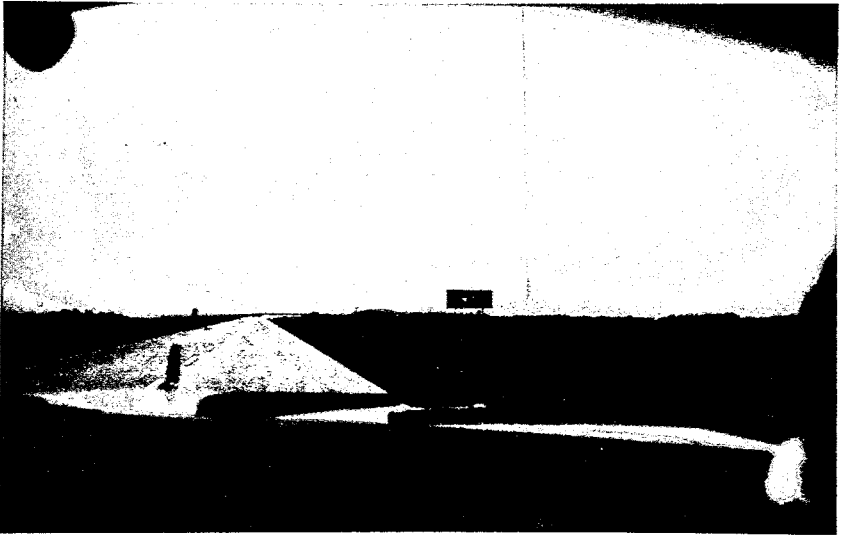


Dr. ROWAN. Then a view off from some distance, showing that it is practically the same as it was except it is 6 inches higher and now it is safe.



There have have been three accidents. One of them was a Volkswagen that brushed the side of one of these and knocked it over. In one of them, the people were hurt seriously. They had gone on through, rolled over down an embankment, and their injury was due to the roll rather than striking the pole, because the area in which the vehicle struck—the area the vehicle had struck the pole would not indicate any major severity. The other one was a truck, and it has been satisfactory.

This picture was made on a recent trip to South Dakota. They have installed a number of signs, 55 feet from the edge of the roadway. Gentlemen, in this dimension that we are dealing with, 55 feet is fairly small. There is something else about the characteristics of the roadway.



Mr. MAY. This points up the fact we should not worship that 30 feet?

Dr. ROWAN. We should not worship any particular dimension. Let us not permit anything become holy on this. There are many things that enter into this problem. For instance, here we have a continuous down slope over to that sign. This would naturally pull the vehicle in that direction. It would take a concerted effort to redirect it. My only comment at this point is why should we consider a philosophy, that it is all right to install a fixed object at a greater distance from the roadway when we can install a safe object at that distance?

Mr. MAY. Yes. Why should we plant a tree 31 feet from the roadway instead of 30 feet?

Dr. ROWAN. That is right. There is nothing sacred about any particular distance. The happenings in an accident are so complex that no two can be depended upon to be the same. Anything can happen when a vehicle goes out of control. The only thing is, we should be real careful about our fixed figures and criteria for design. There is nothing that will surpass good commonsense and engineering judgment.

Now I would like to move on very briefly in the interest of time and talk just briefly about our lighting program. The remaining portions of our lighting research have two phases. First is continuous lighting; that is, lighting along our Interstate facilities so that you have a continuously lighted area. The Texas Highway Department was much concerned a few years ago over the existing standards for lighting. They felt that they were insufficient, so we entered into this research to arrive at a satisfactory and safe nighttime driving environment. The first phase was to investigate and to develop criteria for a more functional and economical lighting design.

(Mr. Blatnik assumed the chair.)

Dr. ROWAN. This research resulted in increasing the mounting heights of luminaires from 30 to 40 feet and in some cases to 50 feet, where we used 1,000-watt luminaires. This was a new innovation, the use of higher intensity sources to provide better lighting.

Now the result of increasing this mounting height was to obtain better uniformity of light distribution—you know, the better the uniformity, the less work the eye has to do.

A second feature that was improved was reduction of glare. Reduction of glare improves visibility.

The third was to increase the longitudinal spacing between these poles mainly in the interest of safety, but a byproduct was economy; a reduction in the cost.

There have been several installations of this new design. Incidentally, Texas adopted our research findings as standard design for illumination. Several of these have been installed and already they feel that they have paid for the research several fold.

Mr. MAY. How high are the poles?

Dr. ROWAN. For a 400-watt luminaire, it is 40 feet. For a 1,000-watt luminaire, it is 50 feet; or 60 feet where maintenance can service them.

Mr. MAY. And those poles can also be breakaway types?

Dr. ROWAN. Yes, sir; you saw in the film 40-foot poles. Well, the addition of 10 more is incidental.

Mr. MAY. Thank you.

Dr. ROWAN. Now the third phase of lighting deals with the lighting of interchanges. One of the big problems in lighting interchanges, where you have several turning roadways, is the number of poles—I will put it as “the forest of poles” in order to light them in the conventional manner. This represents an unsafe condition, so what we are currently working with is a concept by which we can create a panoramic view in our interchange area, one which closely approximates that of daylight driving conditions. If the driver can see the entire interchange area, he can make his decisions in a systematic and orderly manner and will naturally conduct his driving in a safer manner.

Now, the way that we are attempting to obtain this driving environment is by fewer poles, and from 100 to 150 feet in height, each supporting a cluster of floodlights. They will light the area in low intensity condition, but the driver will be able to see the entire interchange in an approach. We have facilities for mounting these, and are studying the photometrics and so on. There are four experimental installations that are now in the design stage. These will be completed

and installed within a year; one at San Antonio, Tex.; one at Texarkana, Tex.; one at Sioux Falls, S. Dak.; and one at Rapid City, S. Dak. This will permit us to make a positive evaluation of the relative merits of this design.

Our overall objective in this research, as I say, is to develop sound criteria for a safe and satisfactory nighttime driving environment. Thank you.

Mr. MAY. Thank you. Dr. Keese?

Mr. Chairman, if I may have the other group of slides there. With the cooperation of the Texas Highway Department, we have been attempting to document all of the crashes with the breakaway sign supports and breakaway luminaire supports, and are now attempting to do the same thing with the various States involved in this larger project.

Just to start out, I have shown a slide here of a typical nonbreakaway type support.



This is a second view of the same accident.



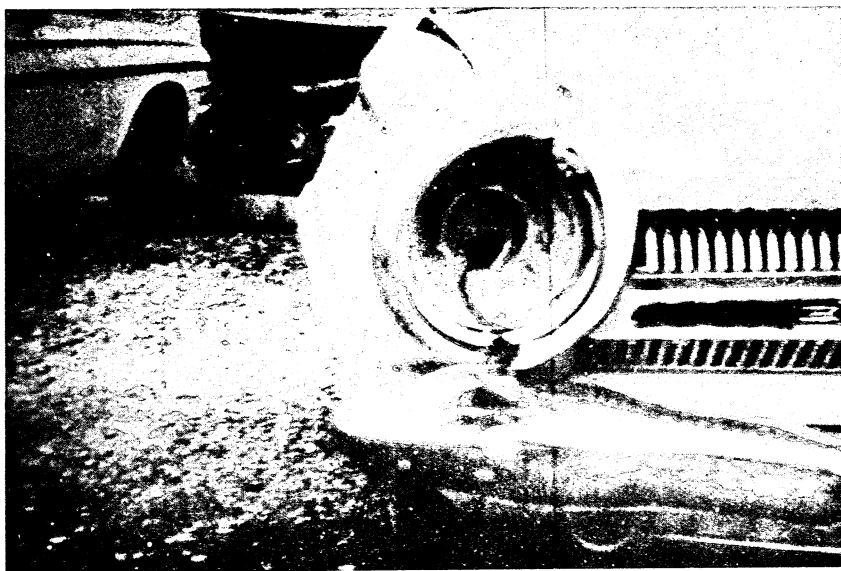
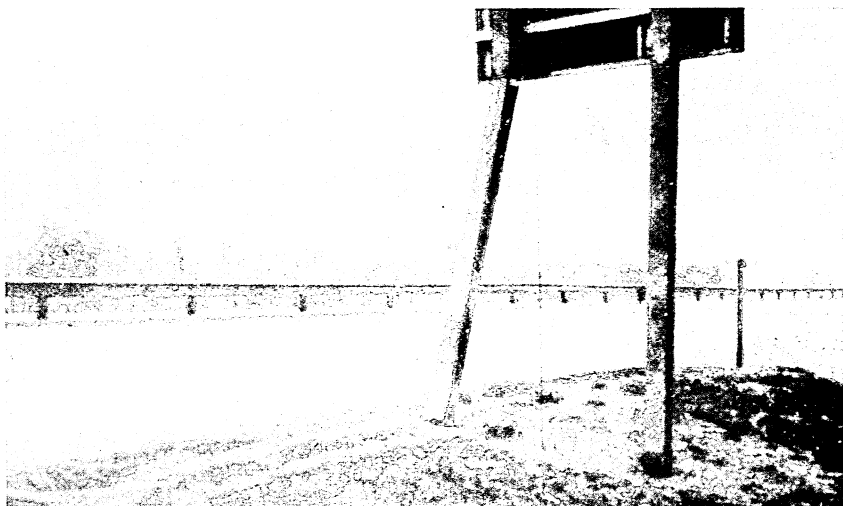
Dr. KEESE. This is a third one. This one has only one person in it, I believe, and of course resulted in a fatality. I think you have seen enough of these.



This is a typical sign of the type hit there.



This happens to be a picture of the first sign that was hit after they started installation of these along the highway, and it just happens that this particular sign was put in or the installation was completed at 5 o'clock one afternoon. The driver struck this sign at 6:30 the next morning, and this is a picture or view of the front of the vehicle after impact.



Dr. KEESE. The Texas Highway Department contacted this individual and asked him what the effect of hitting the sign was, and he replied it was about like hitting a chuckhole in the road. He also said:

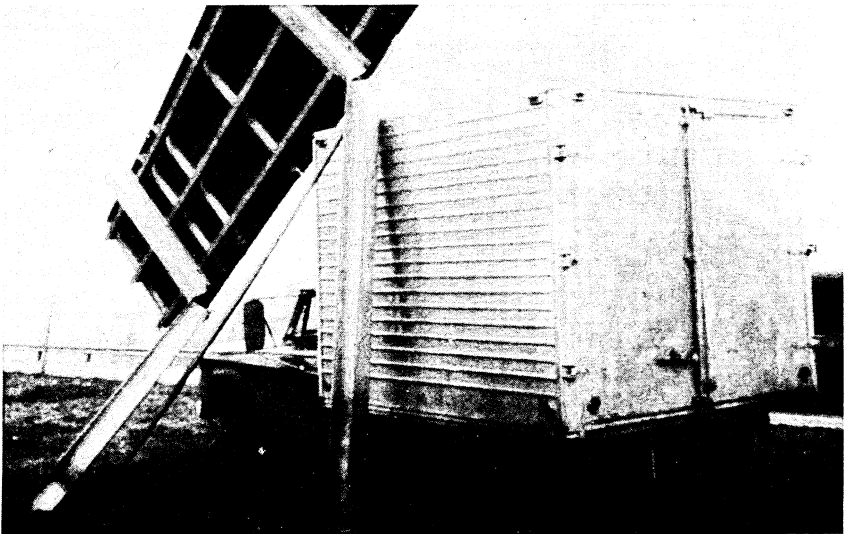
Many thanks for the new sign. If it had been one of the old type, we undoubtedly would have gone through the windshield or turned over. As it was, no injury resulted to my self or friend.

The automobile received only \$500 damage, and by the way, most of this was caused by hitting a 2-inch pipe in a secondary collision.

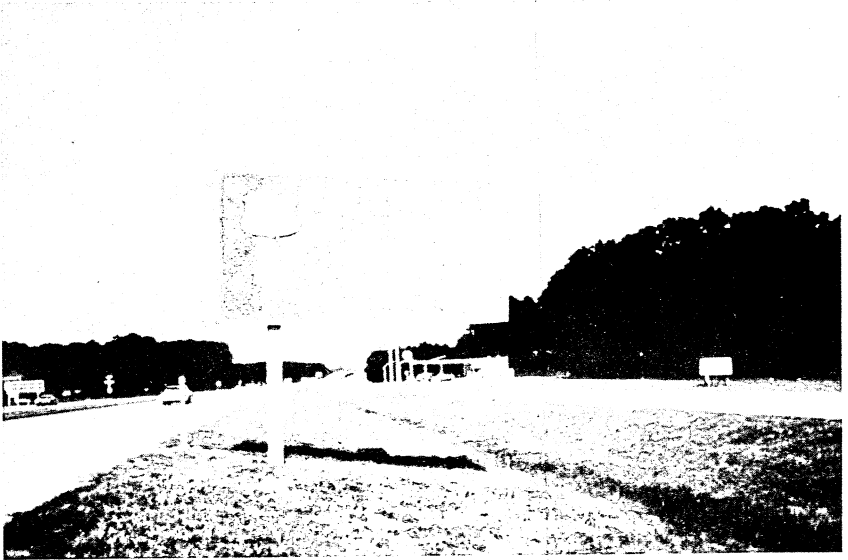
This is a sign that was impacted in a hit-and-run accident. You will note that the angle of departure from the roadway to the sign caused it to strike the outside leg of the support.



This is an accident showing the inside leg of the support struck by a truck. This particular driver went to sleep. There were no injuries or injury, type C. This was "no visible sign of injury," but there was complaint of pain. One hundred and fifty dollars' damage to the truck, \$125 damage to the sign.



This is another picture of an outside post being hit. The driver went to sleep, and I might point out that that post is approximately 25 feet from the edge of the travelway. At that point I might read, if I may, from some of the accident reports. We now have 69 of them documented.



Accident No. 69, the last one we documented, says—

The vehicle left the road 425 feet in advance of the sign, struck the support and returned to the pavement 150 feet beyond the sign.

There was no report of the accident. The maintenance people found the sign in a damaged condition and repaired it.

No. 59—

Leaving the roadway, the vehicle struck the right support at a 15° to 20° angle. Tracks continued diagonally across the ditch and onto the frontage road.

No. 58—

The vehicle was returning to the roadway at a 15° to 20° angle and struck the left support of the sign.

Here is another where the sign was struck at a 29° angle.



One item of interest might be that in accident No. 45, the vehicle struck the right support of a heavy roadside sign similar to this one, at 70 miles an hour, proceeded up an embankment, and diagonally across the frontage road, through a ditch, and through a fence, striking and shearing two braced corner posts 8 to 10 inches in diameter. The sign was hit at 8:45 p.m., repaired by noon.

We could go on and on through the 69 signs of various types along the road.

These have been hit from every conceivable angle practically and they have been caused by skidding on wet pavement, or skidding because of something on the pavement, such as a rock, or the driver going to sleep. In one case the driver was drunk. In another, the vehicle out of control. In another, skidding on dry pavement. Also, missing a sharp curve. Skidding while passing. And secondary collisions, or having been in collision with another vehicle first.

Mr. MAY. Dr. Keese, if a vehicle struck a breakaway sign at a 90° angle, it probably would not break away too easily; would it?

Dr. KEESE. The sign would not function as it was designed; that is correct.

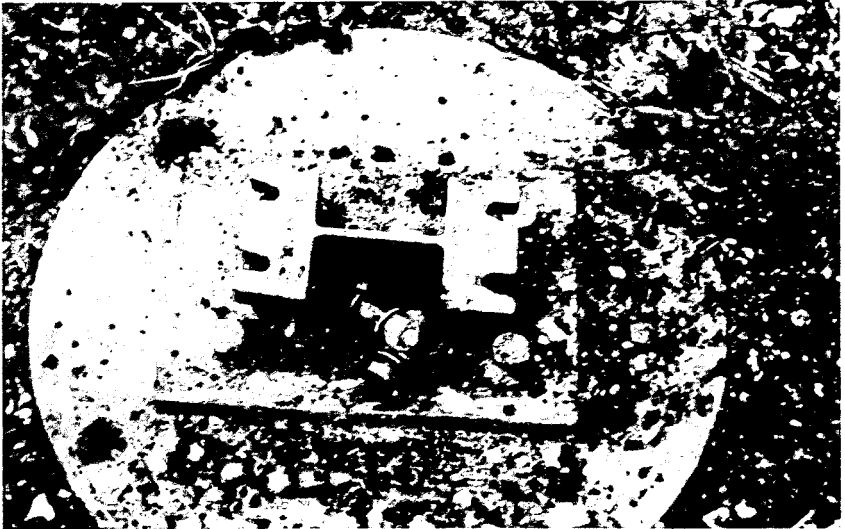
Mr. MAY. But experience shows that a very remote possibility—

Dr. KEESE. Because of the weakness created by bolting this thing down, and we are now looking at the possibility of using the triangular or circular support similar to the one developed for the luminaires. We were of the opinion it was almost impossible for a vehicle to hit these things at right angle, going down the roadway longitudinally. We find this is not the case. In a skidding accident, they hit over against the median and come back across the roadway, and in some cases go off an embankment and hit a sign.

Mr. MAY. Have there been cases of people backing into these?

Dr. KEESE. They have hit them at every angle you can think of. They have sideswiped them, backed into them, front quarter, back quarter, every other way. In one instance, a woman with two children in the car sideswiped, knocked both supports out from under it, and there was no injury. Minor damage to the vehicle.

This is a typical base of the breakaway type of sign. I put it in here to show and emphasize 52 percent, over half the accidents in the 69 cases we have documented, have not been reported as accidents. The maintenance people go out and find these signs and supports in this condition, pull the sign back into place, rebolt it, and the sign is back in business.



Mr. MAY. Do you find you have more hits in the gore areas than at other locations?

Dr. KEESE. The gore area exit signs have been hit in slightly less than half the cases, 31 out of 69 cases; the exit ramp areas, I would say by and large, are the scenes of the majority of cases. However, there have been some 18 typical roadside signs away from any intersection or anything like that, and several others such as speed signs, warning signs, city limit signs, and things like that not associated with a decision point at all.

Mr. BLATNIK. May I ask one question? I notice your circular concrete base is flush with the ground level. For years a similar type of support in concrete bases in many instances was quite a bit above the ground, 2 feet above the ground. Is there any conceivable reason for raising a concrete structure or base like that any distance at all above the ground? Does it improve the strength or what does it do?

Dr. KEESE. The reason for it, I think, sir, was to prevent corrosion of the metal, to prevent the soil and so forth from coming into con-

tact with the base of the sign and causing corrosion, I think, is the principal reason for that.

Mr. BLATNIK. Am I correct, counsel, that some of these concrete bases are at least 2 feet above the ground?

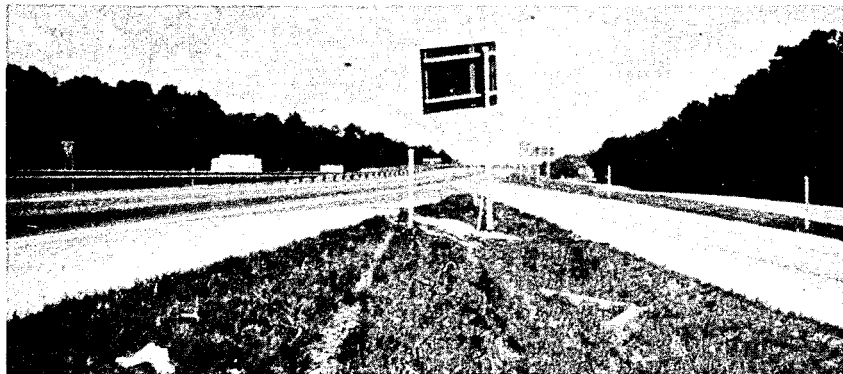
Mr. MAY. More than that, Mr. Chairman.

Mr. BLATNIK. The installation was made in order to have the metal parts above ground level to avoid corrosion?

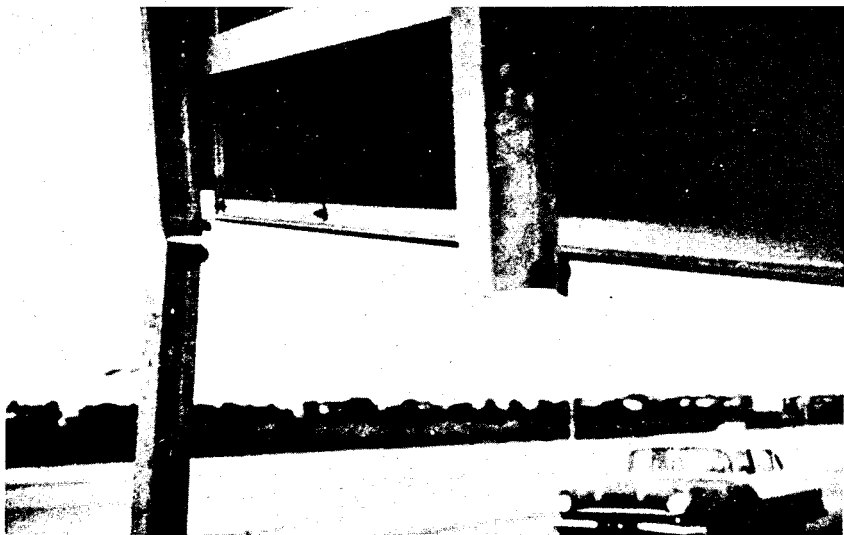
Dr. KEESE. With the galvanized metal I do not believe we have a corrosion problem. It might be of interest, sir, if you like, I have a few slides showing the conversion where the Texas Highway Department has gone back and reduced the level of these concrete bases to ground level, before they put on these breakaway devices.

Mr. BLATNIK. Please proceed. I did not mean to interrupt you too long.

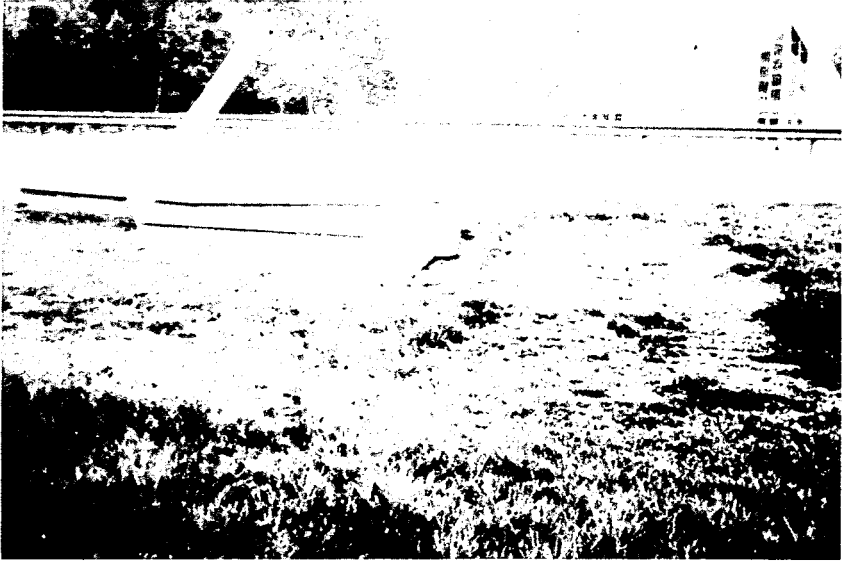
Dr. KEESE. This is a typical sign that was hit. In this particular case, the sign worked properly so far as protection of the precious cargo of the vehicle is concerned, but the post broke loose and caused a little more damage to the sign.



In this particular case here again it broke in half, again no injury.



In this particular case it was knocked completely down. This has been experienced in several of them, particularly on the narrow two-post supports.



This shows the conversion of the base.



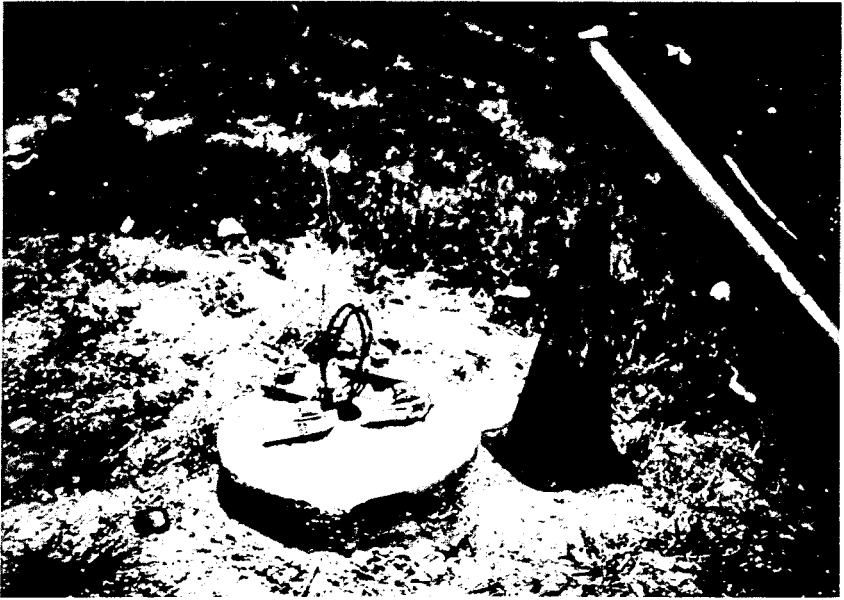
This begins a series of pictures of the breakaway luminaire that was struck by a vehicle; to compare the type of accident that you get here with that picture that Dr. Rowan showed a moment ago.



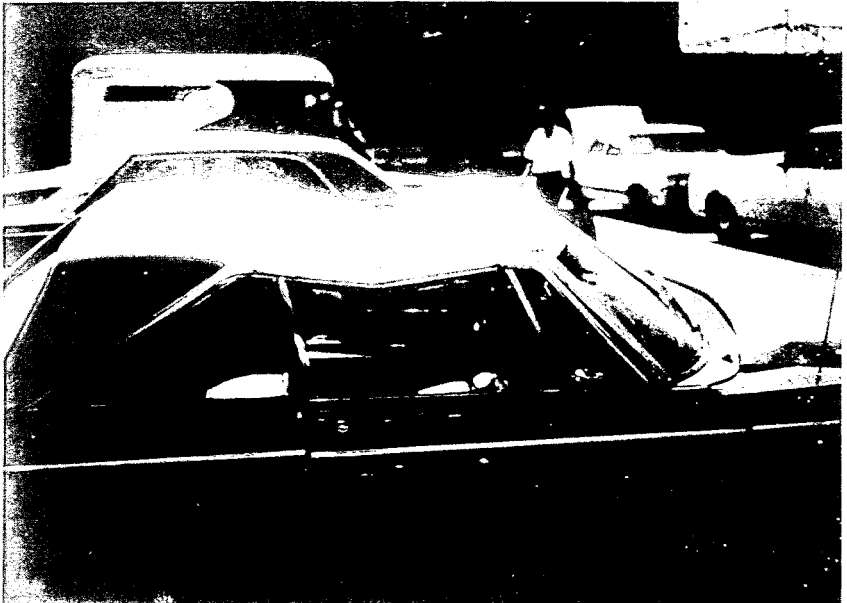
This is the frangible base that was shown.



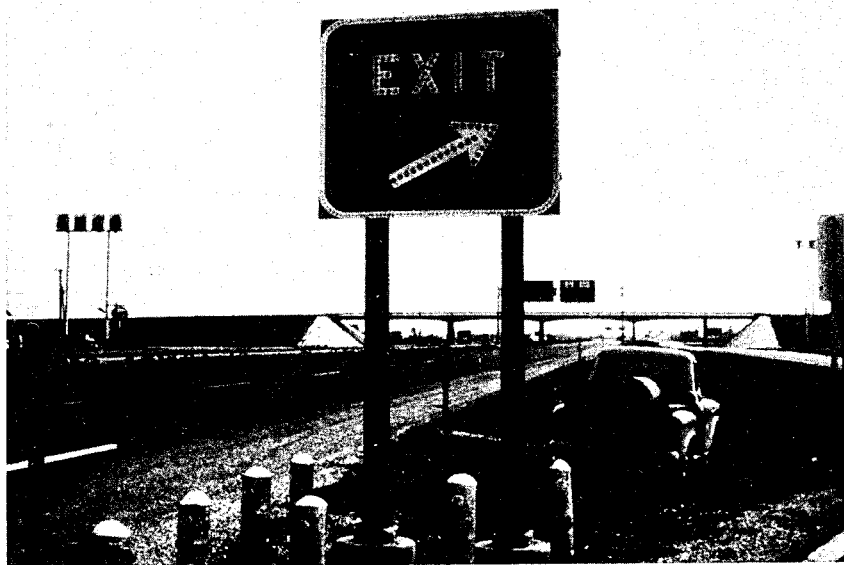
This is the base of the support.



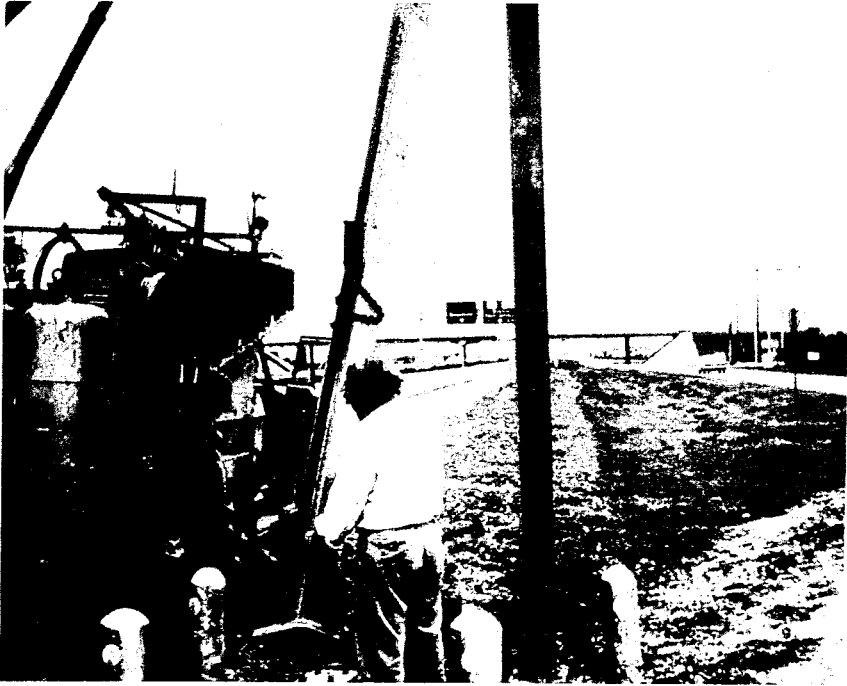
This vehicle hit the luminaire almost exactly the same way as the fatal accident that Dr. Rowan showed. It hit broadside and as you will notice, at such speed that the pole came over the top, but there was no injury to the occupants or the driver.



I have a series of slides showing the conversion of these.



The sign is removed, the post taken down.



And the concrete base lowered.



The sign is modified with the hinged joint—and the base is cut off of the post—and it is welded to the lowered base. He is welding it to what is left of the bolt sticking out of the concrete.



Then the sign is re-erected and bolted on the top of it. As I mentioned, I have a whole series of those but I do think these will suffice.

Mr. MAY. Do we have a problem with the large overhead bridge signs we have seen with real massive supports?



Dr. KEESE. Yes, sir, I think we definitely have a problem there. They must either be protected or made breakaway. We feel and have proposed that they be made breakaway, and we are hopeful of doing a project that will permit them to be designed in this manner. It is completely feasible to do this.

Mr. MAY. You end up with a series of supports?

Dr. KEESE. There are several different concepts that could be used. It would require multiple supports at the end, so that the entire end of the sign support would not be knocked out.

Dr. BENSON. Mr. Chairman, with regard to the question that you asked regarding projections from the ground up. By and large I think most of these, practically all of them, are unnecessary. In highway design it is my personal opinion that we should try to keep everything as nearly as we can, flush with the ground, and certainly not extend it more than an inch or two above it, so the vehicle always has a chance to pass over this without coming into collision with it.

I think there are many changes that could be made to eliminate some of the hazards that we have today, just by cleaning up our designs to provide that we do not have obstructions above the ground.

Mr. BLATNIK. I appreciate that comment because I never did get an answer to why those concrete foundation supports, those obstructions, should be left that far above the ground. Commonsense would indicate if it were needed, 2 inches would be sufficient to prevent cor-

rosion that might exist. As you indicated, you see no reason why, whatsoever.

Dr. KEESE. No, sir.

Mr. BLATNIK. Mr. May.

Mr. MAY. Mr. Chairman, we have here a list of research projects presently in progress at the institute and we will make this exhibit No. 16.

Mr. BLATNIK. Without objection, so ordered.

(Exhibit No. 16 is retained in subcommittee files.)

Dr. KEESE. Mr. Chairman, we have one other matter that we had planned to discuss very briefly, and this is a matter of attenuation devices. We have conducted a feasibility study on these attenuation devices.

Mr. MAY. Mr. Keese, will you proceed to describe that?

Dr. KEESE. I will ask Dr. Hirsch to describe that briefly, if he will.

Dr. HIRSCH. The area I want to cover is impact attenuation or energy absorbing barriers which can be placed around fixed obstacles.

Mr. BLATNIK. Just for the record, Doctor, and also for our benefit, what is a more precise definition of the word "attenuation"?

Dr. HIRSCH. Attenuation is an attempt to stop a speeding vehicle out of control, before it hits a rigid obstacle, and bring him to a controlled stop with controlled deceleration or gravity forces below the level which would result in injury or death or fatalities.

Mr. BLATNIK. That is important. Controlled deceleration, rather than the secondary point of impact?

Dr. HIRSCH. Right. That is right.

Mr. BLATNIK. They may have a wooden support or something frangible so a lesser impact might not cause as much damage as the more severe point of impact, such as rigid steel supports embedded in concrete?

Dr. HIRSCH. That is right. That is correct.

Mr. MAY. Are you going to use visual aids, Doctor?

Dr. HIRSCH. I have a few slides. Just to introduce this problem, though, we have talked about the breakaway sign concept and the breakaway light pole. There are other obstacles in the roadway such as bridge piers which are in the median, wing walls, bridge abutments, supports of large overhead sign bridges, utility poles of various types which still present a problem which at the present time we cannot solve with the breakaway concept.

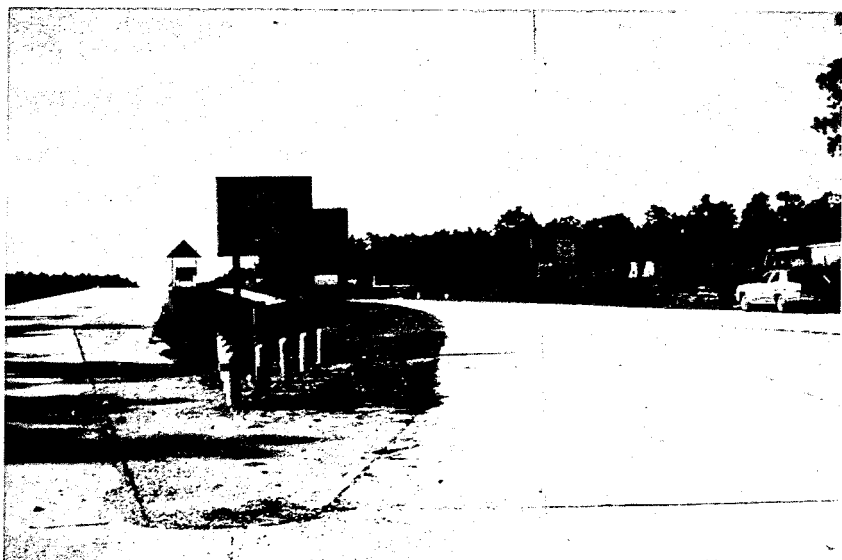
Some guardrail installations have been installed to protect these obstacles. In general, we feel that guardrails as presently designed and installed are not impact attenuators. They have the primary function of restraining the vehicle from leaving the roadway and to redirect it.

We conducted a feasibility study on the possibility of bringing these out-of-control vehicles to a controlled stop. In certain of these rigid obstacles, guardrail installations are placed around them, guardrails required to be 50, 75, or 100 feet long which in effect is enlarging the target and the probability that the vehicle will have an accident with the guardrail, probably much more frequently than if the guardrail had not been there at all, so in this line we have been looking at impact attenuation devices.

In this particular sign shown up there, there is a series of 3 posts, another row of 3 posts, and 2 posts. That is 8 posts. In effect, this is a form of impact attenuation device or energy absorbing barrier. In this particular case, however, these posts were not, I do not think, really designed, considering the kinetic energy of a vehicle. This particular system would probably stop, with satisfactory deceleration levels, a vehicle going 25 miles an hour and would probably be satisfactory in an urban area. However, when you get out on the highway and the vehicle speeds go up to 50, 60 miles per hours, 70 miles per hour, in effect the number of posts required there would have to go up in the order of 4 times. When you double the velocity, you quadruple the kinetic energy.



Dr. HIRSCH. This is another form of impact attenuation device which would probably work up to speeds of 25 miles per hour. Under a present contract we are working under with the Bureau of Public Roads, we are conducting tests and evaluations of various systems to bring out-of-control vehicles to a controlled stop, and incidentally,

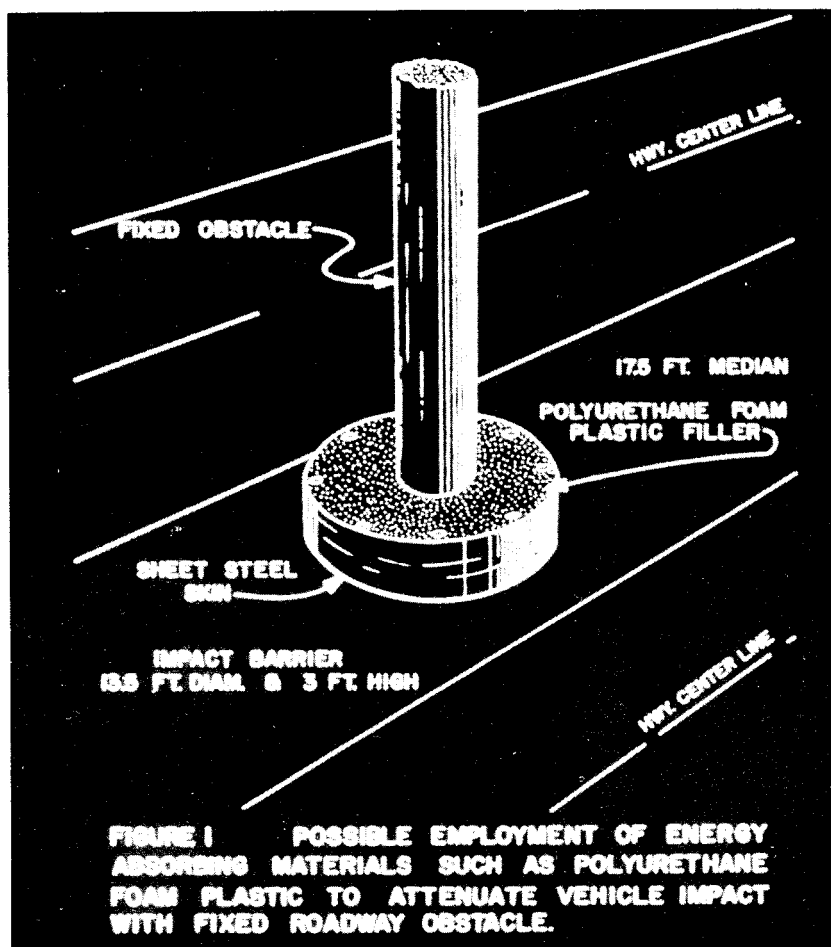


a vehicle going 60 miles per hour, a 4,000-pound vehicle has something over 400,000 foot pounds of kinetic energy. This vehicle can be brought to a stop in 12 feet of stopping distance with a decelerating force on the vehicle the equivalent of 10 g.

I use the figure 10 g. You have heard aviators and pilots going into a 9-g. dive. This means the weight of their bodies is the equivalent of 9 times the weight of ours, sitting in the chair. Colonel Stapp at Holloman Air Force Base has withstood deceleration levels up to 45 g. with no serious effect, so if you can control the magnitude of the deceleration force and the stopping distance, it is possible and feasible to bring a speeding vehicle to a controlled stop at a distance of 10 feet, even as low as 6 feet; if you stop him at 6 feet at 60 miles per hour, you will have 20 g.'s on the driver, which we believe at this time to be a fairly high level.

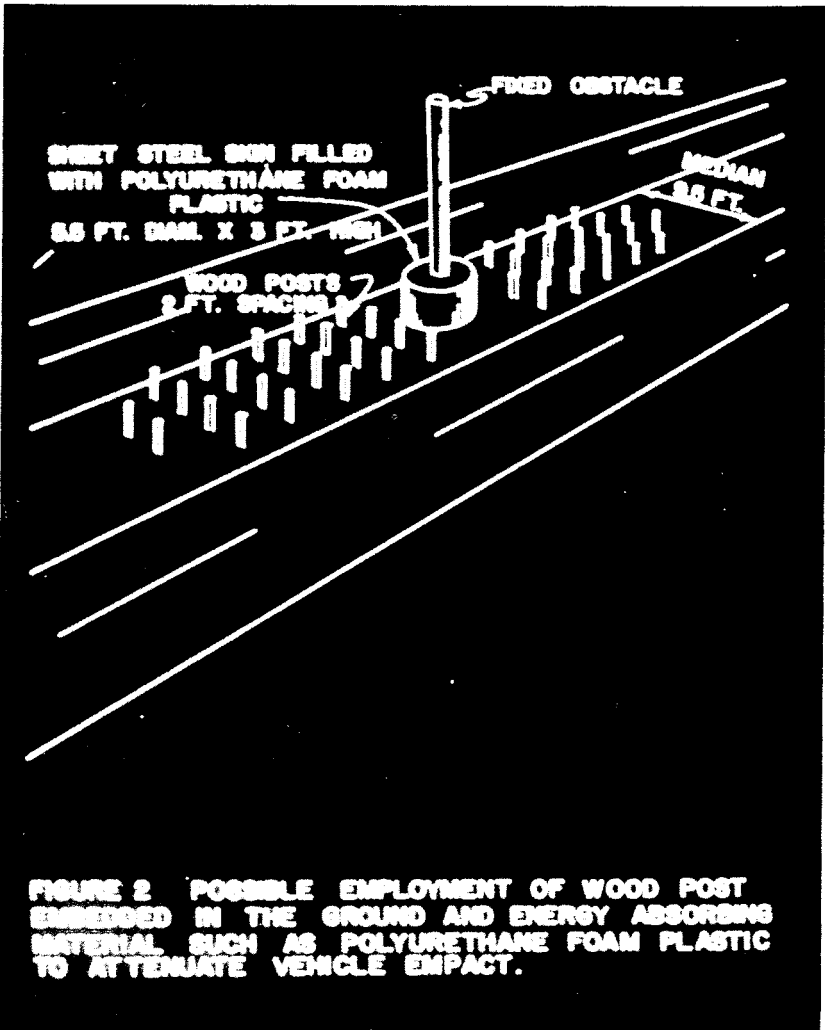
Mr. BLATNIK. It is high but it is tolerable?

Dr. HIRSCH. It is tolerable, if the driver is properly restrained by seatbelts in a safe automobile that is protected from secondary collisions with the windshield, dashboard, doorknobs and this sort of thing.



Dr. HIRSCH. This is a possible system which will be tested and evaluated. The rigid pole there is to represent a fixed obstacle and around such a system you could put in this case a polyurethane foam material, either materials of foam, plastic, foam glass which has a crush strength which you can control, and apply force through a distance which in effect is absorbing the kinetic energy of the vehicle.

Dr. HIRSCH. Another such system employs foam glass or polyurethane or foam plastic or other frangible materials which would be right adjacent to the post, or series of wooden posts, except much larger in number than what we had around the sign. Theoretically it calculates you need about 20 to 24 posts to stop a vehicle going 60 miles an hour, a 4,000-pound vehicle.



Dr. HIRSCH. This is an example of one called Platt's sand-filled can. Mr. Platt is an engineer with Ford Motor Co., who has devised a little can filled with sand to absorb energy of a vehicle on an urban street up to 20 to 25 miles an hour, preventing him from hitting a fixed obstacle and, as I understand, Mr. Platt has had several of these installed.

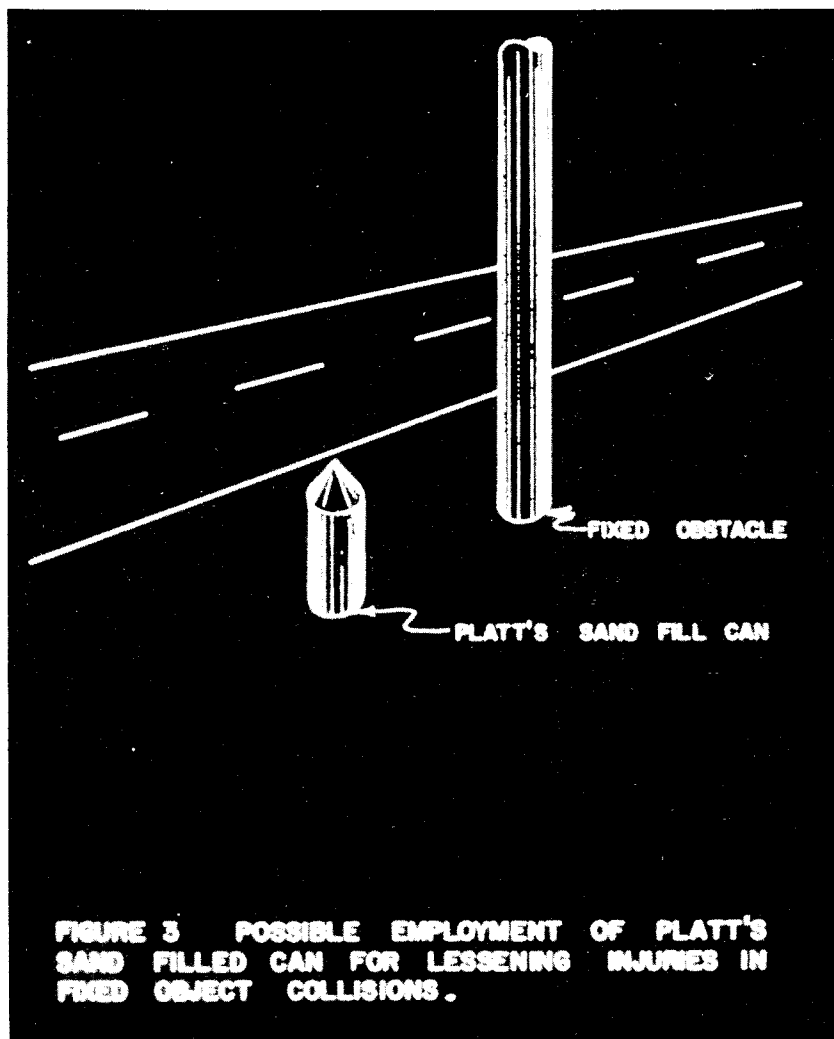
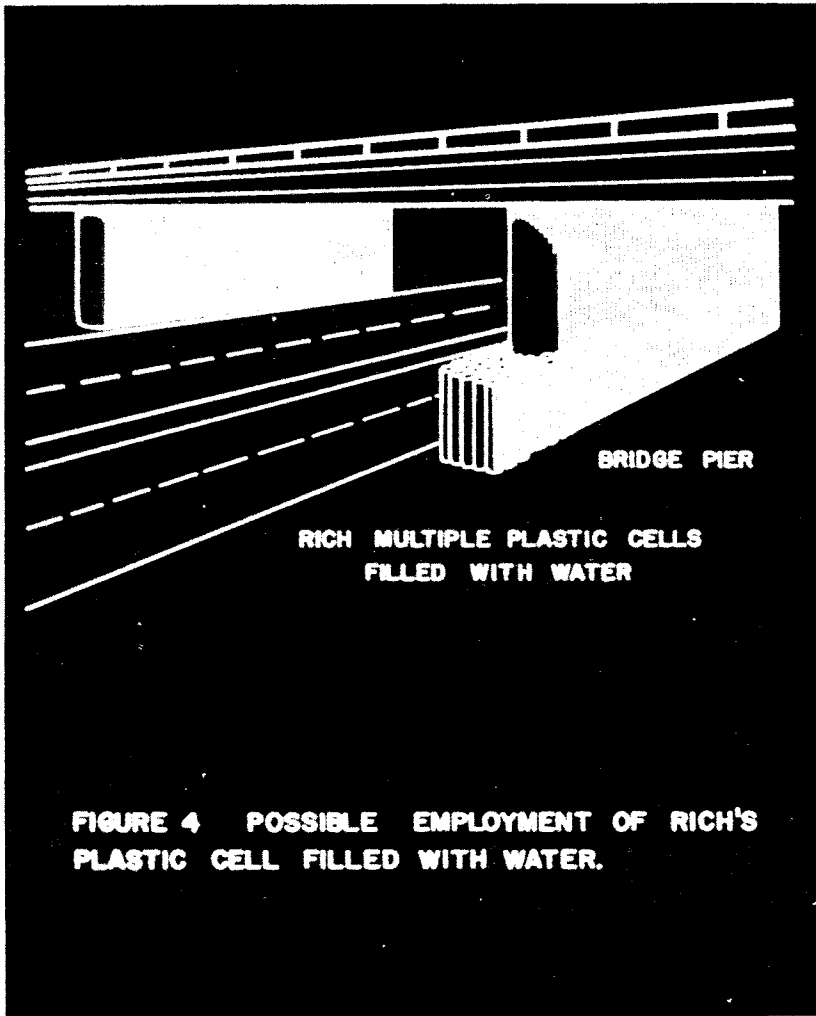


FIGURE 3 POSSIBLE EMPLOYMENT OF PLATT'S SAND FILLED CAN FOR LESSENING INJURIES IN FIXED OBJECT COLLISIONS.

Dr. HIRSCH. Another possible system developed by Rich of Sacramento, Calif., is a system of plastic cells 6 inches in diameter, about 3 feet high. The plastic cells are of wall thickness about a quarter-inch, are filled with water, and when the vehicle hits, it is like squeezing a tube of toothpaste or squeezing the water up in the air, which absorbs kinetic energy. Mr. Rich has tested the system up to 35 miles an hour in Sacramento and has installations in California which work satisfactorily.

The idea is, Can this concept be extended to 60 or 70 miles an hour? But just basically, we are working on this problem and will expect to test a number of the systems of the type illustrated on these slides this summer under contract with the Bureau of Public Roads and Department of Transportation.



Dr. BENSON. Mr. Chairman, that completes our presentation and if there are any other questions, we would be most pleased to try to answer them.

Mr. BLATNIK. An excellent presentation, Dean Benson. Thank you, all of you gentlemen, for the very orderly and concise manner in which you obviously gave a very thorough, representative sampling of the very intensive work you have done in this field. Mr. May, have you any questions on the presentation?

Mr. MAY. Mr. Chairman, I would like to express our appreciation to these gentlemen who have taken a lot of time over the past several months, and we would hope to maintain contact with them.

Thank you very much.

Mr. BLATNIK. Before you leave, Dean Benson, I am very interested in the joint cooperative effort between research institutions such as yours, Texas A. & M. University and Texas Transportation Institute, and operational agencies such as the Texas Highway Department and with the Federal Bureau of Public Roads.

The reason I raise that point is that apparently for years, day in and day out, over and over and over, all across the country, personnel in State highway departments themselves would see things happening. For instance, they would observe that certain signs were being hit much more frequently than others, but no one reported it, or perhaps it was reported and maybe it was not. At any rate, no one assessed or exaluated the situation as to why this was happening. The probabilities for impact were much higher, and since they were higher, even if they did not know why, in view of just the fact they knew the probability was very much higher, why was not something done about it?

We have seen that guardrails inadequately protected the driver from a concrete bridge abutment. After several accidents, some of which were fatal, the guardrails were reconstructed in exactly the same configuration as the original design called for. Someone was not learning.

Do you have any comment, any one of you gentlemen, from your experience? Obviously you have done much advanced work. What can or ought to be done to improve the lines of communication, which exist to some degree, and how do you go about creating them where they do not exist? How can you get your information, your knowledge out into the field and into practice and use?

Dr. KEESE. Well, Mr. Chairman, I would like to comment on that. I would like to preface my comments by the fact this year the Texas Highway Department will celebrate its 50th anniversary, and if you recall the progress that has been made in this 50 years, and the tremendous amount of demand that has been placed on them to keep up with the transportation facilities that are required for today's living, it is understandable that the responsibilities for the various parts of this system are going to be distributed and be segmented and played further and further down the line.

This has probably been our greatest challenge, to bring together the people who are responsible for the various segments of the problem and to try to bring about this mutual respect and understanding, and to find ways to disseminate information regardless of where it is developed across the country, disseminate this information to these people in such a manner that it can be and will be used.

Now we have used all of the methods conceivable, I think, or many of them, except the comic books. We have not gone to the comic book fashion yet of disseminating the information in written form, and probably the best that we have found have been two systems: First, our highway short course which brings these people together and creates a forum in which they can discuss their various problems from their vantage point, with the other people, and secondly, our movies, our motion pictures have done a tremendous job of dissemination of information and have been used quite widely across the country, but this is a terrific challenge to us to disseminate the information to the man who is going to have an opportunity to apply it.

Mr. BLATNIK. How would that dissemination be initiated? Do you have to wait until someone sort of so-called invites you to the dance? Do you have to wait until an agency or State bureau, highway department, some high official seeks you out, asks for your findings, and your recommendations and advice?

Dr. KEESE. Well, we try to get on every program that we can, where groups of people who are interested in the subject are meeting. We prepare and I have furnished to the staff, copies of our "Texas Transportation Researcher," which is written in more or less news form, which we hope will attract people only to the point that something has been done. It does not include generally any real technology, but it does tie into these reports which they can write for.

We present summary reports, very few pages in length, which we hope that a person will have time to read.

Our highway short course, Highway Research Board meeting, AASHO meetings, short courses and conferences of other States and just every opportunity that we get, we tell the story. Dean Benson, having been longer at this than I, could probably tell a better story on this than I can.

Dr. BENSON. Mr. Chairman, engineers are pretty conservative and it is difficult to get them to change. I think probably the most effective procedure we have had is to try to get our people to spend at least the minimal amount of their time in the field, actually talking to the folks who are daily faced with these problems and if we can do this, I think this is one of the most effective ways of getting our people to adopt new ideas or to bring to us their problems, which is just as important, because we do not know what all of them are. But how this is going to be done nationwide, I do not know. We have not successfully resolved it in our State. All I can say is we are trying, and personal contact certainly is very important. If you can talk to the man on the job, then you have a chance to get him to adopt new ideas.

Mr. BLATNIK. The reason I asked the question is because, obviously, from the testimony you have heard so far, in the actual construction of the highway system there are rather elementary situations or errors that are, you know, quite obvious, and where it would require only good judgment, just plain common sense, to avoid or eliminate them.

These errors have been repeated over and over again and carried over into our most modern Interstate highways and freeways. There seems to exist a sort of barrier against new ideas, new concepts, new technologies.

Dr. BENSON. Well, unfortunately, standard designs have a tendency to be very difficult to change, and once you get one adopted, it may have faults in it but people will continue to use it over and over again because this is an adopted standard. I do not know what the answer is. I think that some way or other we need to impress on people more of the idea that maybe a little more change is for the good.

Another problem I think we have is that quite commonly no one really looks at the entire design when it is finished. No one really sits down with these plans, with all of the installations that are going into the highway indicated on these plans, and takes a look at the complete picture. The signing is on one set of plans, the roadway is on another set of plans, the structures are on another set of plans.

Somebody needs to take a look at this whole ball of wax from the standpoint that we built into the design conditions which are a hazard to the driver of the vehicle, and I frankly do not think that we take a look at it very often from this point of view, and in some way or other we need to have people whose sole job it may be to look at the plan from this standpoint: "Have we done things in this design which will be hazardous that we can avoid?"

I go back to what I said in the beginning, I do not think we should put anything in the highway right-of-way that we do not need there. I think everything we put into the highway right-of-way we must look at from the point of view of can this be made not a hazard to the driver of the vehicle, on the roadway or off the roadway.

Mr. BLATNIK. One of the most pertinent points made today is that apparently no one takes a look at the whole three-dimensional picture when it is completed in all its aspects and all of its functions. It seems to me that the whole thing is quite rigidly compartmentalized and some compartments do an excellent job, such as the repair and installation of lighting fixtures that were knocked down.

I am thinking of the story told about a certain gore area where a sign was established—this is a true story—and an evolution took place over about a 3-year period. To see the actual picture, you have a sign on two wooden sticks as temporary, improvised. Six months later the maintenance crew says in effect—I am making this up—"Holy smoke! This sign has been knocked down 14 times in the last 6 months. We have to do something about it."

From that point on, the direction which the train of thinking takes—this is what intrigues me—the immediate thought should have been, "There is something wrong here. There is a frequency of impact. We would like to know why. Let us do something about it." But instead the train of thought goes in the other direction. "We have to do something about this sign. Instead of wooden posts, we will have new steel posts put in." Now, the sign is still being hit with the same frequency, perhaps increasing now, with more traffic coming along. "Holy smoke! It has been knocked down 18 times the last 6 months." Meanwhile there is a little more damage to the impacting vehicles. Nobody thinks about that.

You have steel pipes and that is not strong enough. So now let us get two heavy-duty steel I-beams, mounted on a concrete support which rises 2 feet above the ground. "Now let them try to knock

this one down. This is here to stay," and by gosh it does stay. But the frequency of impact continues and in fact increases because more traffic has been generated.

Suddenly, 2 years later, someone says, "Look. It is still being hit; in fact, it's been hit 14 or 15 times in the last 6 or 8 months. We have killed eight people during that time." All of a sudden it dawns on them that we are killing people with the sign.

First of all, maybe the sign should not have been there in the first place. It is sometimes not necessary, not that important. Or we have found instances where to further protect the sign, a wooden cross-beam on concrete supports is created, for deceleration support which is not adequate at all. In fact, it merely added another impact point. At this stage, someone finally realizes that we are killing people here, so either they remove the sign or go back to the stick or maybe now adopts what you suggest, a breakaway type of support. It took 2 years to make a full circle and come right back to the original notion, where obviously, initially, a breakaway type of structure was indicated. Why that was not realized or awareness was not somehow even reached as experience unfolded, the right information was slow to reach the right people who should have been doing something about it.

We thank you gentlemen very much for a splendid contribution. We are indebted to you for your presentation. We thank you very much and we will close the hearings for this morning.

We announce for tomorrow, Mr. George McAlpin, New York Department of Public Works; Malcolm D. Graham, director of the Bureau of Physical Research, New York Department of Public Works; and Mr. John Beaton, materials and research engineer, California Division of Highways. I am sorry we cannot continue this afternoon. If you gentlemen will be available tomorrow morning, we will appreciate it.

Again, thank you very much, gentlemen. This will close the hearings for today, and we will adjourn until 10 o'clock tomorrow morning.

(Whereupon, the hearing was adjourned at 12:15 p.m., to be reconvened at 10 a.m. the following day, Thursday, June 29, 1967.)

HIGHWAY SAFETY, DESIGN AND OPERATIONS

Roadside Hazards

THURSDAY, JUNE 29, 1967

HOUSE OF REPRESENTATIVES,
SPECIAL SUBCOMMITTEE ON THE
FEDERAL-AID HIGHWAY PROGRAM
OF THE COMMITTEE ON PUBLIC WORKS,
Washington, D.C.

The special subcommittee met, pursuant to notice, at 10:10 a.m., in room 2167, Rayburn Building, Hon. John A. Blatnik (chairman) presiding.

Present: Messrs. Blatnik, Cleveland, Duncan, Edmondson, Howard, McCarthy, McEwen, and Zion.

Staff present: Same as previous day.

Mr. BLATNIK. The Special Subcommittee on the Federal-Aid Highway Program will please come to order, resuming public hearings on design aspects of the Federal-aid highway program, as it pertains to safety.

Our first witness this morning is Mr. John L. Beaton, materials and research engineer in the California Division of Highways, Sacramento, Calif.

Mr. Beaton, we welcome you, certainly, and more than that, we thank you for staying over for at least 24 hours to be available. The session started early yesterday, a long session, and we were unable to have the afternoon hearings which we had anticipated. Mr. Beaton, as is customary, would you please stand and take the oath. Do you solemnly swear that the testimony you are about to give before this special subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. BEATON. I do.

Mr. BLATNIK. Please be seated, Mr. Beaton.

Mr. CONSTANDY. Would you identify yourself for the record, please.

TESTIMONY OF JOHN L. BEATON, MATERIALS AND RESEARCH ENGINEER, CALIFORNIA DIVISION OF HIGHWAYS, SACRAMENTO, CALIF.

Mr. BEATON. I am a materials and research engineer with the California Division of Highways. My name is John L. Beaton.

Mr. CONSTANDY. I would just like to say, Mr. Chairman, we are very fortunate in having Mr. Beaton with us. There is probably no one else in the country who has done as much research in this area about which we are concerned, guardrails and median barriers, as Mr. Beaton has, as we will see through his testimony.

He has had considerable experience in live testing of barrier designs with full-size automobiles in quite a number of them. Mr. Beaton's testimony will be most informative.

If you would, give your background, Mr. Beaton.

Mr. BEATON. I am a graduate, with a Bachelor of Science in civil engineering, from the University of California in 1937. I have been with the California Division of Highways ever since then.

Mr. BLATNIK. The PA system is not an elaborate one. It is impressive looking, but is not a very good sounding one. If you would speak a little more loudly we could hear better and the stenographer would have a better opportunity to keep up.

Do not hesitate to use the ashtray or water, shift the microphone, and be more comfortable. We are looking forward with anticipation to your presentation.

Mr. BEATON. We have been engaged in testing—dynamic testing of these traffic barriers for some 15 years—the last 15 years of my experience. Before that time, I was engaged in a variety of engineering and management duties with the California Division of Highways.

Today, I would like to outline the testing program that has been conducted by the division in developing various types of traffic barrier railings. These barriers, as the committee I am sure is aware, are used on the outside edges of bridges and highways, and in median areas, and also to deflect vehicles away from contact with various objects along the roadside.

We in California have been engaged in dynamic testing of traffic barriers since 1952. Since that time to present, we have conducted approximately 150 full-scale-collision tests at a cost slightly in excess of \$500,000.

Mr. CONSTANDY. That is 150 automobiles which have been run into the different designs of guardrail barriers; is that right.

Mr. BEATON. This is right.

Mr. CONSTANDY. At a cost of \$500,000?

Mr. BEATON. Right.

Mr. CONSTANDY. Roughly a little more than \$3,000 per test?

Mr. BEATON. Yes; that is the average cost. And it is that low when you consider all of the tests because many of these vehicles were not wrecked and many of the tests were made several in 1 day. If you are considering a smaller number of tests, then we consider this costs us, say \$5,000, on the average to run a test. Some tests, when we are considering only one or two tests, will run near \$8,000.

Our traffic barrier program in general has not only benefited from our work but it has also benefited from the work of several others, starting back with the Missouri Highway Department dynamic tests in the early 1930's, and current work by the New York Highway Department, Cornell University, General Motors, New Jersey Highway Department, and others. The Texas Highway Department, as was evidenced yesterday, has done work that has contributed to our work.

It first became apparent to our highway and bridge engineers during the late forties and the early fifties that the traffic barriers that we were then using were not functioning as we had anticipated. The structural capacity as well as the dimensions of such items up to that time had been designed by the application of statically developed criteria. We, therefore, felt that in order to fully understand the problems

involved in such designs it would be necessary to perform a series of full-scale-collision tests so as to determine the dynamics involved.

Mr. CONSTANDY. That would be 1952 or thereabouts?

Mr. BEATON. We started in 1952; right.

Mr. CONSTANDY. We had testimony from the gentleman from General Motors to the effect that when they began in 1958 to upgrade their proving ground they searched for research which had been done. I am not sure whether they mentioned being aware then of what you had done in 1952, but they had come to the conclusion there had been virtually little testing of guardrail median barriers for some 25 years. Did you find that to be true?

Mr. BEATON. This is true. We in 1952 started testing bridge curbs and rails and we worked on bridge structures almost entirely through the mid-1950's, and about the same time as General Motors started in 1958, we started testing and developing median barriers and did test some guardrails at that time. But that had been the first testing that we found in the literature since Missouri did their rather early, very early tests, in the 1930's.

Mr. CONSTANDY. So the standard for guardrail and median design in the early 1950's was not very high?

Mr. BEATON. That is right.

Mr. CONSTANDY. You found that what had been used as a standard was not effective?

Mr. BEATON. Right.

Mr. CONSTANDY. Mr. Beaton has a movie to show us at this point, Mr. Chairman. It is a sound picture. Do you want to say anything about it before we show it?

Mr. BEATON. Only that this picture is the latest picture we have developed and is on guardrails. This picture outlines the program that developed our present standard of guardrail that we are now using. It also includes some median barriers.

(Script of movie prepared by the State of California Transportation Agency, Division of Highways, Materials and Research Department, is as follows:)

Full scale dynamic impact tests such as this to develop and prove various highway barrier designs have been performed by the California Division of Highways since 1952 as a part of the continuing effort to improve the safety of California's highways. This film report presents the results of a recent series of tests performed to observe the effects that would result from certain proposed geometric and material modifications to the standard. California beam type median barrier and guard railing designs. The comparative results of eight full scale impact tests are shown. Four tests involve the median barrier design and four tests involve the guard railing design.

In the median barrier portion of this test series, the first test was conducted on the current standard double blocked-out beam design composed of a 12 gauge steel "W" section beam mounted 30 inches above the ground and a 6 inch structural steel channel centered 12 inches above the ground.

This initial test served as a performance base to compare the results of the modifications made in the succeeding three tests which include one test where the steel "W" section beam was retained but where a 12 gauge steel roll, formed "hat" section was substituted for the structural steel channel and two tests to determine the feasibility of using aluminum alloy members as alternates to the steel. Two thicknesses, 0.125 inches and 0.156 inches, of aluminum alloy "W" section beams were tested in designs utilizing a 6-inch structural aluminum alloy channel as an alternate lower rubbing rail.

This is our current standard beam-type median barrier, designed and tested in a dynamic test series conducted in 1958. This blocked-out design is used in medians less than 22 feet in width when warranted by traffic conditions.

Here is the standard median barrier design erected on the test site. In this test series, all median barrier and guard railing installations were constructed on this simulated, flat, paved median, and were impacted from this 25 degree approach line. The impact speeds were approximately 68 mph for the median barriers and 60 mph for the guard railings.

The standard California beam type median barrier installed for the first test utilizes 8' x 8' treated Douglas fir posts and blocks at 6'-3" centers. The 12-gauge galvanized steel "W" beams are mounted 30 inches above the pavement and the 6-inch, 8.2 lb. galvanized structural steel channel rubbing rail is centered 12 inches above the pavement.

This is the standard median barrier installation ready for impact Test #1. (Sound track of crash.) This view from the tower camera shows the 25-degree approach angle at 69 mph. Here is another tower view showing the 15-degree exit angle. Note the tendency for the car to roll slightly away from the rail rather than into it. The damage sustained was typical of that we have observed from operating experience on our freeways.

The rail was permanently deflected up, presenting a barrier more than a foot above the center of gravity of the average passenger vehicle. The vehicle was a total loss.

The same post and block system was retained for the second test. However, in Test #2, aluminum beams and rail were substituted for the steel members used in Test #1. The 0.125 inch thick beams were alloy 2024-T3, and the 6-inch, 3 lb. channel rubbing rails were alloy 6061-T6. These elements were mounted at the same heights above the ground as was used in Test #1.

This is the aluminum median barrier installation ready for impact Test #2. In this test, the splice of the aluminum rubbing rail was made the same as for the steel rail in Test #1. (Sound track of crash.)

The 25 degree approach angle at 68 mph. Notice that the beam fails first, then the aluminum channel rubbing rail fails at the splice. A majority of the flying debris is fragments of the aluminum beam.

This is a view from the data camera mounted above the back seat showing the kinematics of Sam during this roll-over. Again, flying debris is fragments of aluminum rail.

It was determined from the data film that the failure of the aluminum rubbing rail splice did not materially affect the results of this test. However, this splice was redesigned to provide more edge distance in subsequent tests.

Again the vehicle is a total loss.

For Test No. 3, the same aluminum channel rubbing rail was retained, but the thickness of the aluminum alloy "W" section beam was increased from 0.125 inches to 0.156 inches.

This is the barrier as constructed for Test No. 3, and here is the strengthened rubbing rail splice. (Sound track of crash.) The same 25 degree approach angle at 68 mph as for the previous tests.

Note the similarity in vehicle reaction between this test and Test No. 1 on the steel barrier. Barrier damage was also similar to that sustained in Test No. 1. However, this single successful retention of the vehicle was not conclusive based on the results of subsequent tests made on the same 0.156 thick aluminum "W" section beam in a single beam guard railing design.

Again the vehicle is a total loss.

For this fourth test we returned to the standard 30" high steel beam design used in Test No. 1 and substituted a 12 gauge galvanized steel roll-formed "hat" section rubbing rail for the 6" structural steel channel.

Here is the barrier as constructed for Test No. 4 with the roll-formed "hat" section rubbing rail centered 12" above the pavement.

At the same approach angle of 25 degrees at 68 mph, there was more vehicle rebound with this hat section design than with the structural channel rubbing rail design. Note the flying wood fragments from the crushed timber blocks.

Energy absorbed during the crushing of the timber blocks adds to the resiliency of this semi-rigid barrier system.

Although this design gave a passable performance, there was more of a tendency to pocket under these high speed test conditions than was shown by the channel rubbing rails in Tests No. 1 or No. 3.

Again the vehicle was a total loss.

The second phase of this research project consisted of four tests conducted on guard railing. Developed in 1960, this California standard blocked-out guard railing is placed for the motorists' protection on steep embankments. This design

is also used to protect a vehicle from impacting bridge abutments, bridge piers at structures, sign posts on freeway shoulders and sign structures at exit ramps.

In the guard railing portion of this test series, the first test was conducted on the 1960 standard blocked-out beam design. This 12 gauge steel "W" section beam is mounted 24 inches above the ground on posts spaced at 12' 6" centers.

Modifications in the succeeding tests included halving the post spacing to 6' 3", determining the feasibility of using aluminum alloy as an alternate for the steel in the "W" section beam, and testing the 6' 3" post spacing with the steel beam mounted at 24 inches and 27 inches above the ground.

The 1960 standard California beam type installed for the first guard railing test utilizes 8' x 8' treated timber posts and blocks at 12' 6" centers. The 12 gauge galvanized steel "W" beam was mounted 24" above the pavement.

This is the 1960 standard guard railing ready for impact Test No. 5.

This initial test was designed to serve as a performance base to compare the results of the succeeding three guard railing tests. It also was the first proof test of this design under a 25 degree angle, 60 mph impact from a late model vehicle. (Sound track of crash.)

The impact speed was reduced from 68 to 60 mph for the guard railing tests.

Typical of the sloped back bumpers on American-made cars from the past four years is the bumper on this 1962 Chrysler that strikes the barrier at the center of rotation of the beam. This high point of impact on the beam combined with the sloped-back bumper design increases the possibility of vaulting. During a later test it is found that by halving the post spacing, there was sufficient resistance to beam rotation to successfully redirect the vehicle.

The first step in preventing vehicle vaulting as experienced in Test No. 5 was to increase the height of the beam from 24 to 27 inches and decrease the post spacing from 12 ft. 6 in. to 6 ft. 3 in.

This is the revised guard railing design with a 12 gauge galvanized steel "W" section beam at a 27 in. height on posts spaced 6 ft. 3 in. apart. (Sound track of crash.) Again, a 6 mph impact speed at 25 degrees. The 6 ft. 3 in. post spacing combined with the added 3 in. in beam height eliminated any tendency to vault. The 27 in. beam height places the beam well above the average sloped back bumper and minimizes the tendency for the vehicle to roll.

Damage was understandably more severe with a single beam guard railing than was noted during the earlier tests on double beam median barrier designs. When the beam is mounted this high, the post is exposed to potential wheel entrapment. This 27 in. beam height is considered maximum for barriers without rubbing rails.

For this third test on guard railing we retained the 6 ft. 3 in. post spacing from the previous test and dropped the steel beam back to the original 24 in. design height.

The purpose of Test No. 7 was to determine the most effective and economical modification that could be made to the 1960 24 in. high guard railing design to provide a more protective barrier. (Sound track of crash.)

The additional posts, even with the beam at the original 24 inch height added sufficient rigidity to the system to effectively redirect the vehicle. At this reduced height, there is a slight tendency for the car to roll.

The steel beam of this guard rail system withstood severe deformation and extremely high stress concentrations in the immediate impact area with no evidence of failure. Again, much of the energy was absorbed in crushing the blocks.

For this last guard railing test in the series, the 24 inch beam height and 6 ft. 3 in. post spacing were retained from the previous test, and a 0.156 in. thick aluminum alloy "W" section beam was substituted for the 12 gauge steel.

This is the installation for Test #8. The 0.156 in. thick aluminum beam is the same that performed satisfactorily in the double beam median barrier design. (Sound track of crash.)

Again, the same 60 mph at 25 degrees as for the previous guard railing tests.

An objectionable characteristic of the alloy 2024 aluminum beam revealed in this test is its unpredictable behavior during the extreme impact loading imposed by the vehicle.

While being redirected in the usual manner, the vehicle is suddenly and violently ejected from the barrier.

The difference in performance between the steel and aluminum appears to stem from the difference in stress-strain relationships and the ductility of the two materials. Of most significance is the difference in impact resistance of the two materials. Laboratory tests indicated that the steel beam could with-

stand approximately 8 times the impact loading as this aluminum alloy beam. The first penetration of the rail element into the car was through the left front wheel well.

In summary, the blocked-out steel beam concept has been supported consistently by satisfactory operational performances of field median barrier installations such as this. Investigations of in-service barriers at accident locations revealed barrier behavior patterns, almost identical to those exhibited by successful barrier tests.

Although the type of barrier tested in this series is referred to as a beam barrier, the beam itself must be capable of withstanding extremely high axial stresses if it is to function safely.

The ability of steel to withstand these stresses was well substantiated by the performance of the steel beams used in this test series.

When the imposed axial and tensile stresses cannot be resisted by the beam member, we can expect results such as this: aluminum beam failures generally occur at posts, either through reduced sections at splice holes or at points of high stress concentration. In comparing the ability of aluminum beams to withstand severe impact loading with that of steel, it is apparent that aluminum alloy 2024-T3 in 0.125 inch thickness is an unacceptable alternate for 12 gauge steel beams for use on median barriers or guard railing.

The 0.156 in. thick aluminum in the same alloy is also an unacceptable substitute for steel in guard railing and is marginal for use in double beam median barriers.

Because of the tendency to pocket, the performance of this 12 gauge steel "hat" section rubbing rail is considered marginal and in this form would not be considered an acceptable alternate to the standard 6" 8.2 pound structural steel channel.

The 27 in. beam height is considered maximum for the blocked-out guard railing. Because of the tendency for wheel entrapment, a barrier with the beam placed any higher than 27 in. would require a lower rubbing rail as does the 30 in. high median barrier design.

Guard railing beams mounted 24 in. above the ground on 6 ft. 3 in. post spacing will give acceptable performance in most locations. However, to increase the margin of safety over possible failure from impact by late model cars, it is concluded that for all new guard railing construction the minimum beam height should be increased from 24 to 27 in. above the ground, and the post spacing decreased from 12 ft.-6 in. to 6 ft. 3 inches.

This study was made by the California Division of Highways in cooperation with the United States Department of Commerce, Bureau of Public Roads. (End of film.)

(At this point Mr. Edmondson assumed the chair.)

Mr. CONSTANDY. Very good, Mr. Beaton. I think it says a lot.

Mr. BEATON. Thank you.

Mr. CONSTANDY. These are the current standards in the median barrier and guardrails?

Mr. BEATON. These are the current standards we are using as of now.

Mr. CONSTANDY. I think it might be worth pointing out it appears there is no washer used on the installation of the guardrail. Is it not true that California, instead of a washer, uses the acceptable alternate, the wide headed bolt?

Mr. BEATON. This is right.

Mr. CONSTANDY. There should be something there, more than a standard bolt head?

Mr. BEATON. Sufficient width to hold the barrier to the block.

Mr. CONSTANDY. Can you briefly outline your testing program?

Mr. BEATON. Yes, I would like to. Our program in general rotates entirely around dynamic testing, so I thought it might be well if I outlined our general procedure before I went into the full development of our program.

When we started out, we used retired highway division cars which are lighter cars, in the Ford and Chevrolet class, and they are 4 or 5 years old. Later, and now, as you saw in this picture, we used retired highway patrol cars, which are only slightly over a year old when we get them. They are heavier, they are higher powered than the average vehicle on the road and therefore we feel that they put our barriers to somewhat more severe tests than actually occur in the field. These cars are driven into collision under their own power through a radio remote control by a driver in the following car, as you probably noted. The driver's seat is occupied by an anthropometric dummy who has become very dear to our hearts and we call him Sam because he has been through so much.

He is instrumented with accelerometers in his chest cavity. In almost all tests he is merely retained by a seat belt. However, we have tested practically every other type of restraining device, primarily in cooperation with our highway patrol. Actually, we rely almost entirely on high-speed photographic coverage to obtain our technical data as well as our documentary information for these pictures.

Mr. CONSTANDY. What speed and angle of impact do you use in your live tests?

Mr. BEATON. We use the approach angles and the speeds recommended by the highway research board for testing of guardrails, except that for highway barriers, such as median barriers and bridge rails, our final testing will usually be at a 25° angle of approach and speeds ranging around 65 to 70 and some as high as 80 miles per hour. The HRB standards are two approach angles of 7° and 25° and speeds not in excess of 60 miles per hour. Our tests are all performed on an unused airstrip located near Sacramento.

Mr. CONSTANDY. Could you tell us the evolution of the barriers and guardrails currently used?

Mr. BEATON. Yes; I would like to.

I will follow my presentation with a short filmstrip or excerpts from various moving pictures that we have made during our various tests that will depict some of the comprehensive work we have done in this field. That will illustrate the good points as well as the problems involved in most current barrier designs. I am sure the committee realizes the perfect barrier has not yet been designed and that there is no substitute for a great deal of open space.

We started our program in 1952 by making a series of tests of concrete bridge curbs of various shapes and heights. This series was rather rudimentary in character in that we used a live test driver and for that reason were limited as to severity of collision. This series did prove, however, that an undercut curb was the most efficient and also furnished basic information as to the effect of curbs on vehicle response.

This we followed by a series of tests in 1955 to develop the most efficient height and contour for bridge curbs and the lowest effective height for bridge rails both when they were mounted on curbs and not. We also found that if it was necessary to set a curb in front of a rail, then the lowest effective height of the rail was directly related to its setback until a maximum height of 4 feet above the curb was reached.

Mr. CONSTANDY. Four feet?

Mr. BEATON. Four feet.

Mr. CONSTANDY. Versus your norm, which is 27 inches?

Mr. BEATON. That is right. A little over 2 feet. This is because of the jump of the car as it goes over the curb, or dynamic response.

Mr. CONSTANDY. Quite a significant thing, then.

Mr. BEATON. Yes, it is. Actually, we found later that the additional height need not be added as long as the barrier was set back no more than about a foot from the face of the curb. This is because of the dynamics of the suspension system of most automobiles which I will illustrate in the movies later.

This work finished for a time our development of bridge curbs and rails and we turned to the median barrier problem in 1958. Here the rapidly increasing volumes of traffic on our various freeways were starting to result in many severe cross-median head-on collisions. A two-pronged attack was initiated on this problem—one by our traffic department to determine the parameters of the overall problem, and one by ourselves using the dynamic information gathered during our bridge rail studies to attempt to develop median barriers if they were found to be needed.

We felt that a median barrier should, No. 1, prevent crossovers. This was its first duty.

No. 2, it should minimize possible injury to the occupants of colliding cars.

No. 3, it should minimize the possibility of secondary collisions resulting from cars careening from the barriers.

Mr. CONSTANDY. Just to restate that, you initially want to prevent penetration of the automobile into the opposing lane of traffic.

Mr. BEATON. Right.

Mr. CONSTANDY. You want to reduce the forces of deceleration to those humans within the cars.

Mr. BEATON. Right.

Mr. CONSTANDY. And you want to redirect the vehicle on a path parallel to the road so that it does not go back into the adjacent lane of traffic and cause another accident.

Mr. BEATON. That is right; yes.

From their studies, the traffic department determined that the occurrences of cross-median headon collisions were directly related to the volume of traffic and that median barriers could save lives if properly placed; however, it was emphasized that the placement of median barriers would cause an increase in accidents. In other words, there were many out-of-control cars which invaded the median area without becoming involved in an accident.

Mr. CONSTANDY. Could you explain that a little bit?

Mr. BEATON. Well, if you have a median area with no obstructions in it, in other words, it is absolutely clear, then the car may have a chance of recovery and come back to the traveled way. However, as soon as you install median barrier, then there is an object that can be struck. In other words, you have cut down the evasive area, let's call it, the defensive area, in half, so they fight off to strike the barrier and then they become an accident victim.

Mr. CONSTANDY. I see.

Mr. BEATON. Years of experience have proven these findings to be accurate. The fact that the accident rate would be increased by the placement of median barriers even though lives would be saved made

it even more important that we develop median barriers that would minimize injuries to the occupants of colliding vehicles.

Our work, therefore, was to develop devices that would serve as positive barriers and yet minimize secondary effects on the occupant. This we did by developing a cable barrier for wide medians and a blocked out metal beam barrier for narrower medians. Within a year—1959–60—we had installed more than 100 miles of the cable barrier and 50 miles of the metal beam barrier in the most critical areas of the State, and since that time another 300 miles of median barrier has been added. Operational studies of both types of barriers indicated that the blocked-out beam barrier was serving as designed; however, the cable barrier at first needed refinement as to details and in addition had created certain unanticipated operational problems.

A series of additional tests was then started so as to improve design details of the barrier itself and in addition to determine the effects of the geometry of various roadsides on the action of the cars as they approached the barrier. The effect of these tests was to more clearly define the design considerations for each type of barrier. The flexible barrier system consisting of a cable on light collapsible posts and with a chain-link fence or expanded metal mesh to act as a glare screen proved itself to be remarkably efficient in both stopping an invading car and in minimizing possible injury to the occupants of such a vehicle.

Unfortunately, however, due to its flexible character it proved to be sensitive to the variety of changes in the geometry of the approach roadway and shoulders or to dikes or curbs placed in front of it. In other words, any excessive irregularity of the surface approaching such a barrier could result in the vehicle striking the cable too high or too low which would result in penetration.

Another problem that developed was that the slightest contact with the barrier caused damage which had to be repaired. Maintenance repair trucks positioned to perform these repairs often made it necessary to close the high-speed lanes. This results not only in a loss in efficiency of the freeway but also causes accidents. We have, therefore, found it necessary to restrict this type of barrier to medians that are relatively flat between the adjacent roadways and also where we have a width of at least 22 feet so as to allow sufficient room to park the truck and utilize this equipment during the repair.

The blocked out metal beam has shown no problem so far as placement is concerned and due to the fact that repairs are necessary only after a very heavy collision, closure of lanes during repairs can be held to a minimum. During our testing program, while it was evident sustained decelerations on the occupants of vehicles colliding with the blocked out metal beam were relatively low, we were concerned that the disorientation of the driver due to a rapid change in direction of travel could result in severe secondary collisions. Interestingly, this problem has not developed. In all, our overall median barrier program has been quite successful.

Mr. CONSTANDY. Relative to that program, you have a paper given recently by Mr. J. C. Womack, California State highway engineer, do you not?

Mr. BEATON. Yes; I have.

Mr. CONSTANDY. In the interest of saving time, Mr. Chairman, I would ask that the statement of Mr. Womack be printed in the record at this point.

Mr. EDMONDSON. So ordered.

Mr. CONSTANDY. It is a very fine statement, and as a matter of fact adds another dimension to the question of installing guardrails. It is something to which careful consideration should be given. They find that you increase the incident of injury if the median barriers are installed at the wrong place.

Mr. BEATON. This is right.

Mr. CONSTANDY. I ask the paper be printed at this point in the transcript.

Mr. EDMONDSON. It will be printed.

Mr. CONSTANDY. Thank you.

(The statement, "Median Barriers and Accident Prevention," by J. C. Womack, State highway engineer, is as follows:)

Median barriers were conceived and are installed to prevent cross-median head-on accidents. Accident data show that median barriers are very effective in accomplishing their purpose.

Back in the late 1950's, before the median barrier program was initiated in California, cross-median head-on accidents accounted for approximately 20 per cent of the freeway fatal accidents. At present, with 400 miles of median barrier in place on 2,000 miles of freeways, only one-twentieth of the total freeway fatal accidents are of this type. The 400 miles of median barrier were installed first at locations where accident records and traffic conditions indicated they would do the most good in preventing cross-median accidents, and subsequently have been installed on all freeways where the median is less than 46 feet wide and average daily traffic exceeds 40,000 vehicles, and on all freeways with narrow medians (less than 12 feet) where the average daily traffic exceeds 20,000.

Since the barriers have proved their effectiveness in preventing one of the most vicious types of accident that takes place on California highways, the question quite naturally arises as to why they are not installed everywhere, and this question is very forcibly brought to the attention of highway officials whenever an accident of this type occurs and is reported in the press.

Highway officials are just as concerned—probably much more concerned than most people—by reports of fatal cross-median accidents. Here in California and throughout the nation they have given careful research and study to this most serious matter. The study, based on years of experience, shows that the solution is not as simple as it first seems to be.

The problem is that the installation of such barriers causes approximately a 25 per cent increase in injury accidents and can most definitely cause fatalities.

In 1965 there were 3,800 head-on accidents on California State highways. Of these, only 33 were fatal accidents caused by cars crossing over the center dividing strip on freeways. Thirty-three such accidents are too many, but they also must be viewed in perspective by those in charge of State highways in California who are confronted with a yearly toll of more than 100,000 accidents and more than 2,000 persons killed. In the light of this, the State Highway Engineer must decide whether an all-out program designed to prevent such a small fraction of all fatal accidents is worth the cost, not in dollars, but in the increased suffering caused by accidents that would not otherwise occur, as well as a reduction in other safety programs designed to prevent a much larger number of accidents.

The general increase in total accidents as a result of median barrier installation is due to the fact that the barrier cuts in half the space available for emergency maneuvers in the median. Drivers who might use the median to avoid an accident in an emergency have less room; they may strike the barrier or they may strike another car. In either event they have an accident, often involving "innocent bystanders" on the same side of the freeway. These accidents that might never have happened also cause injuries and deaths.

A median barrier or guardrail can prove just as deadly as another vehicle if you run into it with enough force. One hundred sixty-nine fatal accidents oc-

curred in 1964 and 1965 on California freeways in which vehicles struck some kind of guardrail. Included in this category are 41 where the guardrail was a median barrier.

The dilemma persists. In order to solve it, the probability of a few cross-median accidents must be weighed against the certainty of many accidents of other types, and therefore barriers are only placed when the probability of their doing more good than harm can be demonstrated.

In general, when traffic volume is very high, the number of potential head-on accidents is high enough that their prevention outweighs the negative aspects. But at low traffic volumes and where the divider strip is wide, the chance for a cross-median accident is so small that the added accidents the barriers cause are considered to be too high a price to pay. As traffic volume increases, more barriers will be installed. California motorists may be sure that proven safety devices and safer design standards will be adopted for the California Highway System as fast as they are developed.

Mr. CONSTANDY. Will you continue then, Mr. Beaton.

Mr. BEATON. Our median barrier program testing new ideas and refinements of old went on through 1964. However, during the early part of this project and as a supplementary program we determined that our then 1958 standard guardrail was not as effective as desired. We therefore changed from the curved beam type to a W-section beam on blocked out posts.

Improved bridge rail designs was our next objective. Testing was started in this area in 1965. As I stated earlier, our 1955 program had developed effective concrete bridge rails that were topped with a metal tubular railing. Tests in 1963 further refined these designs and improved the strength of the metal posts and rails. In addition to these concrete bridge rails, we found that we had a need for a railing that would improve visibility, be self-cleaning, and esthetically acceptable. Based on past dynamic studies, our bridge department therefore designed an all steel bridge barrier railing consisting of two horizontal rails mounted on steel posts. This railing proved to be both pleasing in appearance and very effective in redirecting colliding vehicles. It is of special value on interchange structures where visibility of approaching traffic is very important.

Its use, however, is otherwise limited, in that it is important in the normal structure of any length that the driver not be distracted by objects along the side, such as boats and so forth, and also that the rail be somewhat substantial looking so as to give the driver every confidence in the world in them.

Concurrent with our bridge railing studies, we were also conducting a program on guardrailing. This was started in 1964. Our traffic department had observed during their continuing accident studies that the then current standard design of metal beam guardrail was diminishing in its effectiveness due apparently to the higher speeds and heavier weights of the modern vehicle. During this project we therefore studied the effect of various modifications to the metal beam type of guardrail. You have already seen the picture, and we changed our standards, we raised the beam and we cut down the post spacing.

During this time and still underway, we are testing short sections of guardrailing which are used to deflect vehicles away from collision with various objects along the side of the road. Our tests confirmed the findings of others that guardrailing less than 100 feet in length is ineffective unless adequately anchored. We are not satisfied with any of the current anchoring systems and are therefore attempting to develop a better system.

Mr. CONSTANDY. That is an area which is to a large extent ignored by many highway departments in the representative samples we have been shown.

Mr. BEATON. This is an area that needs a great deal of work, actually, because you are working in relatively small areas with very short deceleration distances. So it is a real problem.

At the present time, we are considering the use of the New York box beam median barrier and also the New Jersey design of concrete median barrier for us in areas where each would be especially effective, and we have tested both of these designs so as to obtain firsthand dynamic knowledge to supplement the information that we have already obtained from the other States.

At this time, I would like to show another picture, which indicates some of the design features that we had been concerned with and have tested. This is a silent film which I will narrate as we go along.

(Narrating film.)

The first series of clips I am going to show here indicate the four general classes of median barriers. This first is what we call a flexible system. These terms, by the way, are our own, they are not accepted by any national body. This flexible system is a cable barrier with an expanded metal light screen, or glare screen, in this particular case.

Here is the New York box beam which we termed as a semiflexible system. It is a steel box beam on collapsible posts.

We term our blocked-out metal beam as a semirigid system. This is our standard median barrier design.

This is one of our new bridge rails and we term it also as a semirigid system. And this we term as a rigid system, and it is the same as any other concrete wall barrier.

Here we are testing at 90-mile-an-hour speed our flexible system cable barrier.

Mr. CONSTANDY. Ninety miles an hour?

Mr. BEATON. Ninety miles an hour.

[Narration continued:] Here we are riding Sam through the 90-mile-an-hour collision. You note the energy is eaten up by the collapse of the posts and stripping of the cable. You can see the posts going down in the front of the car, starting pretty soon. We are just now out of the full arc of the deflection and now we are coming back and you can see the posts going down in front of the car.

Mr. CONSTANDY. You were satisfied with the result itself?

Mr. BEATON. Yes. The decelerations on Sam are very low down, in the 1- to 3-g range. There is little or no rebound from this. The car stays in the median area. Damage to the car, actually, is relatively slight, amounting primarily to the cutting up of the sheet metal.

[Still narrating:] Here is a test on semiflexible system, the New York box beam as you can see, the deflection is somewhat less. This is at 65 miles an hour, by the way, and the rest of the tests will be at 65 miles per hour and 25° angle collision. The deflection is 6 feet. There is low exit angle, only 5°.

In all of the interior shots you will see of Sam going through these tests he has a seat belt on. You can see his sideward movement and rebounds somewhat heavier than it was as we went through the cable or flexible system tests.

Damage to the car was a little greater but not too much.

Now here is our semirigid system. That would be blocked-out metal beam. Here at this same 65 miles an hour and 25° angle of collision, you will notice there is little tendency for the car to roll, because of the blocked-out feature. The exit angle is about 15°.

Here the side thrust on Sam is somewhat greater than it was in the last test.

The deceleration on Sam was 7 to 12 g's in this case, which we considered to be tolerable, however, quite high.

As you can see in the impact, the energy was divided between the railing and the automobile. Here again is a semirigid system. However, this has a little more stiffness in it than the blocked-out metal beam.

Mr. CONSTANDY. Is this a bridge rail?

Mr. BEATON. This is a bridge rail, right, used primarily on interchange structures.

[Narration continued:] Acceleration here is a little higher. The reflection angle was somewhat greater; it was 25°. The early decelerations on Sam are greater, as you can see.

Mr. CONSTANDY. More energy is taken up in damage to the car.

Mr. BEATON (continuing). Here is a test of several bridge rails, all the scenes from now on are some of our earlier bridge rail tests. Here we were trying to determine the proper designs, proper height. This happens to be a very lightly designed straight wall, on which we were attempting to find out further information.

This was our early standard design. It was a massive-looking bridge rail. You can see we went right on through it. This shows an experimental ballister design, which while it tested out all right, we never did adopt.

This is one of our standard bridge rails we use at present, whenever we want a safety walkway. This is the same design, however, without a walkway in front of it.

This is the New Jersey median barrier developed for use in narrow medians, and we tested it in our latest series.

This concrete rail failed because it was too low. The punch of the car is concentrated too close to the unsupported edge, and there is insufficient strength to retain this height and it went straight through.

This is lightly designed concrete wall. It failed and the car rolled off of it and rolled over. And this is typical of any barrier that allows the car to roll into it.

Now, in the next shot I will show what happens when you do not block out a wall and you allow the wall to deflect and allow the car to roll into the wall.

This is a very typical roll. That is why we block out our median barriers.

This is our current design of solid bridge rail. Lateral decelerations are relatively high any time you use a rigid barrier. However, rigid barrier is necessary when you do not have space on the other side to accept the deflections of other types of barriers.

Sam lost his head in this one, but this was not primarily due to the type of collision. He had a helmet on and it tripped up on high antenna; Sam has a very limited lateral movement in his neck, so it trapped and it was not necessarily indicative of the crash.

This is the New Jersey design of flat-angle high-speed collision. You can see here practically no damage to the car, a slight amount. A great deal of energy was eaten up in raising the car, rather than in crushing the car. Decelerations on Sam were very low, even though this was a 65-mile-an-hour collision, at 7°.

Now this is at 25°, same speed. You will notice now the reaction of this is just like any other rigid barrier; that is, that it is very severe, very light, all the energy absorbed in the car. Accelerations on Sam were quite high.

No damage to the barrier, however; most of the deceleration energy was absorbed by the car.

This is our standard bridge rail with a safety walkway in front of it. You will notice as the wheel of the car went over the walkway, there was little or no change in elevation of the car. This is due to the spring system of most American automobiles.

If the rail were farther back, then the rebound or the spring system would start to raise the car.

This is a back view of the same accident. The tire blew out as it went over.

A series of tests now showing our test of curbs. We determined the most effective height and design. Our early studies showed that undercut to be quite effective, but even the best curb, high speed, low angle, you would go over them; you go over curbs at low speeds, this is only 5-miles-an-hour collision at 30°.

We wanted to know what kind of jump we would get going over a curb and that happened to be a 60-mile-an-hour collision.

We did find that in the first part of the jump, a great deal of the jump was absorbed by springing system. Here this is going over only a 6-inch high curb you can see the soft spring system did not affect the car at all at first but a little bit later it started to impart a jump.

Now here is a hard sprung sports car going over the same height, same speed. As you can see because of the hard springing, the jump is quite a bit more than over the soft sprung.

Mr. CONSTANDY. You are not enthusiastic for curbs, are you?

Mr. BEATON. No, sir, not enthusiastic at all.

Mr. CONSTANDY. You would prefer that they were not used?

Mr. BEATON. I do not think curbs should be used unless they are absolutely necessary.

[Narration continued:] Here is a sports car going into our cable barrier over a 6-inch height curb. In this case, the barrier is close enough so that the car was not jumping too much before it was caught.

Here we are going to test a series of geometric configurations approaching our cable barrier. This is a typical sawtooth. You will see as the car comes up underneath, a sports car, low anyway, it will penetrate the barrier. We had problems with this at first, and have no longer any use for it in this type of a location.

Here is a car approaching on the high side of the superelevation on a curb. This gives a high-speed car sufficient jump to clear the barrier. Again, we had to recognize this fact in our designs and placement of such barriers.

This is a 66-mile-an-hour collision with precast concrete median barrier that we attempted to develop because it was cheap. We have never used this, needless to say. However, it is a good example, I think,

of the difficulty of trying to make a light unit out of a brittle material. It just does not work with light materials or in dynamics.

You saw this picture in the other group, but it is to illustrate exactly the same thing that I just mentioned, that it is necessary that the beams be properly designed so as to keep a car away from collision with hard posts. The failure, as you can see, is catastrophic.

This is merely to show that if properly designed this type of barrier works real well, prevents the car from rotating, tipping over.

This is our standard design. This is a typical damage on the road from a hard collision; as you can see it more or less duplicates our test findings.

One beauty of this particular barrier design is that light dents do not need repairs.

This is typical damage of our cable barrier and as you can well imagine, with trucks out there to repair this barrier in a relatively narrow median, requiring the closure of the high-speed lane, we no longer use it in such locations. This is the typical location in which we use it. In places where it is relatively flat, we have plenty of room to get out and repair any damage that may occur.

Whenever we have to place ditches for drainage, we either try to get them 6 feet away from the cable barrier or right up within a foot of the barrier.

Any flexible system or semiflexible system, we feel that some space is needed to get our repair trucks in to repair any damage that might occur.

In a semirigid system, we need less space, we can use it in the narrower medians, need less repair, we do not have to stop the traffic at all.

We use this rail in interchange structures, or bridges, where we need sight distance. In other words, where cars are coming up from the side, both the car on the freeway and the approaching car needs to be able to see the approaching traffic. This is the New Jersey concrete barrier. We feel that there is a place for using this barrier in very narrow medians, where repairs should be held to a minimum and interference with traffic held to a minimum. This is our standard bridge rail we use in most locations, throughout the State of California. (End of film.)

(At this point Mr. Blatnik resumed the chair.)

Mr. CONSTANDY. We have a third film, Mr. Chairman, if we have an opportunity at the end of the other witnesses' presentation to see it. It relates to short section of guardrails and the necessity for them to be anchored.

There are a couple of things that come to mind. Do you use the chain link fence I believe you developed?

Mr. BEATON. Yes.

Mr. CONSTANDY. Initially, did you have some difficulty with the turnbuckles?

Mr. BEATON. We had difficulties with the early turnbuckles because they were large and bulky and they snagged the car. We, therefore, went through a series of tests, redesigned these to the same size of the cable by using high strength steel, a pipe type.

Mr. CONSTANDY. I think that you also initially had two heights of cable, did you not?

Mr. BEATON. We had two cables. We had problems with the lower cable tending to raise the car and give it an initial impetus upward. So we removed this cable and found by testing that the barrier system is more efficient with it off.

Mr. CONSTANDY. It raises some concern inasmuch as last week we had pictures from the nine States and two of them were using the original design chain link fence median barrier you developed. Apparently both of them used your original design, because as I recollect in both instances, they do have a turnbuckle of the type you initially had which, as you found, presents a severe hazard.

And they also both used the low cable which you have since abandoned. Since they are on brand new projects, it would seem to suggest both the States that adopted your idea have adopted the early design in which you found some defects. It is hoped that both of those States become aware of it and perhaps make the necessary modifications before they have to learn, as you people did, that there are improvements to be made in the original design.

There were a couple of other items there. I think we should mention your film suggested the necessity of coordination between the design of the automobile and the design of the highway. The design of automotive devices such as the slope of the bumper permitted the car to raise up above the guardrail and in effect defeated its purpose.

Mr. BEATON. We agree with this 100 percent. We feel that there needs to be a correlation between the vehicle and the road. This is a very significant area and very fruitful area in which to do a great deal of work.

Mr. CONSTANDY. It would be a shame to have people in the highway field developing a facility for safety at considerable public investment which thereafter would be diminished in its value, if not negated, as a result of changes in automobile design.

Mr. BEATON. This is right.

Mr. CONSTANDY. Did you have something that you care to state relative to smaller vehicles, sports car type machines, and as your protective devices relate to them?

Mr. BEATON. Well we found, especially with the cable barrier, that the low profile sports car gave us many problems of penetration, gave other safety problems that are very difficult to take care of, especially with a flexible system.

Mr. CONSTANDY. Without diminishing values as relates to the standard size car?

Mr. BEATON. This is right. They are a majority of the cars that are on the roadway.

Mr. CONSTANDY. In your opinion, do roadside protective devices then leave the operator of a small sports type car less protected than he would be in a standard car?

Mr. BEATON. Yes; I think this is true. Of course, I think that anybody in a sports car is less protected from almost anything.

Mr. CONSTANDY. Perhaps they need to do what they did with cigarettes; have an imprint on the side that the use of this machine may be injurious to your health.

Mr. BEATON. It would be well to be cautious.

Mr. CONSTANDY. If you would not mind standing by, we may be able to show the other film in the event we do not conclude. We would

like to thank you for your considerable cooperation and the hours that you have spent with us out in California showing us many, many pictures of the type you showed here today. Your own thoughts have been very helpful and we appreciate it.

Mr. BEATON. Thank you very much.

Mr. CONSTANDY. You have made a vital contribution in the field of highway safety and you have certainly helped us at this hearing.

Mr. BLATNIK. The Chair and all of the members of the committee express our appreciation for your excellent and very, very impressive presentation which you have made here this morning.

Mr. Beaton, we are impressed with your dramatic and well-engineered, carefully laid out test crashes and the scientific and engineering data that you have gathered and carefully collated and evaluated. What use is made of it besides the use within your own State of California Division of Highways?

Mr. BEATON. We prepared and distributed written reports to all of the States, both through the Bureau of Public Roads and also through presentation of the Highway Research Board, and I feel that several States have used this work. I have no way of knowing, of course, which ones have and which ones have not.

Mr. BLATNIK. What I am trying to get at, without getting you to pass judgment, is how it should be handled. You say several States have used it. Would you have any suggestions to make as to how we would get this to all of the States so that they would at least be aware of this information?

Is that your responsibility, or the Federal bureau, the safety section of the Federal bureau?

Mr. BEATON. It could be. In other words, they could have the machinery to disseminate this type of information. I think that everybody has to take this information and study it and make sure they can or cannot apply it in their particular situation.

Mr. BLATNIK. You may have stated it earlier. Were any Federal funds involved in this research?

Mr. BEATON. None of our earlier work but all of our later work has been funded by Federal money.

Mr. BLATNIK. All that information would be available to the Federal bureau then, and it would be their responsibility to see that the States got what was pertinent and significant. It ought to be made available to the States, either in the form of recommended designs, or directives instructing them.

We have thousands of miles of guardrail. Do you have any idea at all how many in the country are inadequate or deficient in some respect, such as being too low, improper spacing of posts, support of posts, things such as that?

Mr. BEATON. I could not even guess as to that, sir. It would be very difficult to make an intelligent guess.

Mr. BLATNIK. The reason I ask the question, in narrating an earlier reel you said this was standard guardrail design and you showed some structures in the period around 1958. You showed and described great weaknesses in it and reported great improvements in subsequent modifications. I am getting at all of the standard designs of that time. There was a considerable amount of that being installed. Do you think it is still in existence?

Mr. BEATON. Oh, yes. We have old standards in existence in our own State. There is a problem, of course, of availability of funds to correct and replace and update the highway system insofar as all of its features are concerned, and this is one of them that we updated and corrected as fast as we could. But you just cannot keep up with it.

Mr. BLATNIK. For instance, you found the 24-inch height to be inadequate. Yet I understand many of our guardrails now in existence are only 20 inches; is that correct?

Mr. BEATON. We don't have any in our State. This may be true.

Mr. BLATNIK. But there are quite a few at 24-inch height which you found to be inadequate in your tests?

Mr. BEATON. Right.

Mr. BLATNIK. Those are to be replaced by the 27-inch guardrail, with the additional improvements, such as closer spacing of the posts, and your rub rail.

Is that cost borne entirely by the State? Is there any cost of replacement of guardrail shared by the Federal funds?

Mr. BEATON. I think it would depend upon the project. I am sure that there are on certain highways, Federal highways, I am sure there could be a portion of the money. I am not an authority on the financing. I do not know.

Mr. BLATNIK. Mr. Beaton, we certainly thank you again, very very much, for a most impressive contribution to our hearings.

Mr. BEATON. Thank you, sir.

Mr. BLATNIK. From the New York Department of Public Works we have George McAlpin, deputy chief engineer for technical services, and Malcolm D. Graham, director, bureau of physical research.

Before you gentlemen sit down, would you please raise your right hands. Do you solemnly swear that the testimony you are about to give before this subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. McALPIN. I do.

Mr. GRAHAM. I do.

Mr. BLATNIK. For the record, and purposes of identification to the committee members, will you please give your full name and official title or capacity to the reporter?

TESTIMONY OF GEORGE McALPIN, DEPUTY CHIEF ENGINEER FOR TECHNICAL SERVICES, AND MALCOLM D. GRAHAM, DIRECTOR, BUREAU OF PHYSICAL RESEARCH, NEW YORK DEPARTMENT OF PUBLIC WORKS, ALBANY, N.Y.

Mr. McALPIN. I am George W. McAlpin, Deputy Chief Engineer, New York State Department of Public Works.

Mr. GRAHAM. I am Malcolm D. Graham, Director, Bureau of Physical Research, New York State Department of Public Works.

Mr. BLATNIK. May I at the outset welcome you gentlemen and thank you for laying over 24 to 48 hours to be available at the committee's convenience. The hearings ran longer than we expected and the session yesterday also was called earlier than expected.

Mr. W. MAY. Mr. Chairman, we are interested in New York's research and development of new concepts in highway barrier design. Mr. McAlpin, will you begin?

Mr. McALPIN. Yes. We would like to present to you the results of our barrier research. We would like to give you a few introductory remarks concerning the substance of this research program. We have a copy of our most recent movie and then, if acceptable, we would like to follow that with a brief statement with regard to performance of our new barriers, on the basis of accident data that have been accumulated. Then a brief statement on the general subject of implementation of research findings, as they apply to our barrier work.

If that is acceptable, Mr. Graham will give our introductory remarks concerning the research project and we will follow that with the movie, Mr. Chairman.

Mr. GRAHAM. Our research program has extended over a period of 7 years. It has resulted in the complete revision of standard designs for guardrail, median barrier, and bridge railing, as specified by the New York State Department of Public Works.

Our project started in 1959, and we more or less built upon the prior work that had been done principally in the State of California. In all, we have run 48 full-scale tests, but in the beginning of our project we wanted to approach it a little bit differently. We wanted to analyze mathematically the barrier vehicle reaction. We tried to write an equation as to what happens when a barrier strikes a vehicle. By doing this, we were convinced that we could minimize the amount of full-scale testing required.

Our full-scale testing program would first of all assist us in developing these equations, and then finally would verify the equations that were developed.

This mathematical program was successful. We were able to write these equations, which are solved on a computer and they have been very useful in assisting us in our barrier development.

The first 14 full-scale tests and the mathematical analysis were formed by Cornell Aeronautic Laboratory of Buffalo under contract to our department. During this time the bureau of physical research of the public works department performed tests, full-scale tests, on the various posts used in guardrail systems.

Finally, after the Cornell contract, the bureau of physical research took over the entire program, and ran the remaining 29 full-scale tests and completed verification with the mathematical models. Throughout our program we have been firmly convinced that the objectives of a guardrail or median barrier could best be fulfilled by a system that yields and, in yielding, absorbs some of the energy of the system, and cushions the impact of the vehicle.

So our entire program is directed toward yielding systems.

One of the most difficult aspects of the barrier design is the posts. With stout posts as you form the rail, you catch the wheel on the first post it comes to and if this is a stout post you get a violent deceleration and possibly a pitching and rolling of the car. There are two ways you can get around this. One is to offset the rail from the posts, so that the wheel does not contact it, as you have seen in the California tests. The other is to make the posts small enough so that when the car does strike it, it can bend it down without these violent decelerations.

All of our work has been directed toward the use of a lightweight post. It gives us sufficient strength in the lateral direction to support

the rail and absorb some of the energy of the car, but yet it is weak enough in the longitudinal direction to be pushed down by the vehicle without violent deceleration.

In order to optimize our posts, to find a post that would do this for us, we ran quite a series of full-scale impact tests on posts alone in a variety of soils. We wanted to get, as I said, this sufficient lateral resistance, we wanted to get a minimum longitudinal resistance and we wanted a post that would react the same in all kinds of soils, whether they be loose, frozen, dense, or what have you. We were able to accomplish this with a 3-inch I-beam post, weighing 5.7 pounds per foot. We were able to equalize the reactions regardless of the type of soil by welding a plate under the bottom of the post, a 6- by 24-inch plate. So when this is driven, regardless of the type of soil, whether it is frozen, freshly thawed or normal, we get a predictable and uniform resistance.

Once the post problem was settled, the barrier design evolved around a rail which is of sufficient strength to limit the decelerations to what you would like to have, and this led to the development of our box beam system. For use in areas where deflection must be minimized we were able, with the heavier box, to limit the deflections to approximately 2 feet, under an impact of 60 miles an hour and 25°.

For situations where a greater deflection could be tolerated, we have developed a W-beam system, again on the same lightweight posts and we have a cable system for side rails also on lightweight posts.

We have two median barriers, one with the box beam and we have another one using W-beams placed on each side of the lightweight posts.

So in all, we have five guiderail and median barrier systems and we have also developed a bridge rail system which at the present time is not used. The lightweight post is.

We had to restrict the deflection even more on the bridge, so there is a heavier weight post but using the box beam railings.

I believe that is all the introduction unless there are some questions.

Mr. W. MAY. Will you run the film now.

(The filmscript, "New Highway Barriers, Practical Application of Theoretical Design," follows:)

FILMSCRIPT, NEW HIGHWAY BARRIERS, PRACTICAL APPLICATION OF THEORETICAL DESIGN, PREPARED BY H & H PRODUCTIONS FOR THE BUREAU OF PHYSICAL RESEARCH, NEW YORK STATE DEPARTMENT OF PUBLIC WORKS

In the United States, each year, fifty thousand people die in automobile accidents. Nearly one fourth of the automobile fatalities are caused by collisions with fixed objects, including barriers. This fatality rate approaches the population of a town the size of Bennington, Vermont. Some accidents cannot be prevented, but many can be minimized by providing safer driving conditions.

Properly designed highway barriers delineate roadway limits and denote hazardous conditions. They must also redirect a colliding vehicle to limit lethal decelerations and to minimize danger to other vehicles. Our film shows highlights of a research program that has resulted in a complete revision of New York State guiderail, median, and bridge barriers. From this project, we have developed analytical procedures for predicting vehicle reaction during a collision, and, for determining optimum characteristics of barriers for use in different applications.

At the beginning of this program, three goals were set: to evaluate existing barriers; to develop analytical procedures; and to design new barriers. A barrier

must prevent a vehicle from passing through or over it; reduce deceleration forces on the vehicle and its occupants; redirect the car to minimize danger to following and adjacent traffic.

Let us examine the criteria of retention, deceleration and redirection; they are the basic requirements barriers must fulfill. In a test of a cable barrier



designed during this program, deceleration forces are limited to the extent that they should cause only minor injury. The car is redirected parallel and close to the barrier, and it can be maneuvered after impact and redirection.

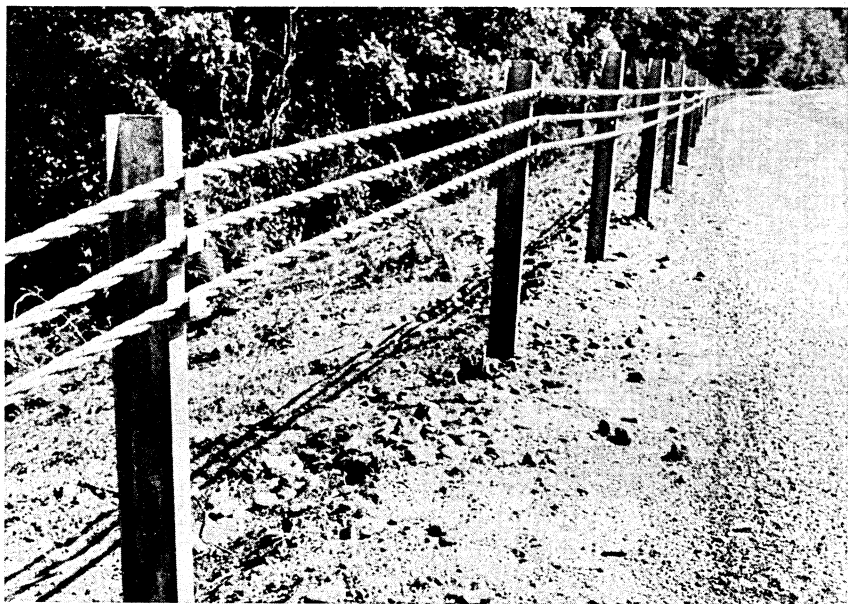
A rigid barrier, such as a concrete wall or an unyielding rail, does not absorb energy, and can cause fatal deceleration forces. For these reasons, we concentrated on developing barriers that not only contain the car but yield to control deceleration.

Initial deceleration is reduced by crushing of the car; however, to keep the deceleration to a tolerable level of less than ten times gravity, or ten g's, the



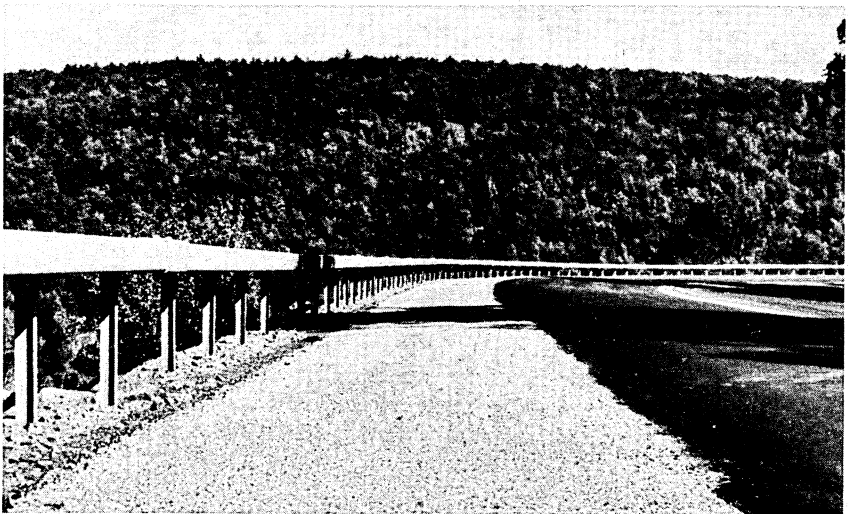
majority of the impact must be absorbed by the barrier as it deflects within the space available.

Our analysis and testing began with the cable guiderail, which produces lateral resistance through tension during impact. Next we analyzed and tested a W section guiderail, which produces lateral resistance through both tension and bending.



After analyzing these barriers, we evolved a new concept: a box beam rail that produces resistance primarily through bending. This barrier, a hollow section, supported on light posts, absorbs energy by yielding as it deflects. By changing section strength and post spacing, we have successfully tested the box beam at deflections from one foot to five feet.

As a result of our analysis, four mathematical models have been developed and programmed for solution on a digital computer. One model computes vehicle trajectory, the others compute the force deflecting characteristics for the three



classes of barriers. Vehicle position is computed for each millisecond of collision until the corresponding barrier deflections agree. The computer then prints out vehicle position, speed and deceleration, and barrier deflection. With this mathematical approach, the effects on vehicle reaction can be predicted when rail and post strengths, post spacing and impact conditions are changed.

This curve (illustrated) represents the measured trajectory of the vehicle center of gravity as the car hit the barrier and was redirected. This blue, dotted line was the trajectory predicted before the test.

Vehicle center of gravity decelerations are plotted in this curve. The predicted decelerations agree with those measured within one g.

Because we could not predict the reaction of posts in soil, we conducted dynamic tests on all eight types then in use. Test conditions simulated a car striking a barrier at fifty miles an hour and twenty-five degrees. None of the existing posts consistently provided the desired reactions. They were, therefore, unsatisfactory for our use. We then tested new designs.

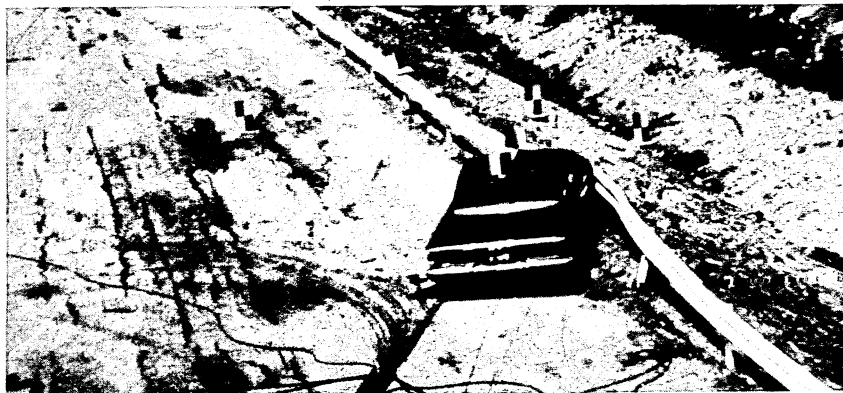
Our new post has nearly the same resistance in all soils and under all impact conditions. Yielding occurs at ground level, and post reaction can be predicted.

The imbalance of post strength and barrier rail is shown in this first of forty-eight tests we conducted. The barrier, a then standard cable design, was supported on heavy 6B8.5 posts spaced ten feet apart. The car hit the barrier at forty miles an hour and thirty-five degrees. With little redirection, it continued into the barrier twelve feet, knocked one post over, cut into one cable, and separated the second cable at a splice. The splice caught in a post offset, and stopped the car abruptly, causing a violent pitch, and yaw. The car stopped, or pocketed, within the barrier, astride the posts which had not yielded under impact.

An improved cable design, using our light posts and end anchors, was tested seven times. In the guiderail finally developed, posts are spaced sixteen feet apart, and cable are supported, by $\frac{1}{4}$ inch J bolts. These bolts release the cables as the posts are pushed down. The cables thus maintain contact with the vehicle as they deflect to absorb the impact. The car hit the barrier at forty-five miles an hour and twenty-five degrees, deflected ten feet, and was redirected and returned to the roadway. When released from the posts, the cables bunched together to control redirection. Average deceleration during impact was only 2 gs. Posts were replaced and the barrier was used in a subsequent test.

This recent installation of our box beam and cable barriers shows the effective use of the two, evidently so placed because of differing allowable deflections. This end treatment of the box beam shows how it is turned away from the roadway. The cable and anchor was designed to eliminate the severe impact that would be caused by an anchored end post. Our new cable barrier is designed for deflections up to twelve feet. The cable barrier should be used only where there are no fixed objects or hazards within the twelve feet of allowable deflection.

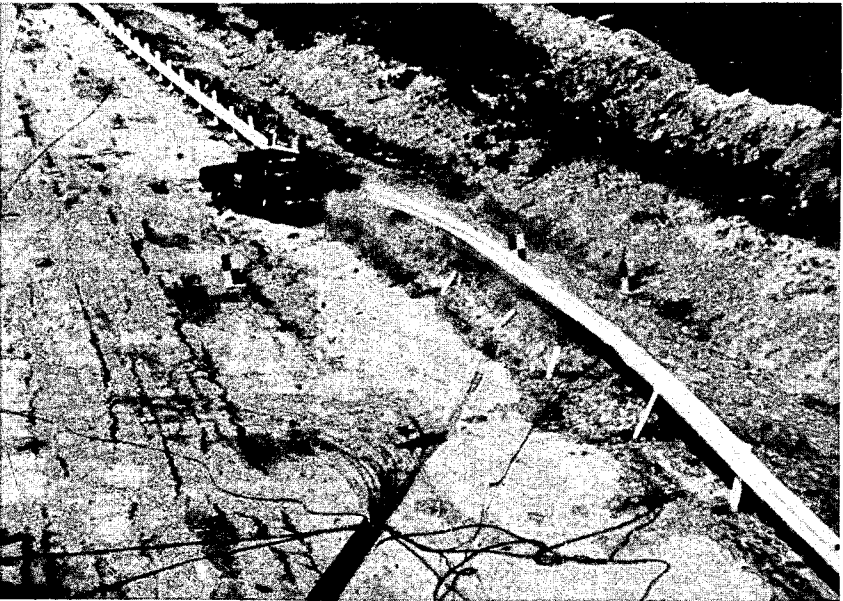
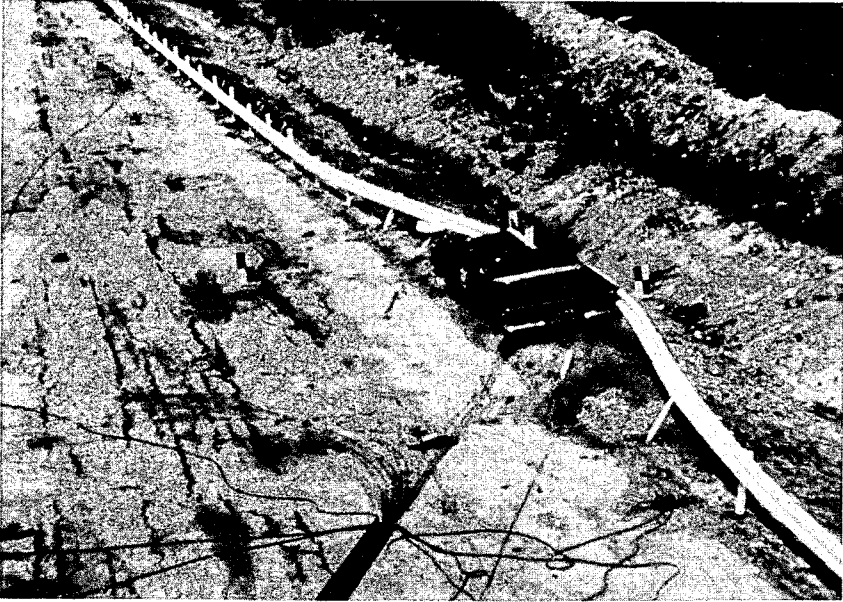
The second test in our series was performed on a conventional W section barrier, a ten gauge rail supported on 6B8.5 posts spaced twelve and one half-feet apart. Impact conditions were fifty-five miles an hour and twenty degrees. The car deflected the barrier six feet, pocketed within the barrier, and stopped twenty feet from the point of impact. The high deceleration, in addition to the violent pitching and rotation would probably have been fatal for driver and passengers. The performance of this barrier illustrates the need to have all barrier components operate as a system.



In this test of our design of the W section, the twelve gauge rail is anchored and bolted to light posts spaced twelve and one half feet apart. The car hit the barrier at fifty-five miles an hour and twenty-five degrees, deflected the barrier seven feet, and was returned to the roadway. Peak deceleration was less than 3 gs.

In another test, the car hit the W section at high speed and low angle to simulate a brushing accident. The barrier deflected less than one foot, provided excellent redirection, and limited deceleration to one g.

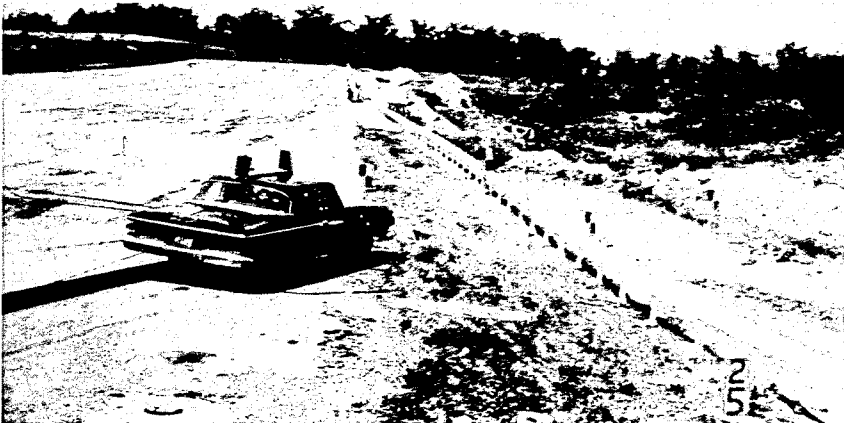
The end anchor bolted to a flared section of a recently installed W section barrier is the same anchor used with the cable barrier. It provides sufficient



restraint to develop the ultimate tensile strength of the rail and minimizes the severity of an end impact. The W sections are attached to the light posts with $\frac{1}{4}$ inch bolts. Thus, when the posts are pushed down, the $\frac{1}{4}$ inch bolts fail and release the rail so that it remains at a constant elevation to prevent the car from rolling. The W section is designed for deflections up to eight feet.

In this test of a box beam designed as a median barrier, several views are shown to indicate the way the box beam reacts to absorb the impact and limit deceleration. The rail is a hollow, structural section 8 by 6 by $\frac{1}{4}$ inch, and is supported on light posts spaced six feet apart. The car impacted the barrier at fifty-five miles an hour and twenty-five degrees, and was redirected parallel to the barrier. In another test the car impacted the median barrier at forty-five miles an hour and thirty-five degrees. In both tests deflection was limited to five feet; this deflection was greater than desired. However the post/rail connection and rail splices were redesigned to provide the desired two foot deflection.

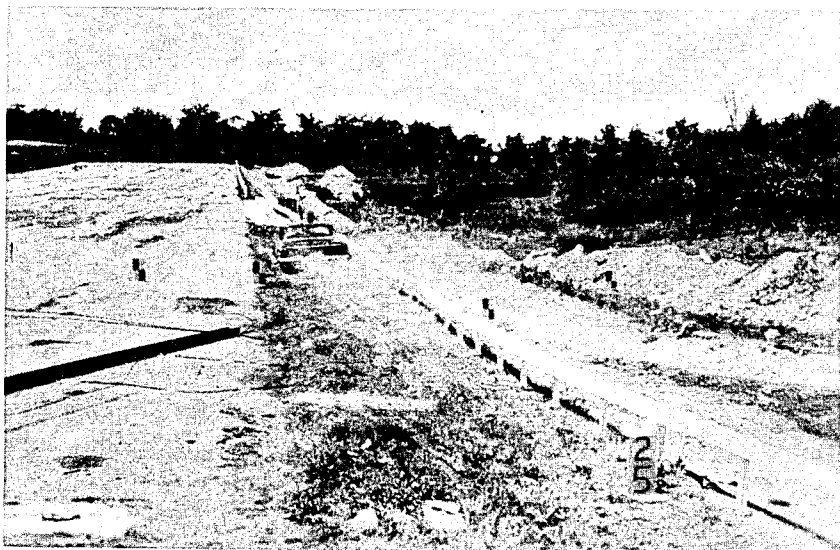
This recent installation of a box beam median barrier shows an effective end treatment. The barrier rail is not attached directly to the posts, but rests on paddles or plates bolted to the posts. These plates are inserted into the tube through slots in the bottom of the rail, and allow the posts to bend down when impacted directly by a colliding vehicle. Without a mechanical connection to the post, the rail remains at the desired elevation to prevent the car from rolling. Median barriers have been designed for allowable deflections of as little as two feet.





The box beam guiderail is shown in these scenes. An end treatment that provides additional protection sweeps up to the roadway. In this test the car hit the box beam guiderail at fifty miles an hour and twenty-five degrees. The rail remains at the same elevation as it is released by connecting bolts. Deceleration was limited to six gs, a reasonable force within the allowable deflection. The car was redirected at thirty-two miles an hour and eleven degrees, then brushed against the barrier and stopped. After impact and redirection, the car was driven away.

The closely spaced posts and splicing arrangement of this newly installed box beam guide rail can be seen. The design allows deflection of up to four feet. (See figure 6-6). On this same roadway, there are some interesting features that show the versatility of the box beam. It has been welded and shaped to



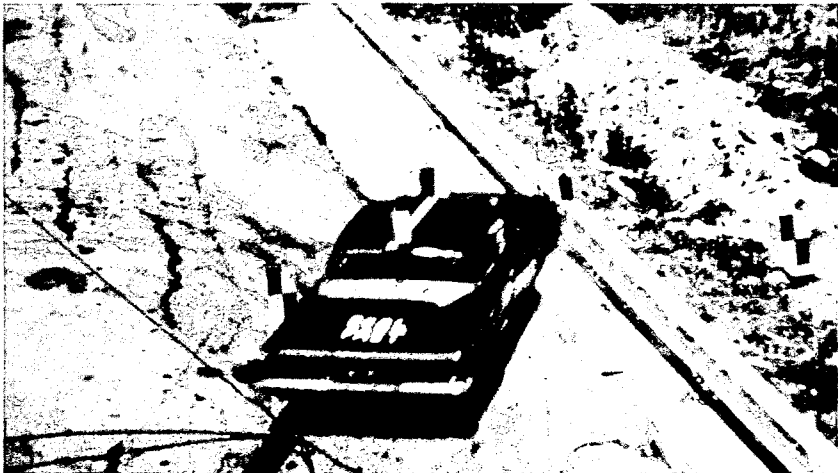
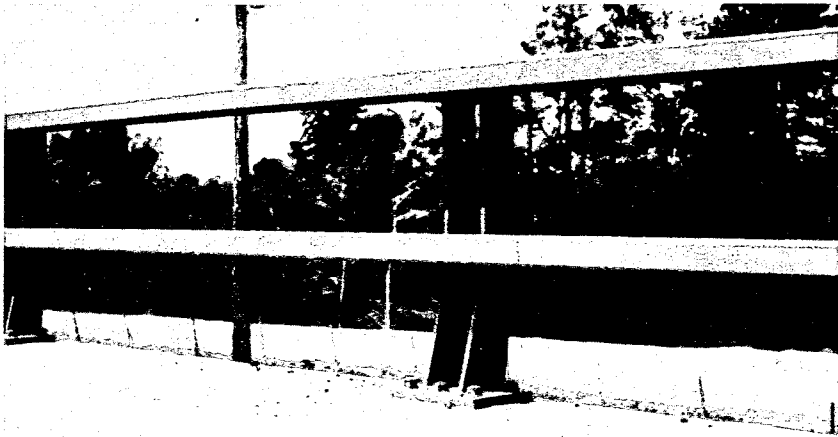
form a protective barrier at all four corners of this intersection. In this scene, the end treatment indicates the way the barrier can be swept away from the road to avoid an unnecessary hazard for the motorist.

Although a major portion of our testing was concerned with median barriers and guiderails, we also performed twenty-two tests on bridge rails.

The guide track, in which the car is moving at fifty-five miles an hour, is set for an impact angle of twenty-five degrees. The test barrier, one of several experimental barriers tested, was designed to meet requirements of the American Association of Highway Officials. This AASHO barrier consists of rigid rails offset on rigid posts. Redirection was satisfactory, and a deceleration of twelve gs was measured during the impact.

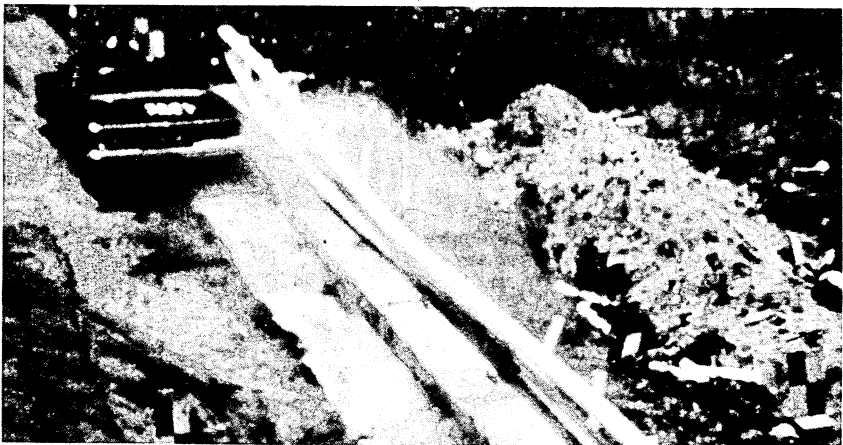
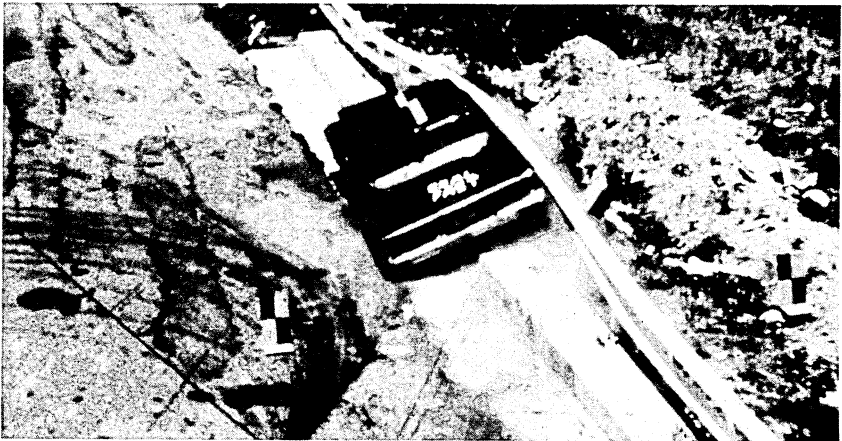
A transition to a recently installed AASHO bridge rail is provided by a box beam guiderail. Of interest to safety engineers is the use of additional bridge rails to enclose the open space between the two roadways to prevent an automobile from dropping on the road beneath the bridge.

In this bridge rail, a prototype box beam consists of strong rails and light, closely spaced posts. After an impact of sixty miles an hour and twenty-five de-



grees, the car was redirected properly and front wheel damage kept the car in a hard right turn. Peak vehicle deceleration was about nine gs.

These sequences show an early test of the box beam bridge rail. This school bus, loaded with sand bags and weighing 14,000 pounds, hit the barrier at thirty miles an hour and twenty degrees. Redirection was excellent, and peak



deceleration was limited to four gs. This test enabled us to verify the mathematical model of vehicle trajectory when it was extrapolated to represent a larger vehicle than a passenger car.

This box beam median barrier is the first installation of our design. It was installed along this section of an expressway two years ago, after we had made several successful tests of the box beam during the initial phases of our program. Posts have been damaged on six separate occasions, and three have been



straightened. No additional maintenance has been reported, and none of the rails has been replaced. Significantly, no collisions have been reported, indicating that there have been no serious injuries. Experience with this installation, in addition to the success of our dynamic testing, justifies the design concepts originated during the project.

As a result of this research program, the New York State Department of Public Works has adopted new standards for guiderail, median and bridge rails which we are confident will result in a marked reduction in the severity of barrier accidents.

The department is pleased to have been able to contribute so significantly to the safety of the motoring public.

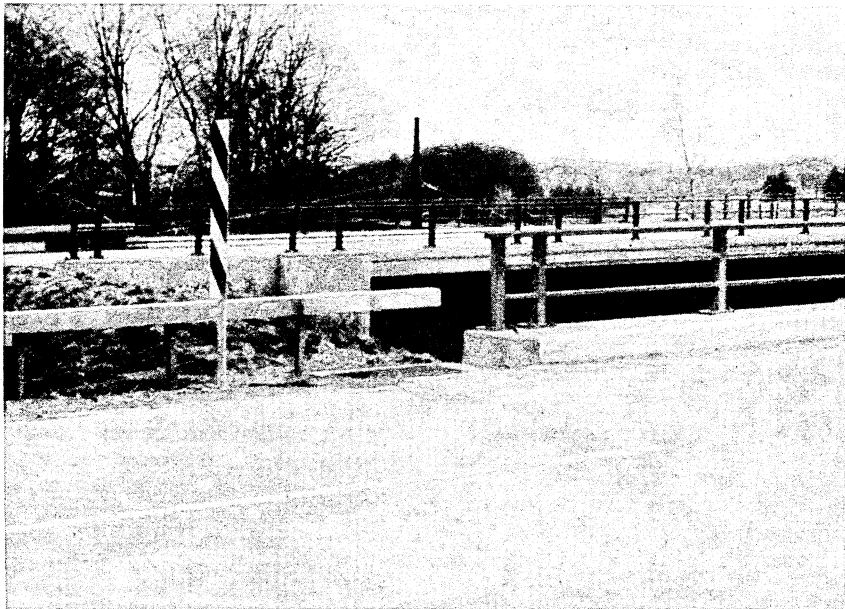
Mr. W. MAY. Mr. Graham, while we have the lights off, I would like to show some photographs taken of some of the installations of this box beam in New York. I notice from the film, to function properly, it should be firmly anchored at both ends. Is that correct?

Mr. GRAHAM. No, sir; it does not need to be anchored. We are attaching the ends, since the early designs; we are now attaching the ends to the ground. But to function properly, it does not need to be anchored.

Mr. W. MAY. Would that function properly as shown here?

Mr. GRAHAM. No; I did not realize that is what you meant by anchoring the ends. That should be attached to the bridge rail.

Mr. W. MAY. I believe that again shows the problem of communication and education down to the people who make the installations of these new systems. Is that not true?



Mr. GRAHAM. Yes, sir; it is.

Mr. W. MAY. Somebody installed this improperly.

Mr. GRAHAM. May I suggest that not knowing the installation, this is complete, except for the transition section, and is it possible that the transition has just not been erected at the time you took the photo? I am not familiar with the circumstances at all.

Mr. W. MAY. It probably was open. Do you recall whether it was open?

Mr. KOPECKY. Yes; it was opened in November 1966.

Mr. W. MAY. I notice in the photograph here there is a section of guiderail, running at a 90° angle to the shoulder guiderail. Is that designed to prevent people from going down into the space between the twin structures?

I was just wondering if that would function properly. Can you see the left end of the photograph?

Mr. GRAHAM. Yes. We have never tested it at 90°. I am not sure that anything would prevent a vehicle going fast enough from getting down in there. This, I would think, would be a credible job though.

Mr. W. MAY. Do we have another slide? Is this a proper installation? That is another location.

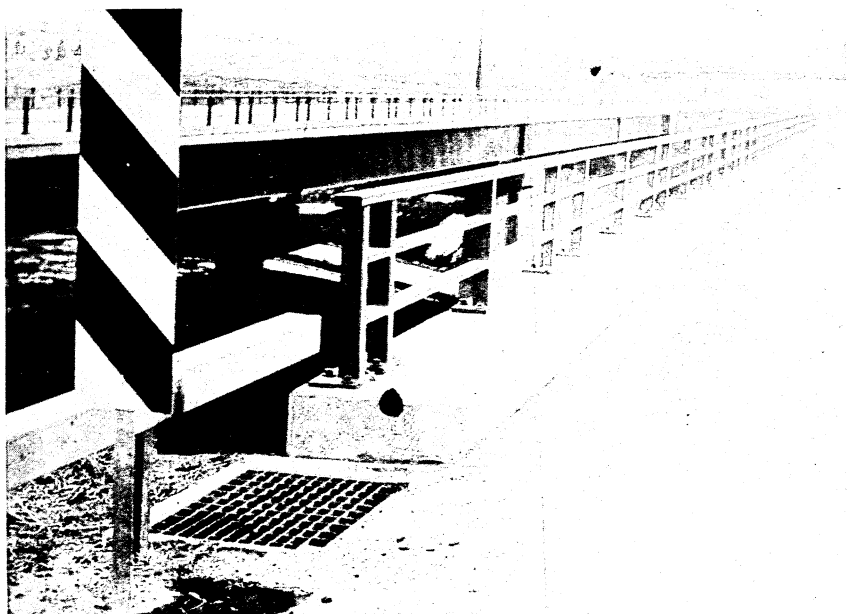
Mr. GRAHAM. Is the red spot symbolic?

Mr. W. MAY. Well, I suppose. It seems that we could make a better transition from the end of this box beam.

Mr. GRAHAM. Yes, sir; we have a transition section.

Mr. W. MAY. Yes. And that curb also presents problems.

Mr. GRAHAM. We are now sweeping the curb away on a shallow angle and it passes under the approach barrier.



Mr. McEWEN. Mr. Chairman, I would like to ask Mr. Graham a question. Should that reflector post be located inside of the traveled portion of the highway and inside of that guardrail?

Mr. GRAHAM. I believe it would be preferable, sir, to put it on the opposite side. It is lightweight and would probably not present a particular hazard, but I would say it should be on the other side of the rail.

Mr. McEWEN. In your work in the Bureau of of Physical Research, you test these materials. Do you develop also the standards for applying them and how they are to be installed?

Mr. GRAHAM. Yes, sir; we assisted with the standard section, standard design sections, for these barriers.

Mr. McEWEN. Now, are there any directives in regard to a situation like that, whether that reflector should be inside or outside of the guardrail?

Mr. GRAHAM. May I refer the question to Mr. McAlpin? I do not know.

Mr. McALPIN. I do not believe that there are instructions that are that specific for this particular installation. I would not agree that there should not be, but as existing today, I do not believe there is.

Mr. McEWEN. Mr. McAlpin, you would agree there is some degree of a hazard to that inside the box beam?

Mr. McALPIN. Inasmuch as it is a fixed object, it could be considered a hazard. There is some disadvantage for an installation of this type, where we still have the butt end of the curb there. This is being revised on our new standards, and as a matter of fact we have a remedial program to fix up these situations. You might, however, say it is in an advantageous place here because of the delineation it affords. This shows the extent the motorist should go before he perhaps would collide with the butt end of that existing curb. So I would say that this is an area where it might be preferable to put it outside, from the fixed object point of view. Certainly within the realm of our current knowledge, we should require engineering judgment for localized installations.

Mr. McCARTHY. Mr. Chairman.

Mr. BLATNIK. Mr. McCarthy.

Mr. McCARTHY. Gentlemen, I see by your report here that in New York State between 700 and 800 people had been killed in collisions with fixed objects. You mention your new guidelines, as a result of your research, which I think is very valuable. Now, since we have been mainly concerned here with the Interstate System, I assume these deaths are on all highways in our State; is that correct?

Mr. McALPIN. That is correct, Congressman.

Mr. McCARTHY. My question is, has the New York Thruway Authority adopted your new standard?

Mr. McALPIN. The thruway authority has recently, as perhaps you are aware, undertaken a major contract for the installation of median barriers. Mr. Graham and his group worked very closely with the thruway in the design of these, and they have fully adopted our new concept for these installations.

This does not mean that they have gone back and changed all existing guardrails on the entire 500 miles of the thruway system. But in their new installations and medians, they have fully adopted our concept.

Mr. W. MAY. Mr. McAlpin, I understand New York has underway a program for guiderail alterations amounting to \$15 million. As I understand, that is underway at the present time. Do you know about that, Mr. McAlpin?

Mr. McALPIN. You are speaking of a remedial program that is a program designed to make corrections in existing installations?

Mr. W. MAY. Yes, sir.

Mr. McALPIN. I apologize, I cannot frame this exactly in the \$15 million category. We have issued directives to each of our districts, to survey all locations in which the extent of protection currently being provided by guiderail is considered inadequate. There has been a tendency through the years to install guiderail and stop it too soon for adequate protection of a fixed object or other hazard. Instructions have been issued that all such cases should be fixed.

We have also issued instructions that we will afford remedial work on the end sections of all existing guiderails at hazardous points in the State. These will be flared, grounded, and anchored in accordance with our new concepts, even though the remaining portion of the existing guiderail would remain under the old standards. The total cost of this is somewhere in the vicinity of a \$15 million program, although I believe this perhaps includes our bridge rail program in addition.

Mr. W. MAY. Yes, I have in front of me a paper sent to us by the department. It says "Summary of Projects for Guiderail Alterations Program," lists the districts, and the total sum is \$15,058,000.

Mr. McALPIN. We have underway a \$47 million remedial treatment under the safety improvement program. This is underway, fully programmed; this encompasses the results of our survey of all hazardous situations that can be classified as spot improvements, other than rebuilding the roadway.

Mr. W. MAY. Do you have another slide?

Mr. McEWEN. Mr. Chairman.

Mr. BLATNIK. Mr. McEwen.

Mr. McEWEN. Before we pass this slide, what about the curb on this bridge; is that the present standard of design?

Mr. McALPIN. That is current standard design. This is a safety walk, I believe, 18-inch setback from edge of curb to railing.

Mr. McEWEN. What is the railing there? Is that steel or aluminum?

Mr. McALPIN. I believe this is a steel railing, sir.

Mr. McEWEN. Now, has that been tested by you people for stability to retain and deflect vehicles?

Mr. McALPIN. Yes, in our early work we tested all existing systems being used in the State of New York, which would include our use of aluminum rail, or our old standard aluminum, our old standard steels. I believe this is a new standard steel rail which encompasses continuity of railing throughout, rather than construction in sections. A little difficult to tell from the slide, but perhaps counsel would know.

Mr. McEWEN. In the films Mr. Beaton showed of the tests in California, I believe on the New Jersey type structure they use, concrete with the rail on top. Has that been tested in New York?

Mr. McALPIN. No; we have not tested this. New York uses very little of parapet type of design for bridge rails. At the time we entered this work in 1958, Mr. Beaton in California had already introduced a very extensive series, concentrating in the early days, I believe, on bridge rails. We followed this very closely, and not having a large usage of parapet type of rails in New York, we did not enter the field of testing.

Mr. McEWEN. Thank you.

Mr. McCARTHY. Mr. Chairman.

Mr. BLATNIK. Mr. McCarthy.

Mr. McCARTHY. On that safety walk. Last week we had a panel of experts, and the general agreement was that the term safety walk was a misnomer, and that it could be a hazard. The general agreement of that panel, as I remember it, Mr. Chairman, was that they would not in the future build safety walks.

I am wondering if you had the experience with this and if you are contemplating eliminating these so-called safety walks.

Mr. McALPIN. I certainly would not contest the misnomer of the term. This is under consideration by our bridge department. However, the use of curbs, whether or not you call them safety or make them 18 inches wide as this case illustrates, offer a drainage feature on the bridge itself. From this point of view, they deserve consideration in the overall bridge structure design.

We have, I believe, a major structure on the Interstate continuing into Connecticut, in which we have eliminated curbs. But at the present

time, the demands for drainage are considered to be sufficiently significant so that we basically are staying with this.

Mr. McCARTHY. Now, do you have an overseer of the plans of bridge engineers? Is approval of your department required before construction?

Mr. McALPIN. In our department?

Mr. McCARTHY. From the safety point of view.

Mr. McALPIN. If I understood the question, do I personally have review and approval authority over bridge design?

Mr. McCARTHY. The department.

Mr. McALPIN. The answer is "No." Our group is a technical service group. Under the staff type of functioning, in many of these areas we work extremely close with the bridge group. We have no authority or veto power over their designs. However, I would say that it would be a rare occasion where, if we had a firm and substantial recommendation, it would be ignored.

Mr. McCARTHY. Thank you.

Mr. McEWEN. Mr. Chairman.

Mr. BLATNIK. Mr. McEwen.

Mr. McEWEN. It appears, looking at this photograph, that a vehicle which collided with that guiderail would be guided into that concrete curb where the red dot is. Is there any reason why—you mention retention of water—that that could not be sloped, rather than a sheer abutment for the vehicle to strike?

Mr. McALPIN. None whatsoever. As a matter of fact, this is exactly the way we are doing it. The curb is being extended from the end of the bridge and curved around so that it continues in behind the rail. And the rail itself is being connected to the bridge rail. This gives continuity in case of impact. The curb would be there, but it will be flared around so it would not be the obstacle that it presents in this case.

Mr. McEWEN. Now as to the determination to use this type of rail, rather than the parapet which we say that was developed by New Jersey and shown in Mr. Beaton's films. Was this rail selected from the safety or esthetic standpoint?

Mr. McALPIN. I do not really know. You are out of my area. If you ask it another way, whether this rail is providing adequate safety, the answer is "Yes."

We elected to do this because of the possible distraction of the attention of the driver, and I am certain this would be a consideration. I believe we are rather open aired in New York, and like the opportunity for vision through rails rather than confinement. Thus, on major high-level structures, we are using parapets. To give additional assurance to drivers, or for the psychological feeling of security, we are using parapets.

(At this point Mr. McCarthy assumed the chair.)

Mr. McEWEN. Do you consider this as safe as a concrete parapet, from the deflection standpoint?

Mr. McALPIN. Yes.

Mr. McEWEN. Thank you.

Mr. McCARTHY. One more question on this approval from a safety point of view. Does the New York State Department of Public Works have a director of safety or someone of that type of capacity, who

looks at all of these plans before they are put under construction; to review them from a safety point of view?

Mr. McALPIN. Yes, we do, Congressman. We have within the structure of our main office in Albany a unit titled "Bureau of Traffic Engineering." This is the focal point for the entire department's operations in regard to safety features, both design and operations. It has review capacity, it recommends in regard to modifications of designs, it has counterparts in each of our 10 district offices, which perform the same functions.

Mr. McCARTHY. They review all of the plans from the safety point of view?

Mr. McALPIN. When you speak of review of all plans, I have to back off just a little to say that with the volume of plans moving through our main office group it undoubtedly does not review all plans. However, their counterparts in the district offices where the plans are originally developed do review and participate in the design of these, of all facilities.

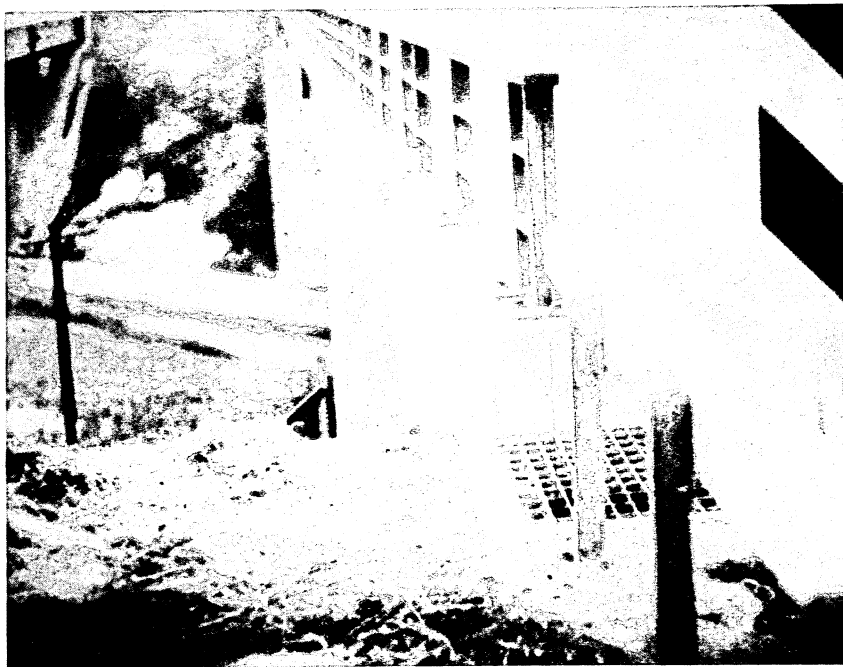
Mr. McCARTHY. And part of their mission is safety; right?

Mr. McALPIN. This is their major issue.

Mr. McCARTHY. Their major issue. Thank you.

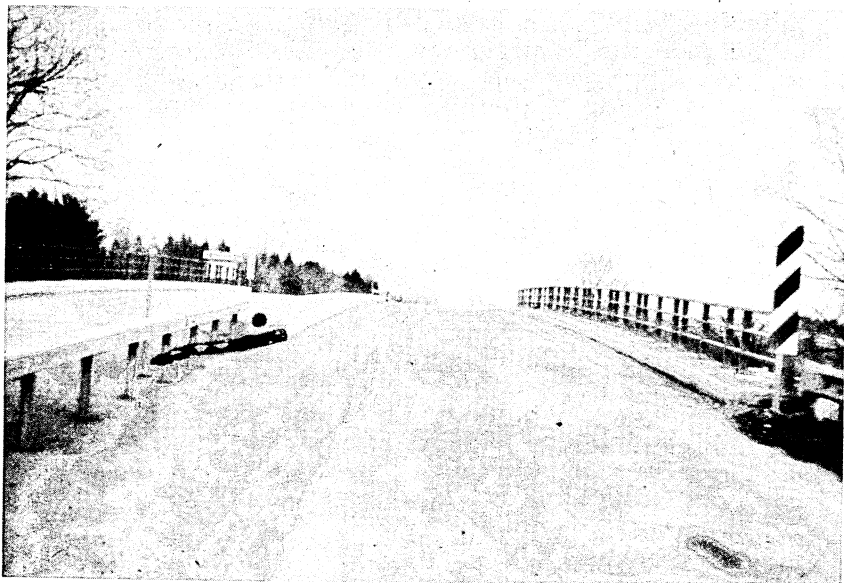
Mr. W. MAY. Could we go to the next slide?

This is just another view of that previous installation we saw. If that were struck in the area that we see in the photograph, Mr. Graham, that rail according to the concept would give way, being a weak post, would it not?



Mr. GRAHAM. Yes, sir; it would.

Mr. W. MAY. Could we have another slide? This is a different installation. But, again, that seems to represent a hazardous area; is that not so?



Mr. GRAHAM. Yes; that is so. The pictures that you call to our attention primarily represent points of transition and these are extremely critical and are receiving full attention, I assure you.

Mr. W. MAY. Could we have another slide?

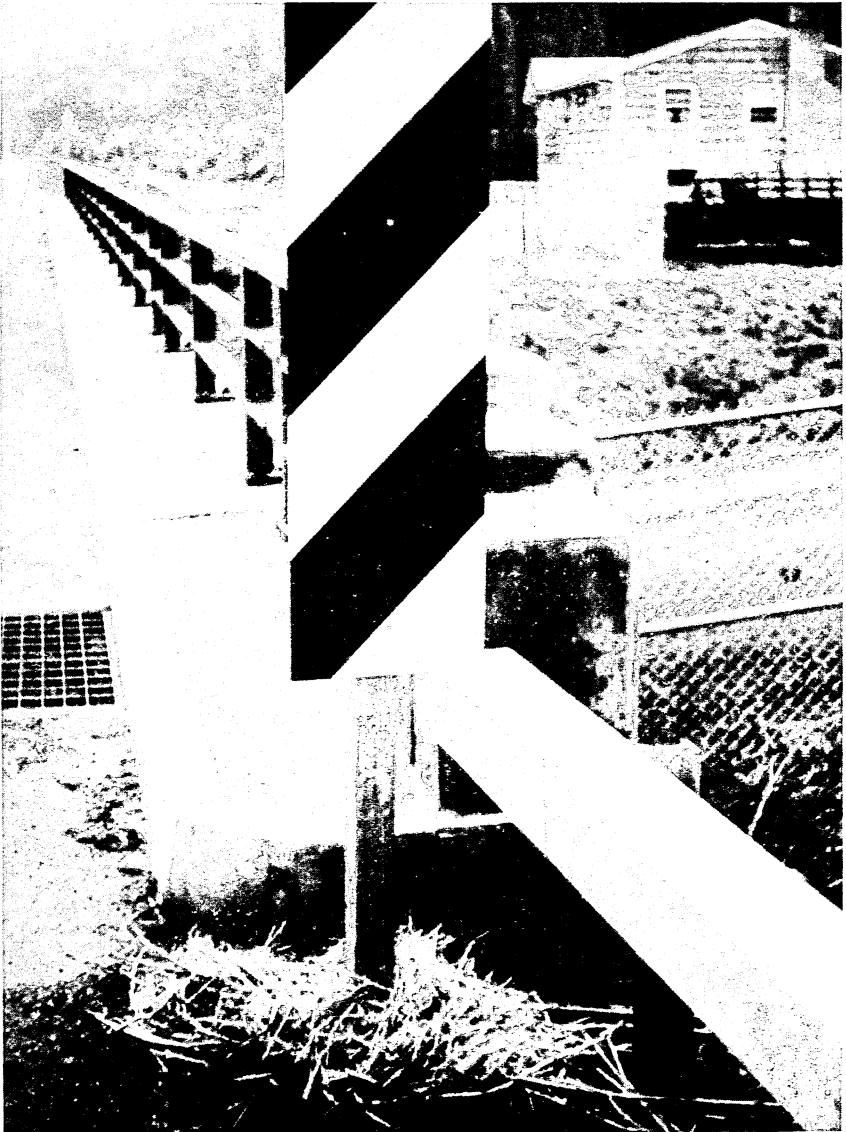
That is the same scene, only on the right. Another transition point that will have to be fixed?

Mr. GRAHAM. It most certainly will.

Mr. McEWEN. Mr. Chairman.

Mr. McCARTHY. Mr. McEWEN.

Mr. McEWEN. We have seen a number of slides showing abutments in all of the States, including New York. The abutment that is behind that reflector sign there appears to be a four-tiered concrete abutment. Can you gentlemen enlighten us as to what structural purpose this concrete abutment serves?



We have seen scores and scores of photographs of automobiles smashed into these big concrete abutments. Are these necessary structurally?

Mr. McALPIN. Absolutely not, Congressman. They have in the past hooked up somewhat with tradition, I presume. This is a peculiarity of this structure that bridge designers felt to be necessary; they are not necessary structures. They have been eliminated on all new designs in the State of New York. Our remedial program, which is included in the \$47 million program underway at the present time, is to remove all of these and provide continuity of transition between the approach rails and the bridge rails. These are going, just as fast as we can provide contracts and forces and funds to take them off.

Mr. McEWEN. As we have sat through days of viewing pictures similar to this, Mr. McAlpin, it seemed to some of us it took a while to make the transition from horse and buggy, if you will, to the automobile. Now the esthetics of this tiered abutment had totally escaped me as a motorist traveling the interstate at 65 miles an hour. I have not enjoyed the beauty of these, and had not even noticed what they were until we got these slides and looked at these objects and saw the damage they had caused the vehicles.

I fail to appreciate, and I think our committee agrees what the purpose of the esthetic design is when you are traveling at 65 miles an hour. You do not have time to look at the beauty of an abutment. It is a hazardous object when it is struck and I am delighted to know the department is now embarking on a program of eliminating these objects.

Mr. McCARTHY. Mr. McAlpin, is the \$47 million all State money?

Mr. McALPIN. No; there is Federal participation on the basis of type of Federal moneys involved. We have had on the safety improvement program the opportunity to go in on Interstate and we have an Interstate traffic formula on the A, B, C, or the regular systems. We match under that formula.

Mr. McCARTHY. What is the share, roughly in terms of Federal funds and State funds, of that \$47 million?

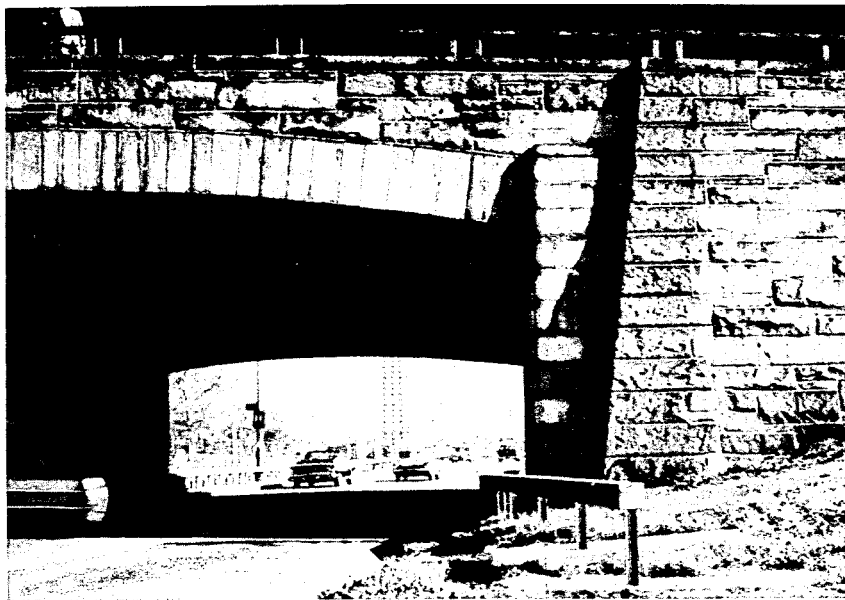
Mr. McALPIN. I am sorry, I cannot tell you. A lot of it we are concentrating on our Interstates in light of new standards. There is a great deal of regular 50-50 money. What this proportion is, I am not prepared to say.

Mr. McCARTHY. So it would be over half Federal money?

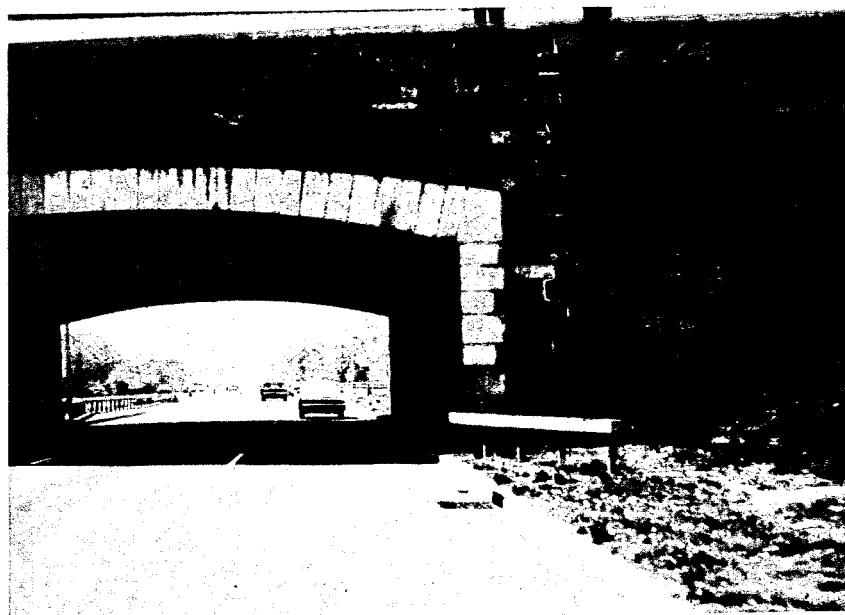
Mr. McALPIN. I cannot even say this, Congressman, I am sorry.

Mr. W. MAY. Do we have another slide? Could that installation be improved, Mr. Graham?

Mr. GRAHAM. Yes; we would ramp that down and attach it at the foundation.



Mr. W. MAY. Could we have another slide? I understand that is another location but similar type installation.



Could we have another slide?

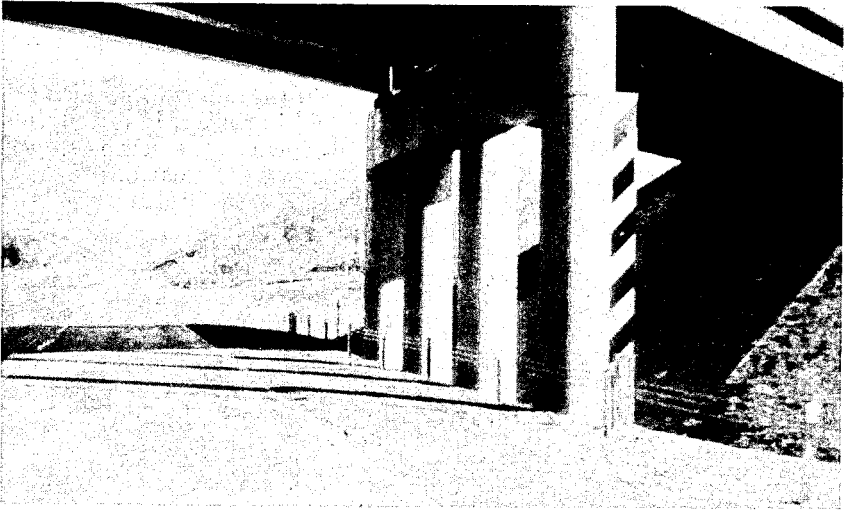
Now there is an installation of your cable barrier that is designed to deflect how far, Mr. Graham?

Mr. GRAHAM. Twelve feet under maximum impact.

Mr. W. MAY. Would that be an improper use of that cable barrier?

Mr. GRAHAM. Yes; it certainly appears so. I do not know how far it is from the post to the face of the piers.

Mr. W. MAY. Could we have another slide?

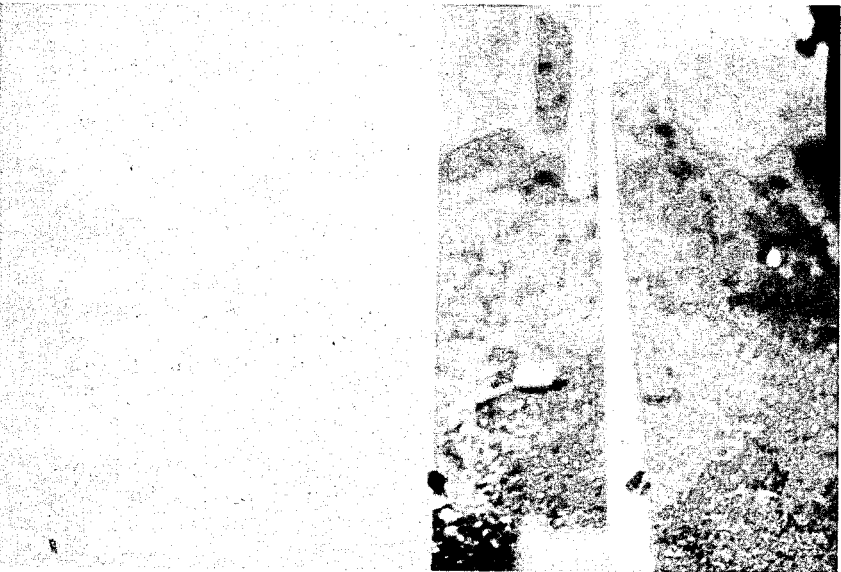


It is about 10 inches.

Mr. GRAHAM. That would have to be changed.

Mr. McEWEN. Mr. Chairman.

Mr. McCARTHY. Mr. McEwen.



Mr. McEWEN. A couple of the slides previous you had your new box beam coming into that abutment. Is that not also a flexible barrier?

Mr. GRAHAM. With the box beam, and with posts at 4 feet, we can restrict the deflection to about 2 feet. We do need 2 feet between the abutment and the rail.

Mr. McEWEN. Now are you using W-beams at all in New York now?

Mr. GRAHAM. Yes, sir. We need 8 feet but for a normal side road installation, where we do not have fixed objects close to the roadway, both the cable system and the W-beam system work very satisfactorily.

Mr. McEWEN. Well, now, what would be the best type of guardrail here, W-beam, box beam, or cable? (refer fig. 6-26).

Mr. GRAHAM. The box beam is the best thing we have for this type of installation. I presume this is a fairly old highway, judging from the type of abutment that is in there. And I believe the box beam was installed to improve a bad situation to the greatest extent possible. Of course, we are not building the abutments like that and we have not for many, many years.

Mr. McEWEN. Would that be considered also too short an installation now under your standard?

Mr. GRAHAM. We would extend it all the way through, and we would extend it back farther, and attach it down to the ground, to avoid any possibility of striking the end.

Mr. McCARTHY. Is it fairly tricky to install this? I have a little sample here. I think, from what we have seen here, the evidence will indicate that this is the best system. But I am wondering if it requires quite a bit of attention to see that it is installed properly. Would that be true?

Mr. GRAHAM. No, sir; I would not say so, any more than any other system. I have observed them putting it in. They drive their posts 6 feet normally. The little paddles that go on top of the posts are bolted on, and the beam, of course, is fabricated in the shop and it is lowered over the posts. Where there are splices, we must insure that those are snug, otherwise we would get more deflection than we wanted. But I would say by comparison with other types of barriers, it is not a difficult or tricky thing to install.

Mr. McCARTHY. Is it inspected before it is accepted by the State, by a qualified inspector?

Mr. McALPIN. As to structural soundness in conformance with existing plans and specifications; yes, in all cases.

Mr. McCARTHY. How about the application, do they check to see that it is properly installed?

Mr. McALPIN. I qualified my other statement to the effect that it would be installed as the directions were indicated on the plans and specifications. If you mean whether we have a review group that would go out to check whether the original indicated design was correct, in the early instances, certainly, as exhibited here with these slides, this was not being done. We are paying considerable attention to this now, and trying to bring our house in order, especially on these transition situations.

Mr. W. MAY. I think that is the last photograph.

I think what we have seen here, Mr. McAlpin and Mr. Graham, is a real excellent concept; a new concept, of highway barriers. There is

no question but that the research people should certainly be commended and so should New York for adopting the new concept. But again it stresses the real problem we all have when it comes to communication and education, particularly to the people who install it, to see that it be done properly. Would you agree?

Mr. McALPIN. Yes; there is a continual communication problem in our business, just as in any other business. This becomes more and more severe each day. With the rapidity of technological changes we find that there is much, much more to communicate.

(Mr. Blatnik resumed the chair at this point.)

Mr. W. MAY. Again, pointing out the communications problem, we on the staff have talked to highway officials in other States, and some of them have mentioned the New York box beam rail to us. So it shows they have heard about it. But I recall one of them told us, "We will never use it here because the maintenance cost will be so high."

For the record, could you tell us about what the maintenance cost has been?

Mr. McALPIN. We have introduced a continuing accident data collection record on our new barriers, including old barriers for the sake of comparison. These data are sort of limited in volume to date. However, they do indicate without serious question that the maintenance costs on the new barriers are not in excess of what we have experienced in the past. This includes all of the four major design barriers, the cable, the W-roadside, the box roadside, and the box median.

Mr. W. MAY. So that the thought that maintenance costs might be extremely high is probably the wrong thought and should not deter them?

Mr. McALPIN. It is not in accordance with New York's experience.

Mr. W. MAY. The film mentioned some experience that you had with prototypes of this barrier. Do you have data along that line?

Mr. McALPIN. Yes; I do. The data as of this date indicates that the accidents on our new cables are considerably less severe than on our old cable system. For example, there were no reported fatal accidents, or any accidents requiring hospitalization on the new cable guidrails. These categories represented 1 percent of the fatalities and 16 percent of the hospitalizations with our old-type design.

Stating this as a ratio on our old cable rail design, the survey suggests that one of every six accidents may result in injury requiring hospitalization.

The data on the old-style W-beam fully supports our research findings that these old designs, too, can result in personal injuries. On the W-beam guiderail of old design at the roadside we recorded 261 hits, resulting in six fatalities and 32 hospitalizations and 56 minor injuries.

On the old W-beam median barriers, we have 51 reported hits, where two were fatalities and eight were hospital cases and seven were minor injuries.

We do have some examples in regard to the box-beam median barriers. We have a continuous 2,700-foot length of this barrier, on a New York City expressway. It was installed in January 1965. Prior to this, the section had no barrier installed. Accident records for 1963 through 1964 indicated five cross-median collisions in the 2-year period. Two of these accidents caused fatalities, two resulted in personal injuries, and one caused only property damage. In all, two people were killed and three people were injured.

In the 2-year period since we installed the new design barrier, it has been hit at least six times in major collisions but no personal injuries at all have been reported. In three of these collisions one post was removed each time and required replacement. In another, one post had to be straightened. No maintenance has been required to the box-beam rail itself.

On a State parkway, we have a 2-mile section of the box-beam median that has been in service since 1966. Accidents on this section during the period 1961-65, prior to the barrier installation, accounted for four fatalities, 14 injuries, and seven property damage connected with cross-median accidents. In all, six people were killed and 42 were injured. During the rather short period of the survey of 3 months since the installation of the new barrier, there have been reported six sizable accidents, and in none of these cases has there been any injuries, except a reported bloody nose in one particular case.

In one accident of this group, there is a report from the operator of the car, to this extent: He stated he was driving south at approximately 45 miles an hour, lost control of the vehicle, crossed the passing lane, struck the center divider rail with the left front of the vehicle, then brought the vehicle under control and continued south.

This type of performance we think verifies our rather substantial research in this area. The general conclusion on the subject—we would say that New York's experience to date, with limited survey information available, does not suggest excessive maintenance on any of these types of barriers, and is a very pleasing and pleasant reaction in regard to the severity of injuries to occupants.

Mr. W. MAY. Very good. Thank you. Mr. Chairman, we on the staff are personally aware of how adequate the New York Department of Public Works has been in the highway safety field in the past several months. There is great activity there. It has some very fine programs and symbolic of their programs appears to be this letter of June 8, 1967, sent out by B. A. Lefevre, deputy chief engineer, to all of the district engineers.

He refers here to the new way in which they will give attention to guiderails, signs, light standards, utility poles, medians, interchanges, piers, abutments, walls, rock cuts, trees, bridges, exit ramps, headwalls, drop inlets, culverts and slopes.

I ask permission to have it printed in the record at this point.

Mr. BLATNIK. Without objection, so ordered.

(Letter of June 8, 1967, from deputy chief engineer to all district engineers, follows:)

DEPUTY CHIEF ENGINEER GENERAL LETTER 67-55

SAFETY IMPROVEMENTS ON GOING PROJECTS

To All District Engineers:

We have been working on these safety improvements long enough so that by now we should not be permitting jobs to progress with some of the recognized hazards still being included. This is not only undesirable but it is costly. We'll have to come along and correct them in the very near future.

So I'm asking you to once again look over going jobs as well as those going to contract with old plans on old standards and to initiate changes *now* to bring these jobs up to a reasonable standard of safety. The following things are to be reviewed and done!

1. *Guide Rail*

Do not install any guide rail of the old type. Use one of the new types. No more heavy posts are to be used. *All ends* are to be brought down near ground level. Make sure approach end is properly located. Do *not* use short sections of guide rail (2 or 3 lengths).

2. *Signs*

No heavy gore signs are to be placed. Use Breakaway type—wood or metal—see new Standards. Also see new standards for other ground mounted break-away signs. Heavy signs less than 30' from pavement that cannot be changed are to be protected by guide rail. Sign foundations are to be substantially flush with the ground.

3. *Light Standards*

Use frangible base and light weight poles. Foundations are to be substantially flush with the ground.

4. *Utility Poles*

Utility poles should be 30' from the pavement on 50 M.P.H. roads. When relocating these utilities on contracts get them back.

5. *Medians*

Install median barrier where median is less than 36' wide.

Slopes to the barrier should be generally 1 on 6 with 1 on 5 as steepest. You will have to watch your drainage—maybe even underdrain if needed.

Barrier can be cable or W Beam as well as box beam where there is room for deflection.

Where you have a narrow raised median (up to 12') with curbs, reduce median width to 3' curbed and use box beam median barrier or eliminate raised median and use flush area plus box beam barrier.

6. *Interchanges*

Separate opposing ramps by box beam or double W as per Standard Sheets.

Install "Wrong Way" signs on "off" ramps. There is a standard for this.

If you have unusual problems at ramp ends, send in your suggested method for review and approval.

Control access at crossroads for 300± in accordance with instructions.

7. *Piers, abutments, walls, rock cuts, etc.*

For fixed objects of this kind less than 30' from pavement on 50+ MPH highways protect with guide rail. For speed zoned areas (under 50 MPH) use your best judgment.

8. *Trees*

Trees over about 3'' in diameter should be 30' or more away from the edge of the pavement on 50+ MPH highways. This is a very critical, emotional, hysterical and illogical problem. Do the best you can. And when you do remove a tree—remove it *fast* and haul it away *fast*.

Where you can anticipate tree removal and can get the OK from property owners, if needed, why not set up a landscape project to plant trees several years ahead of the removal of the old trees?

When you plant trees, do *not* plant a tree that will mature at over 3'' in diameter closer to the pavement than 30'.

9. *Bridges*

Replace such bridge rails as are selected for replacement and approved by the Bridge Subdivision.

Remove pylons from bridge ends.

Connect bridge rail to approach guide rail with positive and adequate connection.

Flare safety walk or brush curb ends back and away to a point under and beyond the guide rail where there is no approach curb.

10. *Exit Ramp*

The area beyond the gore area shall be so graded that if a vehicle goes through the gore, it will be able to be controlled and brought to a stop. This means elimination of the sharp "ravine" and replacement with negotiable slopes. Drainage must be adjusted accordingly.

11. Headwalls—Drop inlets—Culverts

Eliminate headwalls. Where an entrance structure is necessary on a culvert it will be so designed and, *if necessary*, protected by guide rail. Culverts will be extended to provide a safe recovery area. Large culverts are usually in high fills that require guide rail. In those cases where there are large culvert open ends that are not protected there is a potential hazard. However, guide rail placed just above the culvert end of a slope steeper than 1 on 5 is practically useless. Therefore, any protection that you deem necessary for such a situation will have to be substantially in the normal location for guide rail and so placed as to intercept a car coming in either direction on a 2-lane highway or from just the one direction on a divided highway with adequate median or median protection.

Drop inlet grates in medians and other such exposed locations must be flush, with no raised portions, to permit *free* passage of a wheel of a vehicle. It is suggested that you use a bar type grate with the bars parallel to the ditch. Let the grate be rectangular with the long dimension along the ditch line.

12. Slopes

Flatten slopes wherever possible. You may be able to eliminate guide rail by so doing. *All other* things being *equal* and based *only* on relative damage to a vehicle and passengers from striking the guide rail or going down the slope, the following is a *GUIDE* for fill heights *without* guide rail:

Slope	Ht. fill (feet)
1 on 2-----	10
1 on 3-----	20
1 on 4-----	40
1 on 5-----	50
1 on 6-----	60

Remember this is a *guide* and must be so regarded. If there is a river or lake at the bottom of the slope or other hazards or limiting factors such as trees, houses, buildings, or other such fixed objects, this cannot apply. Also if the alignment together with the fill produces a mental hazard or optical illusion or if the curvature is too severe to be adequately marked by delineators, then you must use your best judgment. I am sure you will not find many places where you can spread out so much on *high* fills.

The determination as to which slopes to use is one based on R.O.W. geographic features, neighborhood development, economics and aesthetics.

We expect that you will solve the problems listed in the "Dangerous Dozen" by Orders on Contract and, if necessary, field change drawings. In any case do it *early* in the contract—give the contractor a break. Try to get agreed prices on any work for which there is no bid item. If these changes are initiated early enough, the work can be done concurrently with the rest of the job and no extensions of time should be required.

Mr. McEWEN. What did Mr. Lefevre say about rock cuts? Is that in the letter? Does he refer to rock cuts?

Mr. W. MAY. "For fixed objects of this kind less than 30 feet from pavement on 50-mile-per-hour-plus highways, protect with guiderail."

Mr. McEWEN. What was the date of this letter?

Mr. W. MAY. June 8, 1967.

Mr. McALPIN. Counsel, if I might just add, this is of significance. This concerns going projects.

Mr. McEWEN. Mr. Chairman, the reason I ask this, I say to the gentlemen here present, is that I recently traveled over a very good primary four-lane highway, Route 12 running northeast from Alexandria Bay. This road was opened just last fall. There are a number of rock cuts in there, and at a number of exits the slopes appear to be severe.

There are new type guardrails at several places, but through none of those rock cuts are there any guardrails. And the rock cuts are much closer to the paved portion than the standard set forth in Mr. Lefevre's

letter. You, Mr. McAlpin, I think, or maybe Mr. Graham, one of you referred to the directive now to do away with the short sections of guardrail.

Again, on this highway, just open last fall, there are very short sections of guardrails where there are tributaries flowing into the St. Lawrence River and in a number of these situations, some of them are so short, in my opinion, the only thing they could guard against would be a car, when it got to that bridge or culvert, doing an absolute right-angle turn. They do not guard at all if you lost control; you would go down the ravine into that gully.

This is why, Mr. Chairman, I wonder if the big problem here, when we see the wonderful work these gentlemen are doing, is the lack of communication—a problem of how this gets down to the person at the district level who is doing the job.

For example, who is thinking of safety when that warning marker is put inside of the guiderail, such as we have just seen? There just seems to be no reason why these things are done. It would appear what they are doing is with no thought at all of safety.

MR. BLATNIK. That is a good question. One of the objectives, the end results, will be to find out why.

MR. W. MAY. I would just like to make the physical research report on "New Highway Barriers, The Practical Application of Theoretical Design," exhibit No. 17, Mr. Chairman. This is a most comprehensive and worthwhile report and should be studied carefully by the highway officials who have responsibilities in these areas. This report and other data, may be obtained from Mr. McAlpin and Mr. Graham.

MR. BLATNIK. No. 17. Without objection, so ordered.

(Exhibit No. 17 is retained in subcommittee files.)

MR. W. MAY. I would like to again express the appreciation of this staff to Mr. McAlpin and Mr. Graham. Mr. Chairman, no one in this country helps this staff any more than the highway personnel of California and New York. For the past number of years, we have spent many, many hours with them and they have given freely of their time. We could not do without them.

MR. McALPIN. Might I make just one statement, Mr. Chairman?

MR. BLATNIK. Mr. McAlpin.

MR. McALPIN. I know you are stressing the very difficult problems, and Congressman McEwen spoke of this matter of communications. From the research standpoint, we think of this as implementation of research findings. This is the problem; the gap between the research finding and the implementation or inclusion of these in new designs that become a reality. This is the dividend we are seeking.

I would like to say that there are instances in which this is done, we think quite successfully. The report we are handing you today is our final research report on New York's barriers. It is dated May 1967. New York is fully implementing all of the recommendations in this final research report. In many instances, we in research think of completed research being the terminal point—represented by the date of such report; that is the point at which implementation starts.

In New York, we feel we have successfully bridged this gap between research and implementation to an enormous extent. Had we elected, however, to delay implementation until all of the fine points had been worked out, such as the rail transitions which we are awfully sorry

about being there and which do present real hazards and were called to our attention, then perhaps other problems would have been created. I would say, due to our ability and good engineering judgment in the Department of Public Works, as of this date of this final research report we have let to contract over 740 miles of newly designed barriers.

This has been accomplished prior to the date of a final summary of all the research aspects. Further, we have issued orders to make remedial improvements on all current projects to the maximum extent possible. Further, we have an active program of bridge rail and guardrail replacement.

We believe that we are making some real progress. As for communication between States, I might add for Mr. Beaton's sake that in the middle of our research, we adopted California's median blocked-out barrier in 1962 based on the results of California's experience, as an interim before we moved into our new designs.

Mr. BLATNIK. The Chair on behalf of the entire committee thanks Mr. McAlpin and Mr. Graham, for their excellent and most helpful testimony and presentation. Thank you very much, gentlemen.

This concludes the hearing for this phase of the committee work. I have a short closing statement.

There is one thing that has been clearly established by the testimony we have heard this week, and that is the vital importance of having clear roadsides along our traveled highways.

We have seen demonstrated again and again what happens to the vehicle that hurtles off the road and smashes against some massive, rigid fixed object—which hindsight then often shows should not have been there in the first place.

It is not reasonable to suppose, of course, that our roadsides can ever be made 100 percent free of fixed objects. However, we have learned that many of these pieces of highway hardware that are absolutely necessary can be of a "breakaway" type that readily give way when hit, causing only slight damage to the car, and leaving its occupants uninjured. The difference between this result and what happens when a car hits signs or other objects held by solid, heavy-duty, steel I-beams or pipes mounted upon reinforced concrete bases, is a dramatic one indeed.

If the necessary roadside object cannot be of breakaway construction, then it should be adequately protected by proper guardrail or other impact attenuation devices which will prevent or minimize the damage.

The availability of breakaway and impact absorbing devices has been well illustrated by the testimony we have heard this week from people in the field of research and development. We have watched pictures of speeding cars crashing against sign supports with no serious damage resulting because the objects struck were not anchored in concrete, but readily "gave" or "spun" out of the way when hit. We have seen and heard about whole new concepts in the field of highway design and safety from these experienced and knowledgeable witnesses who so badly need to be listened to and heeded by those in authority.

Some of the more important concepts in the field of safe highway design are not new. The desirability of reasonably clear roadsides and gore areas, for instance, has been known and repeatedly demonstrated

by accident experience for many years. So has the proper and safe installation of guardrail and other concepts that we have found being honored in their breach more than in the use.

It is mainly in the failure to make application of these concepts that the difficulties have arisen. The knowledge is there. We have seen it and others have seen it. It is available upon request. The people in the field of highway engineering research have done an impressive job, which our witnesses these past 3 days have so capably shown. Yet the testimony the previous week showed that some of the most basic concepts of safe highway design had been disregarded in the design and construction of some of our newest, most recently opened sections of interstate highway in each of the nine regions of the United States administered by the Bureau of Public Roads, which had been visited by our staff on a sampling basis.

Naturally, having clearly established the conditions, we asked simple questions. The gentleman from New York, Mr. McEwen, just a few minutes ago, asked the question "Why?" Can we dismiss the problem by observing that there has existed over the years a failure of communication between the people at the top to those in the field who actually make the installations? Hardly, since we realize that although the installations, true enough, are made in the field, the design and plans from which they flow originate and must be approved at responsible levels.

It is the responsibility and duty of this subcommittee to seek the answers to the serious questions that have been raised by the testimony we have heard thus far in these proceedings.

This we shall proceed to do when we resume and continue our public hearings during the coming months.

There being no further witnesses scheduled for today the hearings are adjourned. Further hearings will be held at the call of the Chair.

(Whereupon, at 12:50 p.m., the subcommittee was recessed, to reconvene at the call of the Chair.)

HIGHWAY SAFETY, DESIGN AND OPERATIONS

Roadside Hazards

TUESDAY, JULY 18, 1967

HOUSE OF REPRESENTATIVES,
SPECIAL SUBCOMMITTEE ON THE
FEDERAL-AID HIGHWAY PROGRAM OF THE
COMMITTEE ON PUBLIC WORKS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:08 a.m., in room 2167, Rayburn House Office Building, Hon. John A. Blatnik (chairman) presiding.

Present: Representatives Blatnik, McCarthy, Cleveland, Clausen, Duncan, McDonald, McEwen, and Zion.

Staff present: Same as previous days.

Mr. BLATNIK. The meeting of the Special Subcommittee on the Federal-Aid Highway Program will please come to order.

For a number of weeks we have been holding these public hearings on the safety, design, and operational efficiency of our highways, roads, and streets.

This opening phase of our hearings has been mainly concerned with the problem of roadside hazards. The subcommittee's investigation, however, is a continuing one. And during the months ahead we plan to examine other important areas in the field of highway design.

After further exhaustive in-depth investigation into the subject matter has been completed by our staff, these hearings will be resumed.

Meanwhile, before we conclude this first phase of our hearings on Thursday of this week, it is entirely fitting that we should hear from representatives of AASHO, the American Association of State Highway Officials. Testimony by AASHO officials has been of considerable help to our subcommittee in past hearings covering a number of years. We not only appreciate but we welcome the comments and observations of the gentlemen present with us this morning relative to the subject matter of our current hearings on highway safety and design.

I also say further that close cooperation and coordinated efforts and assistance will be received from AASHO, according to Mr. A. E. Johnson, executive director, and my friend for many, many years.

Mr. Eugene Johnson, Chief Engineer, Mississippi State Highway Department, chairman of AASHO's design policy committee, we appreciate your coming here with the distinguished and experienced gentlemen with you.

As is customary, we do have the witnesses take an oath; so if you gentlemen will please stand and raise your right hands.

Do you solemnly swear that the testimony you are about to give before the committee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. E. M. JOHNSON. I do.

Mr. A. E. JOHNSON. I do.

Mr. IVES. I do.

Mr. SNIDER. I do.

Mr. GOODMAN. I do.

Mr. BLATNIK. Please be seated.

Mr. Johnson, would you please introduce your colleagues and associates who accompany you, and would you please proceed?

TESTIMONY OF EUGENE M. JOHNSON, CHIEF ENGINEER, MISSISSIPPI STATE HIGHWAY DEPARTMENT, CHAIRMAN, AASHO PLANNING AND DESIGN COMMITTEE, AND PRESIDENT, AASHO A. E. JOHNSON, EXECUTIVE DIRECTOR, AASHO, WASHINGTON D.C.; HOWARD S. IVES, COMMISSIONER, CONNECTICUT STATE HIGHWAY DEPARTMENT, CHAIRMAN AASHO COMMITTEE ON ROADSIDE DEVELOPMENT; MARVIN J. SNIDER, CHIEF ENGINEER, MISSOURI STATE HIGHWAY COMMISSION, CHAIRMAN AASHO COMMITTEE ON CONSTRUCTION; AND WARD GOODMAN CHIEF ENGINEER, ARKANSAS STATE HIGHWAY DEPARTMENT, CHAIRMAN, AASHO COMMITTEE ON BRIDGES AND STRUCTURE

Mr. E. M. JOHNSON. Gentlemen of the committee, I am E. M. Johnson, chief engineer, Mississippi State Highway Department, and president of the American Association of State Highway Officials.

I am appearing in the latter capacity and am accompanied by Mr. A. E. Johnson, executive director of AASHO, and several members of the special AASHO Committee on Traffic and Safety.

I would like to introduce these please, Mr. Chairman. Mr. Ives of Connecticut, who is chairman of the Roadside Development Committee of AASHO; Mr. Ward Goodman of Arkansas who is chairman of the committee on bridges and structures; Mr. Marvin Snider, who is chairman of the construction subcommittee.

We understand that Mr. John Morton from New Hampshire, who is chairman of the traffic committee, is en route. There are two other members who are unable to be here due to other commitments, Mr. Prahl of Washington, who is chairman of the maintenance and equipment subcommittee, and Mr. John Meyer, who is chairman of the design committee.

This special committee was created 3 years ago to emphasize traffic safety and to coordinate the work of the various committees that have primary responsibilities in that field.

It is made up of the chairmen of appropriate AASHO committees, and originally included the committees on planning and design policies, design, maintenance and equipment, and traffic, with the president of the association serving as the chairman because of the importance of the operation.

This committee includes several specialized fields, inasmuch as traffic safety transcends the interest of more than any one single committee. Recently, we added the chairman of the committees on roadside development, construction, and bridges and structures to make the special committee even more effective.

It was this special committee, together with four traffic engineers assigned as special observers, that made an inspection trip and study a year ago that resulted in the publication of the AASHO "Yellow Book" entitled "Highway Design and Operation Practices Related to Highway Safety."

We are sure that you are familiar with this publication. It includes the observations and recommendations of those who took part in the study. It was not balloted upon as an AASHO standard, but was issued as a committee report for the purpose of furnishing a checklist or guide in coordinating safety design features and for improving operation to enhance traffic safety.

It has been used to spearhead stepped-up activity in the safety program.

The association has printed and distributed 20,000 copies. We made these available, free of cost, to toll road authorities, consulting engineers, foreign governments, automobile clubs, county officials, city officials, Federal agencies, and, of course, to all of the State highway departments and the Bureau of Public Roads in rather large numbers.

We might say, also, that for the past 6 years we have requested that appropriate AASHO committees include at least one subject on traffic safety in their programs at our annual meetings.

We, of AASHO, appreciate the opportunity of appearing before your committee today. We are pleased that your committee has given of its time and talents to study the whole matter of traffic safety.

Our statement is somewhat comprehensive and lengthy, but due to the importance of the subject matter and the primary responsibility that the State highway departments have in highway safety, we ask your patience as we present it as we believe the information that we have to present is important, and has not been presented by other witnesses.

We also wish to state, at this time, that not all roads and streets in the United States are under the jurisdiction of the State highway departments and, of course, we cannot accept the responsibility for all highway mishaps, but are completely willing to be answerable for those things that are our responsibility.

We feel that all too often there is a tendency, when traffic safety matters are discussed, to automatically and immediately blame State highway departments in large part.

There is without question emotion, hysteria, and sensationalism in the safety field, but if these serve a useful purpose, then we have no objection.

Thirty years ago, when there were only 30 percent as many motor vehicles in the United States as now, almost 40,000 people were being killed on the Nation's streets and highways. Yet, the State highway departments were unable to get any effective public support for a comprehensive and continuing traffic safety program or to get people to be very safety conscious.

Now, 30 years later, when some 50,000 people are being killed in traffic accidents, the factor of emotion and sensationalism has been injected and the lay public and officialdom are becoming aware of the seriousness of the problem.

We hope that the matter will be kept in perspective and that the wide interest will be turned into constructive channels and not result in a destructive or critical attitude.

We know that the work of your committee will be constructive and there will be no tendency to condemn the State highway departments or the highway program.

The expertise of professionals in the State highway departments constitutes one of this Nation's most valuable resources.

While we may be subject to some criticism for not anticipating or recognizing certain problems that have arisen on the Interstate System regarding roadside obstructions, we do not think that we should be severely criticized. Frankly, the limited amount of such roadside appurtenances involved on the interstate, as compared to the multiplicity of these things that are a part of the conventional rural highway or the city street, appeared to involve a rather negligible mathematical probability of being a causative factor of an accident.

The State highway departments first became safety-minded in the mid-1920's. In fact, an AASHO Committee on Standards was created in 1914 to "standardize construction and design to be used in the highway development program to accomplish efficiency, economy, and safety."

The association established a design committee in 1919, a bridge committee in 1921, a construction committee in 1922, a traffic committee in 1922, a roadside development committee in 1930, a maintenance and equipment committee in 1933, and authorized its planning and design policies committee in 1936. This latter committee is the one that develops most of our major design policies and standards and is composed entirely of chief engineering officers of member departments. The advancement of traffic safety was an important part of each of these committees' activities.

In 1925, when we first started computing fatality rates of highways and streets, there were only 21 million vehicles in the country. That year, the fatality rate was 17.5 per hundred million vehicle miles.

In 1926, the State highway departments developed the U.S. numbered system, roadmap symbols, the route marker, and started highway signing and road maps as we know them today, all for the convenience of the public and to promote safer travel.

In 1936, we started in earnest on improving geometric designs and layouts and on more effective highway signing to make our roads more functional. Reflectorized highway signs started about this time to make night travel safer.

Again, we found that the public was still apathetic to highway safety, mostly because of the fierce competition for the dollar to extend the pavement and not to spend the money on other things. In 1936, the fatality rate was 15.5, and there were 30 million motor vehicles.

Now, 30 years later, we find the fatality rate for the Nation to be 5.5, but for the Interstate it is 2.5, however, the roads it is replacing have a rate of 8 or 9 persons killed per 100 million vehicle miles.

As mentioned before, this can be enhanced even further by correcting some relatively minor and inexpensive things such as improving the design, use and placement of guardrail, protecting bridge ends and bridge piers, moving sign assemblies further from the edge of the shoulder, removing trees that are too close to the traveled way, using breakaway sign supports and light standards, changing the design of highway components, such as drop inlets, bridge turnouts and culvert headwalls and, in general, carrying on a program of eliminating or providing protection around obstructions that cannot be eliminated or moved out of critical areas.

We have found that cars going out of control on high-speed Interstate highways travel rather fantastic distances after they leave the road and even though there are a relatively few obstructions on those roads, as compared to older conventional highways, they can become lethal, for a vehicle very often proceeds until it collides with one or more of such objects.

Substantial additional expenditures on the Interstate System could fast reach the point of diminishing returns and such moneys could better be spent on the improvement of roads and streets having higher fatality rates. I am talking about urban streets, the vast mileage of our older rural primary highways and correcting "booby trap" situations on our secondary roads.

We do believe, however, that the AASHO work in improving and upgrading design standards and operational practices has been responsible to a marked degree for the dramatic decrease in highway fatality rates during the past 30 years.

Much of our early highway practice was inherited from railroad practice following the slowdown of the great railroad expansion programs. The first generation of highway engineers came from the railroads so it is natural that the evolution of highway engineering started from that point. It was during this time that much of our existing highway system was constructed. The then current practice dictated the slopes, ditch sections, major and minor structure configuration and right-of-way widths.

It was also at a time when we had much less highway traffic, lower speeds, and much smaller trucks to consider. In fact, very few people, if any, anticipated the extend of the unprecedented growth that has occurred in motor vehicle traffic.

The high cost of moving earth and making rock excavations, together with the relatively light traffic needs, dictated the grades, alignments, sight distances, and the like. Consequently, these existing facilities are incompatible with present-day traffic densities and speeds. We are speaking of the typical rural two-lane highway yet in use and built 30 to 40 years ago on narrow rights-of-way. Extremely limited budgets, limited bridge widths to very little in excess of the width of the pavement, and because of the continued shortage of funds, thousands of these structures are still in service.

The State highway departments could not get full support for increasing the widths of right-of-way for many years. We encountered strong resistance against moving any sizable trees along the roads during construction or in maintenance operations, and during the great expansions of the utility services many pole lines were constructed along these highways in close proximity to the traveled way. In fact,

you will find that these accumulated obstructions can occur as often as 100 per mile on each side of many of these highways.

On arterial streets, you will find that light standards, utility poles, trees, and fire hydrants make up a maze of roadside obstructions that can be lethal, but became an accepted practice and a normal part of the highway and street scene.

For many years, the State highway departments got little public support for even mowing highway rights-of-way or for moving utility poles toward the right-of-way line.

As early as 1950, the State highway departments, through AASHO, started developing design standards for the time that an Interstate program might be authorized. We started with the then present state of the art of freeway design as reflected in the few urban freeways and some of the early toll road practices. The Pentagon network was even studied in detail as one of the starting points for an evolutionary and refinement process that continued until the program was started, and the standards have been constantly reviewed and upgraded since that time.

Great emphasis was placed on such things as widths of pavements, widths of shoulders, controlling curves and grades, sight distances, and the required geometry of interchange layouts.

The purpose was to give the most efficient and safe roadway that could be devised. As stated previously, we were probably guilty at that time of not giving enough thought to the roadside itself and the obstructions that might be placed upon them.

Very few people realize or appreciate the scientific basis used in developing highway standards, for instance, deceleration rates are based on the coefficient of friction of a worn tire in contact with a wet pavement for the particular design speed involved.

These coefficients of friction, of course, change with design speeds and become lesser for faster speeds. By multiplying the coefficient of friction by the acceleration of gravity, the deceleration rate in feet per second is obtained, and this must be kept below that where small children might slide out of the seats of the vehicle. This factor, considered along with the perception and reaction time of the driver determines the stopping distance required.

We use the combined perception and reaction time of $2\frac{1}{2}$ seconds, which includes the slowest reaction drivers on our highways. It is found that even an alert fast-reaction driver, under certain conditions, while driving on the highway may have considerably slower time than when tested in a laboratory and alerted to the test, so it is desirable to include a substantial safety factor in the time consideration.

In other words, a highway is designed with safety factors to provide an extra measure of safety for a driver who is giving reasonable attention to his driving.

In determining controlling vertical curvature, it must provide enough sight distance for a driver to have sufficient time to stop before hitting any obstruction on the roadway 6 inches or more in height. For this purpose, the driver's eye is assumed to be 3.75 feet above the pavement and, of course, must be based on the smaller cars in use today. The larger vehicle provides some added safety factor in this regard.

The vertical curve, therefore, must be adequate to permit a driver to see such an obstruction over a hilltop and give ample time to stop his car if it is traveling at design speed on a wet pavement and the tires are worn. This does not mean smooth tires, a heavy water film and a panic stop. Hydroplaning would result in such an instance.

Deceleration rates are used in developing the length of deceleration lanes and the determination of exit ramp speeds.

Even the 12-foot lane width that is used universally in modern highways is developed scientifically. It is not a function of the physical width of the vehicle, but it is an overall width plus lateral insulation space that is needed to safely accommodate the natural weaving of a vehicle traveling at the design speed, and it is for the purpose of minimizing driver strain that can be a factor on narrow pavements.

The width of the right-hand shoulder of the Interstate System is based on the physical width of the legal vehicle and it being able to clear traffic on the traveled way, yet not apply loads closer than 2 feet to the shoulder line.

It is difficult to maintain structural stability close to the shoulder line because of weather and moisture conditions.

Even the limiting curvature on high-speed highways is based on scientific facts. The curvature is limited by the allowable superelevation rate and the side friction factor of the pavement. The latter two values are generally set at the coefficient of rubber tires and ice, so vehicles will not slide off the pavement during icing conditions.

Highway location itself requires great talent and is an art that relatively few people possess. A person must have a thorough knowledge of design standards and visualize the manner in which the road will fit into the topography when it is built.

It is a continuous linear design which is entirely a different matter than a spot location design, such as a small park or building location. It involves the combining of controlling curves, sight distances and grades, together with the accommodation of necessary appurtenances to give a safe and functional operation, a pleasing appearance, cause a minimum of disruption during construction and in the community, and gives the most economical construction.

We find that often highway location and design is subject to criticism by nonhighway people and especially after the road has been completed. We believe if these critics were assigned the responsibility of going out and actually locating and designing a highway, they would develop a keen appreciation and respect for the ability of the professional highway engineer.

After the location survey has been completed, a high degree of professional competence is required in the design of the project. The laying of grade lines, the determination of the size, type and location of minor drainage structures and the selection of bridge types and the completion of their structural design involves large sums of public funds and expert know-how is absolutely essential.

The design standards that we have developed have resulted in completed Interstate System sections that have no obstructions closer than 12 feet to the pavement edge. This is the first time that a highway system has been provided that can make that claim.

The traveled way and shoulder design, together with the the control of access feature, separation of grades, the dividing of roadways and

appropriate signing, which is a requirement for complex highway layouts to be functional, are things that dropped the fatality rate of these freeways to 2.5 per 100 million vehicle miles.

As we have admitted previously, the effects of roadside features have possibly been overlooked or at least underestimated, and this was becoming apparent to us some 3 years ago. We refer to the matter of vehicles leaving the Interstate System and other highways and running out of control.

This was one of the major reasons for the AASHO "Yellow Book."

A freeway is the only type of highway where the necessary signing and the sign locations can be predetermined and not subject to constant change. As a result, sign supports, in many instances, were constructed to be more or less permanent in nature. These have turned out to be hazards in some instances.

The same is true of guardrail ends. No one at this time knows the best way to start a guardrail installation, and we doubt if one can be absolutely hazard free. Both the flareout and grounding treatments have objections.

Before the Interstate program, major rural highway construction was limited to about \$100,000 a mile. We are speaking of a primary two-lane facility with high type pavement. Guardrail was not used extensively because of its cost. It was used to delineate certain conditions or to serve as a warning that an embankment or a culvert or something similar existed. In some States delineator posts were used instead of railing.

In many instances, where the rustic design concept was embraced on park or forest roads, large boulders were placed on the shoulders of the road for this purpose.

Now, as we build the Interstate System and the budget is not quite so restricted and a more liberal use of guardrail is indicated, it has raised some entirely new situations and design problems.

The cost of guardrail versus flatter slopes, of course, is an economic question that must be determined by the highway designer. Not only must the first cost be considered, but the continuing maintenance cost of guardrail and the problems of mowing around it is a controlling factor.

Of course, there are many places where the topography prevents slopes flat enough to eliminate the need for guardrail.

The assignment given the AASHO Design Committee this year included a complete look at guardrail practice and design, as well as a critical review of all highway components to make certain that they perform their primary function, yet are attractive and, above all, enhance traffic safety. This will involve a review of all minor drainage structure configurations.

The bridge committee has been asked to study the matter of bridge railing. With extremely wide roadways, more vehicles are colliding with the bridge curbs and rails at relatively high speeds and at angles closer to 90 degrees. That creates a very difficult design and safety problem.

It is entirely different than designing bridge rails for light angle impact that has been past practice when the solution is to deflect the vehicle instead of stopping it without serious injury to the occupants.

or to the bridge or to persons or property that might be under the bridge.

To stop a typical automobile traveling 60 miles per hour involves absorbing 500,000 foot-pounds of energy which presents a challenging task to a designer. Of course, safe bridge design is further complicated where pedestrian traffic is involved.

All in all, we are now completely cognizant of the roadside problem and its seriousness and the roadside is becoming an engineered and designed element of the highway facility, instead of a byproduct of the grading and drainage operations.

With all of the appurtenances that are necessary for the functioning and operation of a modern highway, which includes signs, guardrails, light standards, headwalls, and many other items, it is essential that these appurtenances not be planned and constructed independently, but reviewed together and coordinated by a field review at the time of construction.

It may be possible to move a light standard or a sign installation to where a guardrail installation is already provided. If such is not possible, then these necessary obstructions need to be relocated so as to minimize hazard.

Almost every State has had some experience in having proposed design rejected or reduced by so-called Bureau of Public Roads frugality, because of the costs involved.

Full width bridges, the elimination of shoulder piers, additional lanes, full width left-hand shoulders on six- and eight-lane freeways, and the like, are examples.

We do not wish to make an issue of this and do not propose to offer it as an excuse. It is our opinion that cost will continue to be a major control factor in this and all other highway programs.

Even if there is considerable feeling of a liberalization in spending at this time, by the time the next cost estimate for the Interstate program is submitted, undoubtedly there will be a tendency to swing back the other way and become extremely cost-conscious once again.

In 1958, AASHO was questioned by the Senate Public Works Committee as to the possibility that the States were overdesigning the Interstate facilities and using wider rights-of-way and median strips than justified.

Now, it is well known and accepted that such charges are not true, and it indicates an evolution in official thinking.

We might add that we have encountered some minor conflicts between highway safety and highway beautification proponents. This is not a serious problem, but it does take the attention and action of the State highway administrators to correct. There is a tendency on the part of landscapers to plant trees close to the shoulders and locate shrubbery where sight distances are impaired.

We have heard some criticism of the highway signing on our highways, and in particular, on the Interstate System. We have had more experience in communicating with the public through signs than anyone else.

It is very definite that with over 100 million registered drivers having different levels of education, mental and physical reaction and background, that the intended and proper use of highway signing

cannot be instinctive to all of these drivers. What might be clear to many, could be confusing to a few, or vice versa.

It is essential that drivers be taught how to use the signing and the complex geometry of modern highways for as time goes on and traffic increases, such things are not going to become any simpler. We already have 60 percent more vehicles on our highways than when the Interstate program was started.

Signs must have target value day and night and be large enough to be legible and read at highway speeds. They must stand out but not be unsightly and must not require more than a glance to be read. Smaller artistic or rustic offerings have no place on high-speed high-density arteries.

Highway safety involves three areas—the vehicle, the highway, and the driver. In fact, it is a three-legged structure and for such a structure to be stable, each support must be completely adequate.

We readily admit that some further progress in traffic safety can be made on even our most modern highway facilities, but the most fertile field for achieving traffic safety lies with the improvement of the driver.

Highway administrators and engineers are firm in this position.

We see far too much hazardous and wasteful use of our highway space even though the average driver generally does a good job.

Some of the things you can see that contribute to accidents are driving when fatigued, driving when intoxicated, driving beyond conditions, aggressive driving, tailgating at high speed, driving too slow, driving with smooth tires, not planning a trip in advance as to proper routes and exits, exiting from the wrong lanes, and not knowing how to drive on a freeway. One of the most hazardous things on a two-lane facility is passing on hills.

These things are entirely too prevalent and while we accept the responsibility in the highway field of enhancing chances of survival in case a vehicle goes out of control, to a large extent we are merely treating the symptoms or the results and not correcting a major cause of accidents.

Recently, at a national conference, we were advised by outstanding motor vehicle administrators and State highway officials, that no less than 10 percent of the drivers on our highways were operating with a revoked license or had no license at all. This further underscores the need for improving the quality of the person permitted to operate a vehicle.

We admit that we have experienced some delay in getting improved designs and applications incorporated into our highways. This is especially a problem when your personnel is involved in a very heavy and continuing workload that is part of moving a big highway program.

Essential leadtime may cause design features to go into the pipeline 2 or 3 years before construction is started and construction may require 1 or 2 years. There is a tendency, under such conditions, to use existing standard design sheets and not take time out to upgrade or correct them, and to overlook making desirable changes during construction by change order.

The larger an organization, the more serious the problem of internal communication and coordination between the various engineering offices becomes. This is the responsibility of the chief engineering officer

and the chief administrative official of a department to correct or to accomplish.

The highway departments are involved in a spot improvement program that can enhance traffic safety and we intend to continue this activity.

We are involved in research efforts. Some of these projects are carried on through the national cooperative highway research program financed with pooled funds from the several State highway departments.

The program is administered through the Highway Research Board of the National Academy of Sciences and the National Academy of Engineering. Attached is a listing of research projects dealing with safety that have been initiated since our research program was started in 1963.

Groups of States have pooled funds or have worked individually to research breakaway supports for highway signs and light standards, improve guardrail design and to determine wind loads on highway signs as they affect supporting structure design. Our committee on bridges and structures is currently working on the matter of the structural design of sign supports and adequacy, appearance, and safety in mind.

In many places, overhead sign structures are absolutely necessary. Their supports must be located and protected to enhance safety, yet they must be structurally dependable. If one were to collapse on a high-speed highway, the results could be catastrophic.

It is our feeling that some of the industries supplying products have lagged in their responsibility to develop safer highway elements.

Recently, when we appeared before your parent House Public Works Committee on the matter of the next Federal-aid highway program, we indicated that emphasis in the next program should be placed on improving urban highway facilities, modernizing our vast rural primary network, and in improving our rural secondary system.

Just as we started the development of design standards for the interstate program some years in advance, we have already started our appropriate committees on developing design standards for this next program.

We assure you, however, as worthwhile improvements might be evolved, that they will immediately be incorporated into current design work, and not wait until the next Federal-aid highway program is authorized.

At this time we make brief reference to the new highway safety standards issued on June 27 by the Department of Transportation. Only a week ago, most of the State highway departments had not yet seen these standards, and could not comment on them.

As a result, we requested sufficient copies from the National Highway Safety Bureau to send to the State highway departments.

In the original draft form, the safety standards made reference to AASHO design standards and policies as those to be used in the highways safety program. We were surprised that the final standards makes no reference to the AASHO material, but instead carried a notation, "Standards applicable to the specific programs are those issued or endorsed by the Federal Highway Administrator."

We believe that the standards and policies that will be used for highway design, construction, and maintenance operations in connection with the safety program, as it applies to the State highway systems, will be those developed by AASHO and submitted to the Federal Highway Administrator for his official concurrence.

We are assuming that this will be the case, and it is the intention of the State highway departments to continue in the field of developing such technical and engineering standards and specifications that are used in the State highway departments' operations. This is a definite position.

AASHO standards are accepted worldwide and our procedure for developing such things uses a vast reservoir of education and experience from all of the State highway departments that does not exist anywhere else. It has resulted in the United States being the top authority in highway technology.

As we study the complex matter of accidents and their costs, we find that some may defy diagnosis, but it is evident that we need to know far more than is available of causative factors and how to cope with them.

It is our feeling that the work that will be done by the National Highway Safety Bureau and AASHO will be able to give far more information than has been available up to the present time and will help materially.

Facts and figures on the safety problem have been entirely inadequate and we believe mostly because the public, to a large degree, has been apathetic and disinterested in actively supporting any proposal that might eventually inconvenience them individually. We believe this is one reason that coping with the alcohol problem may be difficult.

Much of the current public interest in traffic safety is emotional and has been cultivated to a considerable extent by sensational publicity setting the number of people expected to be killed over a given holiday or weekend period. This is a scare program and leaves the impression that if one returns home safe and sound that he is indeed fortunate.

Actually, when one analyzes the mathematical frequency of traffic accidents as compared to the exposure factor created by 100 million motor vehicles operating on our highways, it is surprisingly low. However, the safety problem is extremely serious and one that must receive the complete attention of everyone and be brought to an irreducible minimum, whatever that might be, in the shortest possible time.

We appreciate the privilege of appearing here and will be happy to answer any questions that you might have. The members of our special traffic safety committee are here for the purpose of answering questions pertaining to their own specialized fields.

Thank you very much, Mr. Chairman.

Mr. BLATNIK. Thank you, Mr. Johnson.

Mr. John Morton, commissioner, Department of Public Works and Highways from the State of New Hampshire has come into the room with a member of our committee, Mr. Cleveland. Mr. Morton is also chairman of the AASHO Traffic Committee.

Mr. Morton, I believe you have a statement with you. Please take the chair. I hope you did not mind our going on.

We have already sworn the other witnesses. Would you raise your right hand. Do you solemnly swear the testimony you are about to give

before the subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. MORTON. I do.

Mr. BLATNIK. Please be seated.

Mr. Johnson, it would be proper perhaps just for the sake of continuity, since you have a very comprehensive and informative statement which you have just presented, that we have Mr. Morton's statement follow; and then we will begin the interrogation or dialog between the staff and the members of the committee and your panel.

Mr. Morton, give the reporter your full name and your official capacity in the State of New Hampshire and also your capacity in AASHO as chairman.

**TESTIMONY OF JOHN O. MORTON, COMMISSIONER, DEPARTMENT OF
PUBLIC WORKS AND HIGHWAYS, STATE OF NEW HAMPSHIRE,
CHAIRMAN, AASHO TRAFFIC COMMITTEE**

Mr. MORTON. My name is John O. Morton. I am commissioner of the New Hampshire Department of Public Works and Highways. I have the honor and privilege of serving as chairman of the AASHO Committee on Traffic and also serving as a member of the Special AASHO Traffic Safety Committee.

The statement that I have, Mr. Chairman, is rather brief. It is not a particularly profound statement. I find that Mr. Johnson's statement has been most comprehensive covering the field. However, if you have no objection, I would be pleased to read this. I think it might take 5 or 6 minutes.

Mr. BLATNIK. Either way. It will appear in full at this point in the record; or since it is a brief statement, you may wish to read it.

Mr. MORTON. I would appreciate the chance and opportunity to read this.

Mr. BLATNIK. You may proceed.

Mr. MORTON. In 1956 when construction of the Interstate Highway System was provided for by an act of Congress, one of the strongest items in support of this legislation was the fact that the building of a 41,000-mile network of interstate highways would save 8,000 lives a year. Prior to the year 1956, the States and the Federal Government were keenly aware of, and greatly disturbed by, the huge economic losses, and the human suffering that was being sustained through highway accidents. Records maintained by the States, by the Federal Government, and by the National Safety Council have accurately described the growth of traffic in this Nation. Statistical records have been used to describe the percentage of fatal accidents in relation to traffic growth.

Over the past 15 years the New Hampshire Highway Department has investigated and carefully evaluated every fatal accident occurring on the State's highway system. The accuracy of the investigations and the use made of the information developed, is now much superior and more intelligently employed than it was in the early years of this type of activity.

It was in 1959 the New Hampshire Department of Public Works and Highways initiated a tree removal program. Since that date over 100,000 trees in close proximity to lines of travel on the State's high-

way system have been removed. This comment is made for it well dates and illustrates the department's concern with the removal of fixed objects in close proximity to lines of highway travel.

In 1962 the Bureau of Public Roads established the position of Director of Highway Safety. This position was established for the purpose of expanding the Bureau's operations in the field of highway safety.

In 1964 a special AASHO Traffic Safety Committee was established in cooperation with the Federal Highway Administrator and the AASHO organization. It is this traffic safety committee that is appearing before you today.

In 1965 at the annual convention of AASHO in New York City, the AASHO Committee on Traffic and Bureau personnel met with Joseph Linko and viewed showings of his slides which depict accident-prone locations on some of the New York expressways. At this same meeting, many members of the AASHO Traffic Committee visited and studied the highway locations that were identified in the Linko pictures.

At the 1966 summer meeting of the AASHO Committee on Traffic we devoted two full-day sessions to highway safety. At these sessions members of the committee presented informal reports concerning the activities of their respective departments with reference to work being performed in the field of highway safety. In addition, the committee membership reported on what they believed to be some of the most critical areas associated with highway designs, signing, pavement marking, and operational features of expressways from a safety viewpoint. The following statements briefly describe some of the reporting:

Virginia reported multifatal accidents involving trucks parked on shoulders on Interstate highways.

Nebraska reported an increase in railroad-crossing accidents.

California stated that fixed objects cause 39 percent of fatal accidents on freeways, that hydroplaning is a definite factor in wet roadway accidents, also that only 40 percent of total accidents occur on State highways.

Oklahoma also reported a large percentage of accidents are occurring on local roads. In addition, Oklahoma encountered a problem with U-turns on expressways.

Connecticut reported accident experience at left-hand off ramps, short weaving distances and at signals. Of 50 high-accident locations, 47 were at signals.

Maryland reported that a compilation of locations with 10 or more accidents showed all except one were at intersections, 71 percent of which were equipped with standard signs and signals. Also, Maryland reported that State police are tabulating and publishing a list of accidents caused by drinking drivers.

New Hampshire reported that a high percentage of fatal accidents involved drinking drivers.

In 1966, the special AASHO Traffic Committee visited the most heavily populated areas of the Nation for the purpose of studying the operation of traffic over both new and old expressways. This committee took into consideration the design, signing, and pavement marking of highways from a safety viewpoint. Of particular note was the fact that this committee discussed with many of the law-enforcement agencies, law enforcement as it relates to highway design and operation.

At the annual convention of AASHO held in Wichita, Kans., in the fall of 1966, four members of the AASHO Committee on Traffic had served as observers to the special traffic safety committee, showed slides and offered comments of the pictures they had taken during the studies made by the special committee. Many of the pictures related to fixed objects in close proximity to lines of travel on modern highways.

The development of the report by the special AASHO Traffic Committee dated February 1967 is a condensation of the findings of the special committee. It is extremely well done and its findings should be used as a guide to better highway designs. It is my opinion that it is impossible to develop a set of standards that can be made to function effectively in all parts of the Nation. The great variances in climate and terrain encountered in the various States must be treated with commonsense and judgment from a design viewpoint.

It is my personal belief that the greatest contribution toward increased highway safety will come through the elimination of the drunken driver from the stream of travel.

In New Hampshire we have analyzed the character of roadside litter encountered on our highways and this analysis definitely emphasizes that in the past 20 years the amount of liquor consumed while driving on our highways has substantially increased. I have brought with me three photographs that were taken in connection with our spring litter cleanup in 1964. I hope the committee will have the opportunity to view these photos and in doing so, will note the high percentage of beer and whisky bottles that were gathered from an 11-mile section of rural highways in my State.

I am appreciative of the opportunity to present this statement, Mr. Chairman. Could I leave these photographs with you?

Mr. BLATNIK. Thank you very much, Mr. Morton. This is an 11-mile section [indicating on photograph]?

Mr. MORTON. Eleven-mile section of rural two-lane road taken in the spring of the year after the snow is gone.

Of interest to me is that fact that when we first started to analyze roadside litter we found a very small percentage of beer cans or whisky bottles; but now our roadside litter is predominantly made up of that.

Mr. BLATNIK. That is in the State of New Hampshire?

Mr. MORTON. Yes, it is.

Mr. CLEVELAND. Mr. Chairman, I would like to comment if I may.

Mr. BLATNIK. Just a moment and then I will yield.

It is an awful shame that we have people throwing cans, all kinds of cans, beer cans, just cans, bottles, whisky bottles. What can be done with something like this? What can be done to make the public more aware of this?

Mr. MORTON. There are all kinds of programs, antilitter programs, keep America beautiful, and some of it is taught in schools.

We have laws, antilitter laws, where if they are apprehended discarding litter on the roadside in our State it is a \$50 fine. Still most of this is deposited under the cover of darkness where it is hard to detect.

The costs are tremendous that are involved in removing this litter from the roadside.

Mr. BLATNIK. I just came back from some lovely Canadian-Minnesota boundary water areas, lovely area, and it would seem that any

place human beings stay long enough it is going to get messed up. Man has the capability and the capacity for littering and messing up anything that is lovely. Just give him a chance to stay there long enough. Cans, junk, broken glass—go to any beach, any place that people want to enjoy the scenery and beauty on the highways, picnic places, the ball parks. Mr. Johnson?

Mr. A. E. JOHNSON. Mr. Chairman, it is our understanding that beer cans and whisky bottles are the predominant part of the material that is being picked up out of the roadside ditches at this time. Several States are spending more than a million dollars a year on this operation.

If you were out on the Shirley Highway in the last couple days, you would see a truck out there from the Virginia Department of Highways where they are picking up litter. There is a sign on the back of it: To Help Virginia Save \$700,000 a Year.

Mr. BLATNIK. Mr. Cleveland.

Mr. CLEVELAND. I just wanted to comment, Mr. Chairman. You may recall that when the Public Works Committee was having hearings on the beautification bill, Mr. Morton appeared before this committee, and at that time I commented that he had long been a staunch advocate of highway beautification. I suggest that these pictures that were taken in 1964 be further proof of this statement.

This was 1964, and the highway department was picking up these cans and bottles. I want to remind the committee that Mr. Morton, of the State of New Hampshire, has concerned himself with beautification and did so early in the game.

I might add one other item of interest, that the garden clubs of New Hampshire and the Boy Scouts every spring engage in a very active cleanup program along our roads. This is another way to meet the problem which so regrettably faces us.

Mr. BLATNIK. Any further questions? I would like to get into this aspect of drunken driving. It is a little beyond this immediate phase of our hearings, in which we are talking about design aspects and fixed hazards; but it is definitely something that ought to be gone over very thoroughly.

Some of us are quite familiar with what other countries have done—Germany, Denmark, particularly in Sweden. I believe they are very severe—I will not say harsh—but very strict to show the importance—the emphasis they give to this important and difficult problem. Is not Sweden very severe in its regulations or dealings with drivers that are drunk, whether they are involved in accidents or not? Is that not true?

Mr. MORTON. Yes. I understand that if you are found guilty of driving under the influence of liquor in Sweden, I guess you lose your license for a good many years. I saw one article with reference to Helsinki, Finland, where it said that the airport had been built by prominent businessmen and industrialists and so forth, and they had been found guilty of driving under the influence of liquor. When they were found guilty, they were sentenced to labor on that nation's airport.

I am sure that all the Scandanavian countries apparently have a very good record and are very stiff in their dealing with the drunken driver or the drinking driver.

Mr. BLATNIK. It is a great disparity, is it not, in placing importance on infractions? For instance, I know if you are caught hunting without a license, they may take away all your hunting gear, expensive rifle, and even the automobile. You can be driving the same automobile without any permit or license to be driving in the first place, with or without a rifle. They often do not do very much about it. It is very interesting to consider at this time.

Mr. CLAUSEN. Mr. Chairman.

Mr. BLATNIK. Mr. Clausen.

Mr. CLAUSEN. Thank you, Mr. Chairman. I will not prolong this very much.

In your statement, Mr. Morton, you brought out something interesting, and I would like to have a little expansion on it. You said:

It was in 1959 that the New Hampshire Department of Public Works and Highways initiated a tree removal program. Since that date over 100,000 trees in close proximity to lines of travel on the State's highway system have been removed.

This interests me. I would like to know what experience you have had, and if you have any figures on the number of lives saved? Let me say why I am asking this. We in California are somewhat on the horns of a dilemma. You have heard a little bit about the redwood controversy, and there are people that want to improve the highways, and yet we have the other side, people who want to preserve all the redwoods.

I know from personal experience that there are a number of people who are killed every year as they piled into these redwoods that are right next to the highway.

With that background, could you elaborate just a little bit on the experiences you have had in New Hampshire, how far back was your setback arrangement on highways as far as cutting of these trees and that sort of thing was concerned?

Mr. MORTON. Mr. Clausen, at the present time on our Interstate system it is standard practice in our designs to clear back 30 feet from the edge of the paved shoulder. Now on a primary and secondary road we are not able to attain anywhere near that distance.

Many of our highways are in rather heavily wooded areas, and I would say that if we are able to move the trees back maybe 10 or 15 feet from the line of travel we are doing exceptionally well.

If we have isolated trees in open areas that are in close proximity and are definite hazards, we try to remove the isolated trees first.

This program by no means is able to provide the degree of safety that we should have.

I do not have good statistical information, but I do know that a very high percentage of our fatal accidents involve single cars striking the fixed object, most usually a tree, and quite often involving a drinking driver too.

Mr. CLAUSEN. I was wondering if there would be a possibility of your providing us with some of the statistical information for the

record. Let me say this, I am keenly concerned about the objective of the conservation programs, but there is a question here of balance between conservation objectives and safety. I would like to know what your experiences have been with the conservation organizations in your State relating to the removal of some of these esthetic trees.

Mr. MORTON. Amazingly enough we have had very little interference from the conservationists.

Mr. CLAUSEN. I see.

Mr. MORTON. I think maybe that is because we have such a luxurious wooded growth that the removal of these trees does not show up as much.

Mr. CLAUSEN. Thank you, Mr. Chairman.

Mr. CLEVELAND. Mr. Chairman.

Mr. BLATNIK. Mr. Cleveland.

Mr. CLEVELAND. Mr. Chairman, I would just like to make one comment that brings back many memories. I was in the State senate at the time the legislation was enacted that I think launched this program of the New Hampshire Department of Public Works to take down some of the trees. I remember the debate we had at the time, whether some of the trees were dead or decaying because of the salt that the highway department was using on the roads. I am not sure that debate has ended. It brings back many memories of that legislative debate.

Mr. CLAUSEN. I wonder if the gentleman from New Hampshire could give me a copy of the debate. We have the same problem in California.

Mr. BLATNIK. Mr. May.

Mr. W. MAY. Mr. Eugene Johnson, your statement covers a number of topics which we as a subcommittee will be looking into in the coming months. We certainly appreciate your views concerning it.

However, today we will discuss for the most part in the time remaining, the roadside hazard problem.

First, however, I go to your statements on page 3, paragraphs 6 and 7.

Mr. BLATNIK. Page 3, paragraphs 6 and 7.

Mr. W. MAY. It is mentioned that the 1936 fatality rate was 15.5, and we find the fatality rate for the Nation today to be 5.5 and the interstate rate is 2.5.

Mr. Kopecky of the staff has brought together certain information concerning statistics and rates which might be helpful to us. Mr. Kopecky, would you begin?

Mr. KOPECKY. Yes, Mr. May. I would like to make three points. The first one is an analysis of deaths, motor vehicle deaths, and compared with vehicle miles of travel. The second point will be discussion of studies as to what points on or off the road were the scenes of these fatal accident events. Third is an analysis of what type of road system was involved.

With regard to the first point I would like to use these two charts. The first one is this mimeographed chart of motor vehicle deaths, and the other one is this chart behind Mr. Johnson.

Mr. BLATNIK. Just a moment. What chart are we talking about now?

Mr. KOPECKY. These figures on this chart, Motor Vehicle Deaths are taken from the data of the National Safety Council.

Motor vehicle deaths

<i>Year</i>	<i>Total deaths</i>	<i>Year</i>	<i>Total deaths</i>
1912	3, 100	1949	31, 701
1913-17 (average)	6, 800	1950	34, 763
1918-22 (average)	12, 700	1951	36, 996
1923-27 (average)	21, 800	1952	37, 794
1928-32 (average)	31, 050	1953	37, 955
1933	31, 363	1954	35, 586
1934	36, 101	1955	38, 426
1935	36, 369	1956	39, 628
1936	38, 089	1957	38, 702
1937	39, 643	1958	36, 981
1938	32, 582	1959	37, 910
1939	32, 386	1960	38, 137
1940	34, 501	1961	38, 091
1941	39, 969	1962	40, 804
1942	28, 309	1963	43, 564
1943	23, 823	1964	47, 700
1944	24, 282	1965	49, 000
1945	28, 076	1966	53, 000
1946	33, 411		
1947	32, 697		
1948	32, 259		
		Total, 1900 through 1966--	1, 613, 000

Source: National Safety Council.

It is interesting to note for calendar year 1966 there were 53,000 deaths. During the period from 1950 to 1961 the range is between 35,000 and 40,000 deaths. Then, for the first time the deaths go over the 40,000 mark in 1962 and they increase substantially each year thereafter until they reach the 53,000 mark in 1966.

The total from 1900 to 1966 of recorded deaths is 1,613,000 killed.

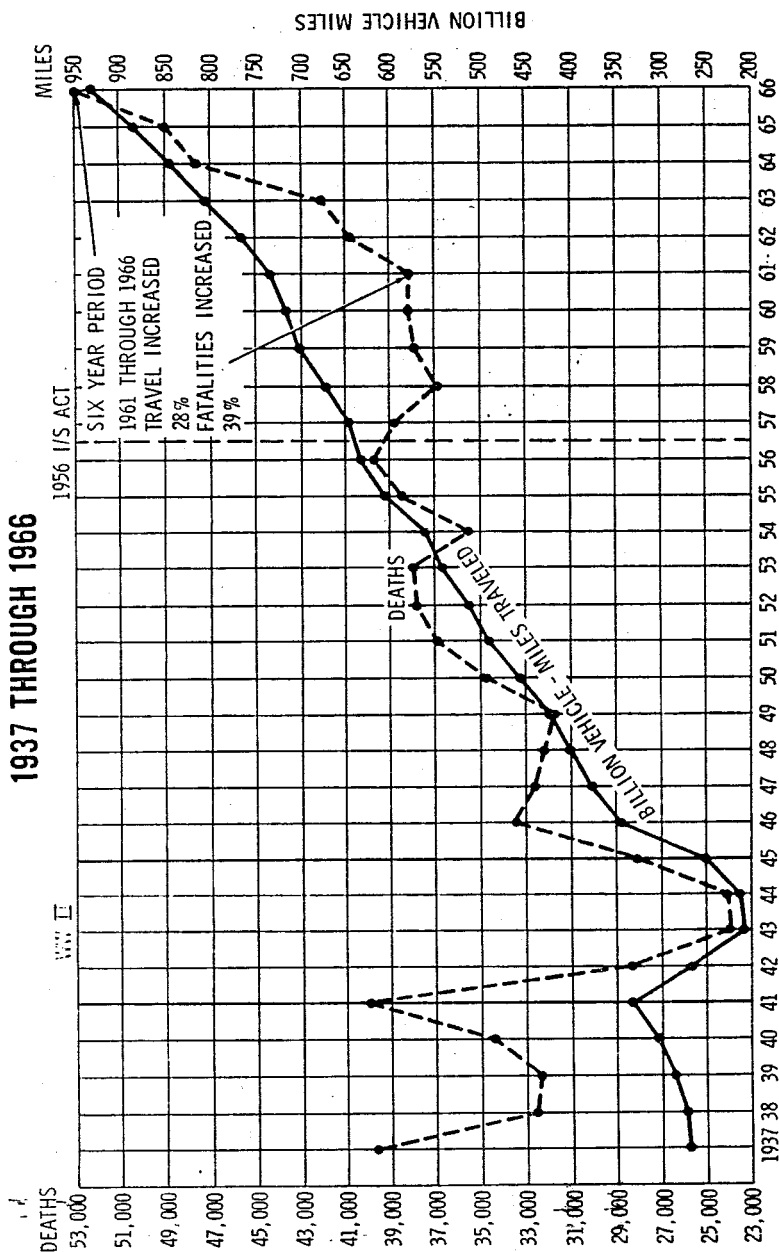
The other chart is titled "Motor Vehicle Deaths Compared to Total Vehicle Miles Traveled." The broken line shows the number of deaths from 1937 through 1966, and the solid line is the billion vehicle miles traveled.

As is noted, for the 6-year period, 1961 through 1966, the travel increased 28 percent and deaths increased 39 percent.

Mr. W. MAY. Mr. Kopecky, I am looking at that schedule you drew up that says "Motor Vehicle Deaths." I notice that in 1941 the total deaths were 39,965. Twenty years later in 1961 it was 38,091. For each succeeding year the number of deaths has increased; for example, in 1962, 40,804; 1963, 43,564; next year, 47,700; next year, 49,000; and in 1966, 53,000.

MOTOR VEHICLE DEATHS COMPARED TO TOTAL VEHICLE MILES TRAVELED

1937 THROUGH 1966



Mr. KOPECKY. That is correct.

Mr. W. MAY. You say that the rate is increasing more than the vehicle miles?

Mr. KOPECKY. That is true. As indicated, during the 6-year period of 1961 through 1966 the deaths have increased 39 percent, while the vehicle miles traveled have increased 28 percent.

Mr. W. MAY. I might say that if any of the witnesses have any comments, we will be glad to hear them.

Mr. E. M. JOHNSON. May I make one comment?

Mr. BLATNIK. Mr. Eugene Johnson.

Mr. E. M. JOHNSON. I notice here on the chart that you are displaying that it is based on the deaths shown on the last tabulation attached, which came from the National Safety Council. I notice on the other tabulations of sheets showing fatal injuries, so forth, deaths, that the source is the Bureau of Public Roads which came from the various State tabulations. I also notice there is some difference in them.

Were you going into that?

Mr. KOPECKY. Yes.

Mr. E. M. JOHNSON. Excuse me.

Mr. BLATNIK. At this point I should say that any changes or questions can be added on in the record later on. None of us can grasp the full import of figures yet, table form or chart form, merely by glancing.

If there are any questions as to discrepancies or validity, the record will be open for quite some time for either further elaboration or correction.

Mr. KOPECKY. Mr. Johnson, that is a good point, and I was going to handle that. As long as the subject is up now, I will go into it.

The 51,032 as recorded by the Bureau of Public Roads covers those deaths actually reported by individual States in 1966. The National Safety Council figures include some other areas, namely, Guam, Virgin Islands, Puerto Rico, which account for some of the difference. In addition, the National Safety Council includes deaths which occur anytime during the 12-month period following the accident itself. So there were some accidents which took place in 1966, deaths will occur in 1967, which will revert back to the 1966 accident.

Mr. W. MAY. Also this is a report of 46 States.

Mr. KOPECKY. That is true.

STATEWIDE FATAL INJURY ACCIDENTS, 1966 (46 STATES)

State	Total, all systems		Interstate system		
	Total deaths	Rate (per 100,000,000 vehicle-miles)	Deaths	Rate (per 100,000,000 vehicle-miles)	Rate of total
Alabama.....	1,089	7.51	(1)	(1)	(1)
Alaska.....	67	8.07			
Arizona.....	645	7.28	69	5.60	11
Arkansas.....	666	7.08	36	5.29	6
California.....	4,830	4.78	250	2.11	5
Colorado.....	602	5.74	118	6.46	19
Connecticut.....	406	3.00	67	2.05	12
Delaware.....	125	4.83	2	1.00	2
Florida.....	1,819	5.84	53	2.13	3
Georgia.....	1,601	7.00	73	3.06	5
Hawaii.....	105	5.04	2	2.35	2
Idaho.....	267	6.79	15	3.78	6
Illinois.....	2,522	5.19	124	1.90	5
Indiana.....	1,566	5.93	91	3.26	6
Iowa.....	904	6.90	38	3.69	4
Kansas.....	733	5.77	55	5.03	8
Kentucky.....	1,086	6.96	65	4.46	6
Louisiana.....	854	6.30	52	6.95	6
Maine.....	233	4.60	13	2.65	6
Maryland.....	755	4.36	49	1.98	7
Massachusetts.....	898	4.15	45	2.09	5
Michigan.....	2,226	(1)	161	3.28	7
Minnesota.....	977	5.52	21	2.44	2
Mississippi.....	799	8.58	19	3.42	2
Missouri.....	1,379	6.22	115	4.50	8
Montana.....	276	7.19	9	4.69	3
Nebraska.....	424	5.02	20	3.31	5
Nevada.....	211	7.48	26	6.60	12
New Hampshire.....	148	4.04	6	1.63	4
New Jersey.....	1,127	3.26	43	2.33	4
New Mexico.....	431	7.23	58	7.02	13
New York.....	2,806	4.86	167	2.21	6
North Carolina.....	1,709	7.59	54	3.68	3
North Dakota.....	209	6.01	9	3.41	4
Ohio.....	2,602	5.39	156	2.56	6
Oklahoma.....	796	5.43	51	3.03	7
Oregon.....	678	6.13	72	4.03	11
Pennsylvania.....	2,180	4.25	116	2.04	5
Rhode Island.....	110	2.74	7	1.68	6
South Carolina.....	968	7.47	(1)	(1)	(1)
South Dakota.....	265	6.55	11	3.24	4
Tennessee.....	1,258	7.29	60	4.37	5
Texas.....	3,406	6.26	318	4.12	9
Utah.....	328	6.46	(1)	(1)	(1)
Vermont.....	123	6.80	7	3.52	6
Virginia.....	1,106	5.08	97	3.46	9
Washington.....	823	4.94	99	4.15	12
West Virginia.....	518	6.92	18	5.07	3
Wisconsin.....	1,126	5.69	57	3.68	5
Wyoming.....	153	6.0	30	8.09	19
District of Columbia.....	97	3.73	6	3.37	12
Total.....	51,032	5.49	3,030	3.15	6

(1) Not available.

Source: BPR and State compilations; tables TA-1.

Mr. BLATNIK. Mr. Kopecky, I have a question at this point. It is a very interesting chart. From 1942 all the way through to 1962, a 20-year span, there is a good positive correlation between increase of vehicle miles traveled and the percentage of deaths. It is a favorable chart all the way up to that point, that 20-year period.

Could you give us now or could we obtain later the reason for the sudden increase from 1961 through 1966? There was a rapid acceleration of the vehicle deaths in that 6-year period.

Mr. KOPECKY. That is what we are attempting to find out as a result of these hearings, Mr. Chairman.

Mr. BLATNIK. And also I would like to know the nature of the deaths and their location, whether Interstate, primary or secondary or on city and urban streets.

Mr. KOPECKY. That is what I will discuss in a few minutes; yes, sir.

Mr. BLATNIK. All right.

Mr. CLEVELAND. Mr. Chairman.

Mr. BLATNIK. Mr. Cleveland.

Mr. CLEVELAND. I would also like to inquire of Mr. Kopecky if he is going to study the rather sharp decline in deaths that occurred in 1938, 1939, and 1940. There was a sharp decline during the war period, and that is understandable, I suppose, because of people protecting their tires, et cetera. But in that 1938, 1939, and 1940 period there was a rather noticeable decline.

Mr. KOPECKY. If you would like, we can inquire.

Mr. CLEVELAND. I think you should, just as you are going to inquire as to why it increased in the last 6 years. It might shed some light on the problem to find out why there was a sharp decrease in the 1938, 1939, and 1940 period. If any member of the panel has any ideas on that subject, I think the committee would appreciate it.

Mr. BLATNIK. Mr. Johnson?

Mr. A. E. JOHNSON. Mr. Chairman, I would like to make an observation at this time, that you are confronted with one of the problems that we have had over the years. That is the adequacy of the data and whether or not it is actually good.

For instance, in 1961 we know we had a fatality rate of 5.1 average, which was the lowest we have ever had. Since that time we have been in the neighborhood of 5.6 and 5.5.

So for that reason I can't see the disparity in these two lines on this chart. I cannot find it at all. I notice that they show 53,000 deaths. I think the National Safety Council does as good a job as they can; but I think they also use lots of round figures at the National Safety Council.

I checked with the Bureau of Public Roads yesterday on what was the fatality total in the United States in 1966, and it was their feeling that it was something over 51,000.

Now you have got 51,000 there shown for a certain number of States. It was their estimate yesterday that it was something less than 52,000 killed in the United States on highways. We got this information, too, and that is that 54 percent of the fatalities occur on our State highway systems compared to 68 percent of the travel—total travel that occurs in the United States on the State highway systems—68 percent is on the State highway systems.

I would think that you are faced here with almost an impossible task of being able to correlate these two curves because of the inadequacy of the data that we have had in the past.

In 1941, I remember that period very well. That was when we first began to have quite a step-up in highway use. In fact, we started on another big highway program; and World War II then terminated that. We did have a pretty decided growth in traffic, and we did have an increase in the traffic fatalities.

But, as I remember, I cannot remember it being to the degree that is shown on this dotted line. I know that many of the States were getting revenues on an increasing, an almost uniform increasing amount,

and they were planning highway programs. Actually, we picked up on about the same curve after 1946 that we had started in the 1940's up to 1941.

This disparity, this 22-percent-travel increase, 39 percent fatalities, I do not believe it is correct.

Mr. W. MAY. Do you have any better figures?

Mr. A. E. JOHNSON. I doubt if figures are available, Mr. May; but I do know the fatality rates we have at this time do not bear this disparity out at all.

Mr. W. MAY. Maybe we can learn something as Mr. Kopecky progresses.

Mr. BLATNIK. Mr. Kopecky?

Mr. KOPECKY. Yes. The second point we would like to discuss is about those studies which have been made as to at what points, on or off the road, these accidents took place. We have had some testimony about these subjects, the Bureau of Public Roads, No. 1, conducted a study of fatal accidents on certain sections of the completed Interstate System during the last 6 months of 1966.

In that study it was found that single vehicle "ran off the road" accidents accounted for 57 percent of the total fatal accidents, and of those 78 percent subsequently struck one or more fixed objects.

We noted in that study that guardrails, bridge elements, and signs accounted for two-thirds of the fixed objects struck.

Mr. W. MAY. May I interrupt there, Mr. Kopecky? I am reading from the Bureau's report. Guardrails were the first objects struck in a third of the cases that might be expected since they constitute most frequent targets of out-of-control vehicles. Later it says that bridge or overpass objects were the objects next most frequently struck initially.

As a matter of fact, guardrails were struck 33 percent of the time; bridge element, 21 percent; signs, 10 percent. That is important for the record because the hearings do relate to roadside hazards, and you see the significance of them.

Mr. KOPECKY. In addition, in that study it was indicated that in 21 percent of the multiple-car fatal accidents vehicles then left the road, and of those that did, 75 percent subsequently struck a fixed object. These would add to the problem.

Another study that was made that shed some light on these situations, a number of studies, were made by the California Department of Public Works in which they analyzed all freeway fatal accidents for 4 years. The first study was 1961 and 1962. The second study was 1964 and 1965. These studies covered 1,700 fatal accidents involving 2,068 deaths. In these studies, single vehicle "ran off the road" type accidents accounted for 50 percent of the total fatal accidents; of those, 65 percent of the vehicles subsequently struck a fixed object. The balance involved embankment slopes, ditches, or gore areas.

Another study made by California was of the 1965 fatal accidents on the State highway system, 14,260 miles. This indicated that 53 percent of the fatal accidents involved a single vehicle. Of those, 63 percent subsequently struck fixed objects.

Still another analysis made by California, that of fatal accidents on their freeway system, 1,788 miles in calendar year 1966, indicated that 63 percent were of the "ran off the road" type.

Another study, and on which we had testimony by Dr. Donald Huelke in and around Ann Arbor, Mich., disclosed 60 percent were single-car "ran off the road" type accidents and that 72 percent of those vehicles subsequently struck fixed objects. Those accidents took place on all kind of roads.

Still another study, by the Connecticut State Highway Department, disclosed that all fatal accidents on the State highway system in 1965 involved fixed objects to the degree of 43 percent.

The third and last point I wanted to make related to the type of highway administrative system on which the fatal accidents occurred. The Bureau of Public Roads is now collecting some information from the States, and we have had the opportunity to analyze that data.

In summary, it indicates that approximately 50 percent of the deaths are occurring on the Federal-aid primary system.

Mr. W. MAY. That includes the Interstate System?

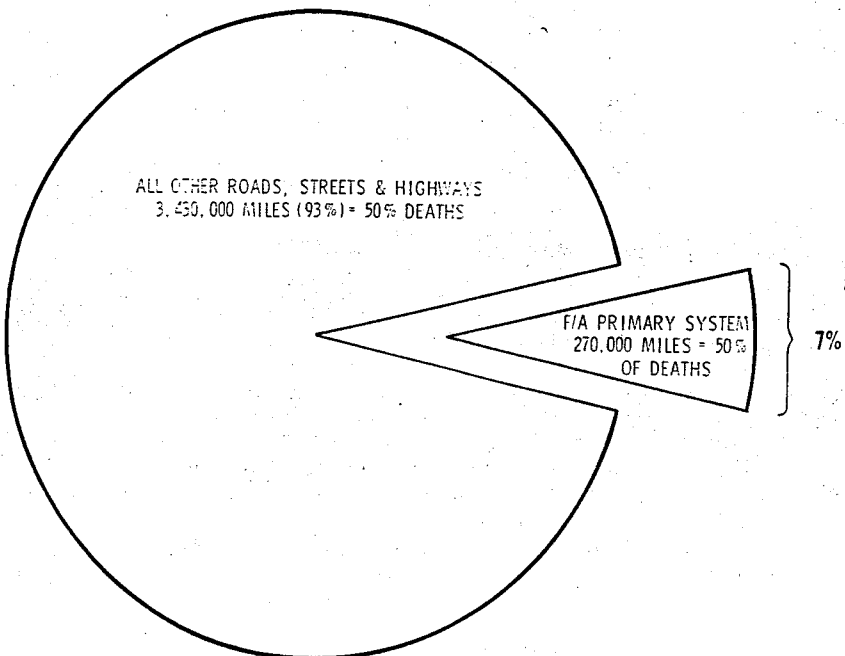
Mr. KOPECKY. That includes the Interstate System. The primary system by definition is the principal highway system, the main highway system. It accounts for 7 percent of the total miles in the United States. It totals approximately 270,000 miles, including the Interstate, out of a total of 3.7 million miles of all roads and streets in the country.

For this discussion, I would like to use this pie chart and two charts which we have handed out.

The first mimeographed chart is entitled "Statewide Fatal Injury Accidents, 1966." This compares deaths on the Interstate System with the death total of all systems.

TOTAL MOTOR VEHICLE DEATHS COMPARED WITH DEATHS ON FEDERAL AID PRIMARY SYSTEM

TOTAL ROADS, STREETS & HIGHWAYS IN U.S. = 3.7 MILLION MILES



The other mimeographed chart is "Statewide Fatal Injury Accidents." This compares deaths on all systems with the deaths on Federal-aid primary system, including the Interstate.

STATEWIDE FATAL INJURY ACCIDENTS, 1966 (42 STATES)

State	Total, all systems		F/A primary system (including interstate)				
	Total deaths	Rate (per 100,000,000 vehicle-miles)	Deaths	Rate (per 100,000,000 vehicle-miles)	Percent of total		
					Deaths	Miles	Traffic
Alabama.....	1,089	7.51	(1)	(1)	(1)	8	52
Alaska.....	67	8.07	48	12.34	72	25	47
Arizona.....	645	7.28	317	7.59	49	8	47
Arkansas.....	666	7.08	371	7.64	65	5	52
California.....	4,830	4.78	(1)	(1)	(1)	6	43
Colorado.....	602	5.74	357	6.62	59	5	51
Connecticut.....	406	3.00	(1)	(1)	(1)	7	43
Delaware.....	125	4.83	90	4.64	72	13	75
Florida.....	1,819	5.84	728	5.70	40	6	41
Georgia.....	1,601	7.00	(1)	(1)	(1)	(1)	(1)
Hawaii.....	105	5.04	78	6.44	62	15	50
Idaho.....	267	6.79	159	7.53	60	6	54
Illinois.....	2,522	5.19	1,260	5.17	50	9	50
Indiana.....	1,566	5.93	835	6.29	53	6	50
Iowa.....	904	6.90	545	6.90	60	9	60
Kansas.....	733	5.77	364	6.05	50	6	47
Kentucky.....	1,086	6.96	547	7.42	50	6	47
Louisiana.....	854	6.30	432	7.13	51	6	45
Maine.....	233	4.60	108	4.51	46	9	47
Maryland.....	755	4.36	331	4.11	44	8	47
Massachusetts.....	898	4.15	(1)	(1)	(1)	9	46
Michigan.....	2,226	(1)	873	4.70	39	6	42
Minnesota.....	977	5.52	545	4.93	46	6	52
Mississippi.....	799	8.58	491	8.94	61	9	59
Missouri.....	1,379	6.22	795	7.17	58	8	50
Montana.....	276	7.19	192	8.31	70	8	60
Nebraska.....	424	5.02	188	4.43	44	6	50
Nevada.....	211	7.48	134	8.08	64	5	59
New Hampshire.....	148	4.04	52	(1)	35	9	50
New Jersey.....	1,127	3.26	453	3.96	40	6	33
New Mexico.....	431	7.23	254	7.30	59	6	59
New York.....	2,806	4.86	927	3.46	33	11	46
North Carolina.....	1,709	7.59	(1)	(1)	(1)	5	38
North Dakota.....	209	6.01	109	6.08	52	4	52
Ohio.....	2,602	5.39	1,143	5.41	44	7	44
Oklahoma.....	796	5.43	458	5.63	58	7	55
Oregon.....	678	6.13	346	6.38	51	5	49
Pennsylvania.....	2,180	4.25	1,013	4.76	46	7	41
Rhode Island.....	110	2.74	49	2.62	45	10	46
South Carolina.....	968	7.47	(1)	(1)	(1)	(1)	(1)
South Dakota.....	265	6.55	152	6.34	57	7	59
Tennessee.....	1,258	7.29	654	6.75	52	8	56
Texas.....	3,406	6.26	1,693	6.04	50	7	51
Utah.....	328	6.46	184	(1)	56	11	54
Vermont.....	123	6.80	64	5.21	52	10	60
Virginia.....	1,106	5.08	637	5.31	58	9	55
Washington.....	823	4.94	368	5.98	45	5	37
West Virginia.....	518	6.92	296	8.33	57	7	47
Wisconsin.....	1,126	5.69	(1)	(1)	(1)	(1)	(1)
Wyoming.....	153	6.0	129	7.59	85	5	66
District of Columbia.....	97	3.73	63	4.65	65	13	52
Total.....	51,032	5.49	18,741		50	7	50

¹ Not available.

Source: BPR and State compilations; tables TA-1.

The chart on the Interstate System shows the Bureau of Public Roads figures as obtained from the States. These figures show that for 46 States reporting there were 3,030 deaths on the Interstate System in 1966, and the combined average rate per hundred million vehicle-miles, which is the method of reporting, is 3.15 deaths per hundred million vehicle-miles of travel.

Of the total of all deaths on all of the highway systems, the Interstate accounted for 6 percent. Understandably, there is a substantial

range. The Interstate accounted for as much as 19 percent of the deaths in one particular State in 1966. And the death rates ranged from a low of 1.00 up to 6.95, 6.60, 7.02, 5.60, per hundred million miles.

Mr. W. MAY. Excuse me, Mr. Kopecky. I wonder if any committee members have any observations to make on that particular schedule?

Mr. A. E. JOHNSON. Has the staff checked to see whether multiple fatalities in a single accident might be involved in some of those?

Mr. W. MAY. Not yet.

Mr. A. E. JOHNSON. Like a bus or something of that nature?

Mr. W. MAY. Not yet.

Mr. E. M. JOHNSON. Mr. May, in that Interstate report made by the Bureau for the last 6 months of 1966, that information is given; but I do not remember exactly how it came out. There are many more fatalities than there were fatal accidents, which is to be expected.

Mr. W. MAY. That is true. But this is the same kind of data that we use or whoever comes up with a national rate uses this same kind of data.

Mr. E. M. JOHNSON. Right.

Mr. W. MAY. And No. 1, you have the 3.15 rate for the completed Interstate System and in some States, the death rate is running higher than the national average for all roads. For example, 8.09, 6.46. If we look at where those rates apply, I wonder if we can learn anything at all. Are they rural-type States? The reason the staff is having great difficulty with rates, is that we are not quite so sure that the rate is the real indication of whether or not a highway was designed and built safely.

We are concerned because the beltway right here in Washington had 30 people killed last year, and we have checked and during rush hour from 6 to 9 in the morning and 4:30 to 6:30 at night, no motorist was killed. If we knew the rate, it would probably run about 2.5.

We just challenged the fact that somebody suggested a rate would indicate whether or not the highway is safe. In rush hour nobody was killed, the same highway; and other hours, 30 people were killed. We do this to suggest that nobody can be satisfied with a rate, particularly a national rate. Mr. Kopecky.

Mr. KOPECKY. Yes. Just to conclude with this interstate chart, we noted that in two of the States the death rate per hundred million vehicle-miles on the Interstate System was higher than for all of the roads in those two particular States. Also, that in six States the death rate per hundred million vehicle-miles was higher on the Interstate System than the combined national average rate of 5.49 for all systems in all States.

Mr. W. MAY. Yes, sir.

Mr. KOPECKY. Further, the Bureau of Public Roads data as taken from the individual States differentiates between urban and the rural Interstate systems. And in that regard the death rate on rural Interstate was higher in 11 States than the combined national average rate of 5.49, and it was higher on urban Interstate roads in seven States.

So, again, these are the observations that we obtained from our analysis with Bureau data.

The last point we want to discuss is this other chart listing the statewide fatal injury accidents on all systems, and as compared with the Federal-aid primary system, including Interstate.

This material was obtained for 42 States that had such information and were able to report to the Bureau for the Federal-aid primary system. And the chart indicates at the bottom that it accounts for 7 percent of the total miles in the United States, and it accounts for 50 percent of the deaths and 50 percent of the traffic for the 42 States reporting.

Mr. W. MAY. When we see the initial "NA," what does that mean?

Mr. KOPECKY. NA would mean that is "not available," and the States at this particular point in time were unable to report this.

Mr. W. MAY. Thank you.

Mr. KOPECKY. Again, as Mr. Johnson noted, the first column on this chart would show there were 51,032 deaths. That is what Mr. Johnson referred to. The National Safety Council reports approximately 53,000 deaths. The difference is due to the fact that the National Safety Council reports include Guam, Virgin Islands, and Puerto Rico. In addition they also include a factor for those deaths which take place in 1967 but involved an accident in 1966, and they include the 12-month time period, if a person dies within that time from the date of the original accident.

Mr. W. MAY. Mr. Chairman, I wonder if we may make that data an exhibit, and insert the material in the record where appropriate—motor vehicle deaths compared to total vehicle-miles exhibit 18; and the pie chart exhibit 18A; motor vehicle deaths, 18B; statewide fatal injury accidents, Interstate, 18C; and the one referring to the primary system, 18D. May we do that, Mr. Chairman?

Mr. BLATNIK. Without objection, so ordered.

(Exhibits Nos. 18, 18A, 18B, 18C, and 18D were marked and have been incorporated at the proper places in the record.)

Mr. W. MAY. Mr. Johnson, to get back to roadside hazards, I notice in your statement on page 7, paragraph 3, you say—

As we have admitted previously, the effects of roadside features have possibly been overlooked or at least underestimated, and this was becoming apparent to us some three years ago.

The staff made a study. We reviewed various writings over the years, and it seems to us that the roadside hazard problem is not new. It has been spoken of by various people over the years. I mention just a few.

Back in 1917, a Mr. DuPont writing relative to road construction and maintenance and safety of travel stated, "Construction should tend to promote freedom from accidents. Overhanging rocks and culverts are conducive to recurrence of accidents. Where possible, these defects should be obliterated and all new location work should avoid them." That was 1917.

In 1938 a report from a study of motor vehicle traffic conditions in the United States made by the Bureau of Public Roads and submitted to Congress in 1938 states in part 5, page 52:

Practically any road can be driven over without mishap, provided everyone who uses it drives properly; but ample evidence demonstrates that everyone does not drive properly and a safe highway must provide a factor of safety for those who are forced off the surface by the faulty action of another driver or who may because of momentary inattention slip over the edge of the pavement.

And we all remember WPA, back in 1939, September, Works Project Administration, technical series, Circular No. 1, Survey of Traffic

Obstructions, "Motor Vehicle collisions with fixed objects are reported by the National Safety Council to have been the cause of 3,750 deaths and 95,000 injuries during 1937. Deaths from this cause have increased 244 percent since 1927. The problem is significant enough to warrant attention leading to possible improvement of the situation. Obstructions include bridge support columns, end posts of narrow bridges, utility poles, pedestal types, stop and go signals and flashing beacons," and so forth.

In 1941, Maxwell Halsey in his book, "Traffic Accidents and Congestion," stated, "Obstructions should be pushed back far enough from the roadway so that if a motorist is forced off the roadway, he will have sufficient space in which to slow down and stop."

We had testimony of Mr. Ken Stonex of General Motors during these hearings. He was talking about these same matters, certainly as early as the middle and late 1950's.

The staff is perplexed that it was only until recent times when highway people seemed to be giving their attention in a forceful way to these roadside hazards. I wonder if you want to comment on that.

Mr. E. M. JOHNSON. Well, through the years, the geometrics of the highways have been improved, standardwise, and there is no question particularly on a rural primary even today, there are many, many miles with inadequate length pavements and inadequate length shoulders, and I think by virtue of these particular features being too narrow, that the tendency or the justification even for moving obstructions farther out was somewhat discouraged or not feasible or maybe impossible to achieve really in view of what public reaction might be.

I am just commenting, as you suggested, because certainly as we say in our statement, we have to assume the responsibility for obstructions being too close. But I don't think that it could be said that they have been entirely ignored through the years.

Now, if I am not mistaken, and you probably have the statistics on it, this roadside obstruction matter has become much more critical with the faster Interstate traffic. I am not sure that that statement is correct, but I am under that impression. And the Interstate actually as we all know in this room has greater lateral clearance than any other highway.

Mr. W. MAY. Yes. I notice in your statement on page 7, first paragraph, you say:

The design standards that we have developed have resulted in completed Interstate System sections that have no obstructions closer than 12 feet to the pavement edge. This is the first time that a highway system has been provided that can make that claim.

I would suggest it is probably a claim because that might only apply to the right side of many of our Interstate highways. If you have a 10-foot shoulder and you place the obstruction 2 feet from the shoulder, then you have 12 feet. If you have a 4-foot shoulder on the other side, you have it very close, and it would not be 12 feet. Would it apply on the right side when you come to narrow bridges where we do not carry the shoulders through?

Mr. E. M. JOHNSON. If you consider the bridge ends and bridge rail as obstruction, and the bridge is not full roadway length, your statement is correct.

Mr. W. MAY. We do consider that obstruction. Do you?

On page 4 of your statement you say:

Substantial expenditures on the Interstate System could fast reach the point of diminishing returns and such monies could better be spent on the improvement of roads and streets having higher fatality rates.

What could we suggest there?

(Mr. McCarthy assumed the chair.)

Mr. E. M. JOHNSON. The fact that we had there, Mr. May, is that in the first place that should be "substantial additional expenditures." And our feeling is that certainly there are many things which you have pointed out, such as signs, and major obstructions as compared to bridge piers, for example, bridge supports, that could and should be moved with little additional expense. But it could be that in lengthening bridge spans or even eliminating intermediate bridge supports or widening your bridges to full roadway width, all of them, it could be that the expense involved there could not be justified in the reduction of fatalities that would accrue as a result of those improvements.

Then, too—and, of course, I am mixing funds here, I realize that—but some of the safety features, for instance, on primary—we will not mix funds—some of the money that would be spent in moving back roadside obstructions and particularly in lengthening bridge span and in full roadway width bridges, might be better spent in improving the geometrics of rural mileage, that is pavement widths and shoulders and so forth. That was the thought that we had in that statement.

Mr. CLEVELAND. Mr. Chairman, may I inquire?

Mr. MCCARTHY. Mr. Cleveland.

Mr. CLEVELAND. Right on this point, Mr. May, can you tell me will the Federal Bureau of Public Roads authorize 90-10 money for these improvements that you are suggesting in the rearranging of obstructions; because as I read Mr. Johnson's statement on page 2, he makes it pretty clear that the expense factor here has been important and it was not really until he got into the 90-10 situation that some of this more elaborate safety designing could be taken from the drawing boards and put on the ground.

Now you are suggesting that these changes are going to be made—my question is, If these changes that we feel are necessary are going to be made, is this going to be at the rate of 90-10 and does the Bureau have a position on that?

Mr. W. MAY. Yes, sir. When it comes to going back to our completed sections of the Interstate and making this type of correction, generally roadside hazards, guardrail, and signs and replacing them with break-away supports and that type of matter, the Bureau has already participated in some States in 90-10.

Mr. CLEVELAND. Are there examples of that for the record that they have put up 90-10 money?

Mr. W. MAY. Yes, sir.

Mr. CLEVELAND. I would like to ask another question. Have there been some States that have recommended some changes that the Bureau said, "No, we do not feel they are necessary?"

Mr. E. M. JOHNSON. I will attempt to answer that, Mr. Cleveland. In recent months, I do not know of any such refusal on the part of the Bureau. But it has been and always has been, and this is not a critical statement at all, a frugal attitude in design to provide what was thought to be needed, but not to go much, if any, above minimums. And I am sure there have been many cases in the past, and I am speaking of, let's say, a year or more ago, various States wanted wider

bridges—and that I can think of in particular—and were not able to do so on a participating basis with Federal funds paying the share of that cost.

Mr. MORTON. Could I offer one comment here? There are various instances, I think, that are disturbing, maybe if certain rules are attempted to be promulgated here. And we have, for instance, a primary road, primary Federal aid—this is on a 50-50 matching basis—where we are occupying part of a river and valley on a rather high embankment. Our road was designed with 24-foot pavement and then a 10-foot paved shoulder on either side with the guardrail out at the 10-foot line.

We were asked to move the guardrail out and widen the shoulders to 12 feet. Well, we made some computations as to widening the shoulder 2 feet and setting the guardrail back 2 feet more. If I recall, to do a mile of that widening was going to cost us maybe \$70,000 or \$80,000 more. And I am sure it was our feeling, and the feeling of our people, that we were not buying 25 cents worth of safety for the expenditure of \$70,000 or \$80,000.

There are expenses of that kind where I feel we need to use certain judgments. We could spend a lot of money that would not be well spent.

Mr. W. MAY. Yes. You are going to have great difficulty in putting all the answers or directives in one book. You are going to have to still use your judgment each time for each item or each project.

Mr. MORRISON. If I might go back one step here. In the earlier question that you posed, that is these fixed objects. In my particular State, we have several thousand miles of rural State highway system that are bounded by stone walls in relatively close proximity to lines of travel. And certainly I mean you can view a stone wall to be as much a fixed object as almost any other thing.

Now, we have lived with this type of wall, and we know that it would be financially impossible for us to go in and take all of these stone walls down. In fact, some of them are rather prize possessions by the property owners. And so I feel that you learn to live with these objects in close proximity and sometimes because of that, why you do overlook other objects.

Mr. W. MAY. In the future on some roads you probably will still end up having stone walls. On freeway type roads, there will not be stone walls. What is relatively disturbing to the committee is having looked at some relatively new projects, new Interstate projects out through the country, and having found a series of this same type hazard: Gore areas, signs too close, massive supports, and that type of matter. And many, many times it would not have cost any more money—sometimes less money—to have done it safely.

That statement you made relative to expenditures, together with your mentioning that the research is being done prompted me to go back and review some of the writings we had.

On December 12, 1950, an engineer addressed the Louisiana Safety Association Conference down in New Orleans. And he said:

I sincerely believe that the accident rate here in Louisiana or in any State can be cut 25 per cent without our having to learn a single new fact about designing for safety. What we must accomplish now will not come by research, it will only come by conscientious determination to give safety a better chance. Streets and highways are expensive, so from the time the first design plans

are begun, we start sniping at desirable standards to cut the cost estimates. Right-of-way is costly, so we buy less than we should have and try to get along cramping the cross-section design.

Out in the country the location plans show an isolated sharp curve, and what do we do? Well, we decide it is not feasible to do anything, and the curve is built, a sure accident trap for the inattentive driver. Shoulders that ought to be eight or ten feet wide, we design for six feet to save a little dirt and money. This straying away from design standards is what we call being practical and against this whittling of initial expenditures, we are deliberately gambling with the safety of the next generation at least. We need to apply more of what we already know about safety and design. People ought to be worth more than the pavement.

I will say that engineer was Mr. C. W. Prisk.

There is a philosophy here. There is a thinking that many times we have an opportunity when we are building new projects to do a fine job. We may not come back to it for a while. And I think that is what is striking on the committee, as we progress with this phase of the hearing.

Perhaps we could do this, beginning at the left with Mr. Morton each chairman of a particular AASHO committee might relate to the subcommittee here how your particular committee fits into this overall picture and what your observations might be as to what we can do about the fixed object roadside hazard problem that is facing us. Mr. Morton?

Mr. MORTON. I think from a traffic viewpoint, probably one of our difficulties in any organization is the difficulty of communication. Surely at our traffic committee meetings we try to draw from the traffic engineers of the respective States the hazards they are encountering and the methods they are employing to overcome them.

I feel that we have made substantial progress in recent years of moving back the signposts. We have pretty well accepted now the theory of using the breakaway sign or the sign with the signposts with a weakness created in them so they are not a fixed object.

Mr. W. MAY. You mentioned the breakaway signs, which seem to have such considerable merit. But in the nine new projects that were analyzed, only one State used breakaway supports on the project, and then only partially. Only one out of the nine.

Mr. CLEVELAND. May I inquire at this point?

Mr. MCCARTHY. Yes.

Mr. CLEVELAND. Can you have any breakaway sign that supports a sign that goes across the highway? A breakaway sign by its nature has got to break away; and if you have a situation where you have to have a sign all the way across the highway, it cannot be a breakaway sign. Am I correct or false on that statement?

Mr. A. E. JOHNSON. You are right.

Mr. W. MAY. That may be true right as of this minute; but it is difficult for at least the staff to consider that we cannot develop a breakaway overhead bridge sign. Texas A. & M. is about to work on it. They have ideas about two supports to the side located in such a way that you could not strike both supports at the same time. If you broke away one, one could still hold up a sign.

Mr. CLEVELAND. Is that feasible from an engineering standpoint to have a sign where the impact of a car could break away one of the supports and the other support would be strong enough to hold it?

Mr. E. M. JOHNSON. It would have to be so designed to do that. As Mr. May says, I certainly would not say that is an impossibility, but

you are placing two additional roadside obstructions, but offsetting that with the breakaway feature.

Mr. W. MAY. That is something that should be given real prompt attention.

Mr. A. E. JOHNSON. Mr. Stonex with General Motors worked on a breakaway support for overhead sign structures. But it did dump the sign in the middle of the road. It let the car that hit it go through safely, but it dumped the sign in the middle of the pavement.

Mr. W. MAY. We would not be anxious to do that. It is something that we believe could be developed. Did you have anything else, Mr. Morton?

Mr. MORTON. Well, this question of signs, to me, is an extremely difficult problem. I mean to know just exactly what the messages should be on the signs.

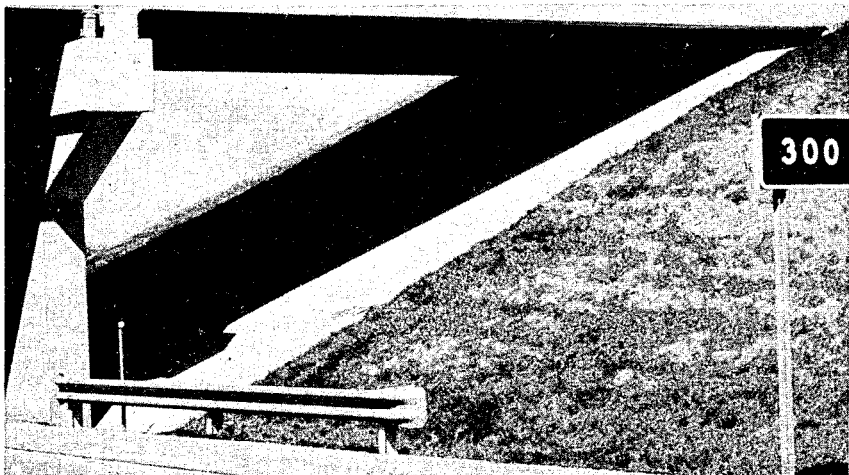
In many instances, I think we oversign. Personally, my feelings go along this way. If I am driving in New York State, New York City, and I see a sign that says Franklin D. Roosevelt Highway, all of these highway signs by name do not mean too much to me. They have no significance.

If I drive in California, the various San Diego freeways, these names are repeated time and time again, using up valuable space. As a stranger, they have no significance to me. I would much rather travel by route number and work my route out and use an exit numbering system. You can map your trip out and do it. I think our public should be educated in this direction.

Mr. W. MAY. The problem of signing or indicating where the motorist is heading is going to be enquired into during the next several months. Perhaps we can do this. You people are at some disadvantage in not having been able to observe some of the features that we found on some of the projects. We will show you just a sampling of some of the types of hazards that were found on these recently opened projects around the country, and perhaps you will have some comments then.

Mr. Constandy?

Mr. CONSTANDY. Of course, we would not be able to show you the 632 slides which we used during the hearing. We did put together 17 slides that are not the worst situations. They are situations that seemed to be typical.



This is a section of a guardrail intended to protect the motorist from the shoulder here on the right. The guardrail is 25 feet long and supported by three steel posts.

You will notice that the approaching end of the guardrail is aimed directly at the car. There are a number of fatalities each year where the driver is pierced by such an approaching end.

The other end of the guardrail ends here at the pier and a car impacting the guardrail would in all probability bend the guardrail back. This particular installation has no blocked-out feature to prevent the wheel of the automobile from catching at the post. It does not contain any washers to prevent the heads of the bolts that attach it to the post from pulling through the guardrail.

This was a typical installation in the State in which we found it which happened to be Indiana. We found in all nine States that either the design or the installation of the guardrail left something to be desired.

Would anyone care to comment about this photograph?

Mr. E. M. JOHNSON. Mr. Constandy, may I ask you a question?

Mr. CONSTANDY. Please do.

Mr. E. M. JOHNSON. In your studies, have you any comparison of the safety value of an adequately flared guardrail as compared to the buried-in-line guardrail? Your point, of course, that you make there is well taken. I am going a little further.

Mr. CONSTANDY. If you are asking for my personal judgment or opinion, I have none. However, I am somewhat familiar with the Special Report 81 of the Highway Research Board, which represents at the time of publication in 1964, the composite knowledge of those people who conducted sufficient research into the matter to justify having an opinion on this.

I think you will find that in Special Report 81, in reference to the point you raised, they recommend that in all cases the guardrail be anchored on the approach ends. They give two illustrations, one of which shows the buried end parallel with the traveled roadway while the other shows an offset or flare from the travel way.

My recollection of it is that they recommend 4 to 10 feet flare and they then recommend that before it comes back on a tangent that the distance be some 10 to 15 times the amount of the offset. This latter installation of being both anchored and flared was the recommended design by the Highway Research Board Special Report 81.

They have recently come out with an additional publication which perhaps puts in more perspective the problems involved in guardrail installation.

In the course of our speaking to the people who have conducted research, we found that there was much that could be said as to the advisability of a washer and advisability of blocking out the guardrail.

Mr. Beaton tested the guardrail in attempting to find out how short a section would be effective. In the course of his study at one point the test was approximately 90 feet, and the car tore it away. He concluded a section could not be less than 100 feet and be effective, particularly if it was not anchored. When Mr. Stonex testified, I believe he said they use a length 500 feet in advance of a bridge. This is 25 feet, one section.

I think everyone would agree that this is not only inadequate, but it presents additional hazards, at a cost of some \$100 to \$150, and only increases the target area.

Mr. E. M. JOHNSON. I am familiar with the Research Board findings, but I just wondered if in your observations you had found where a flared guardrail without being buried had caused a fatality due to the end of the guardrail impaling the vehicle?

Mr. CONSTANDY. Where the end was not buried? Not on any of the projects that we looked at. We have to remember, however, that those projects were only opened in late 1966 or 1967. So the amount of traffic they have carried to date has not been significant enough to give it experience. But we are acutely aware of a large number of accidents of this type throughout the country. There was one in the Washington area yesterday afternoon.

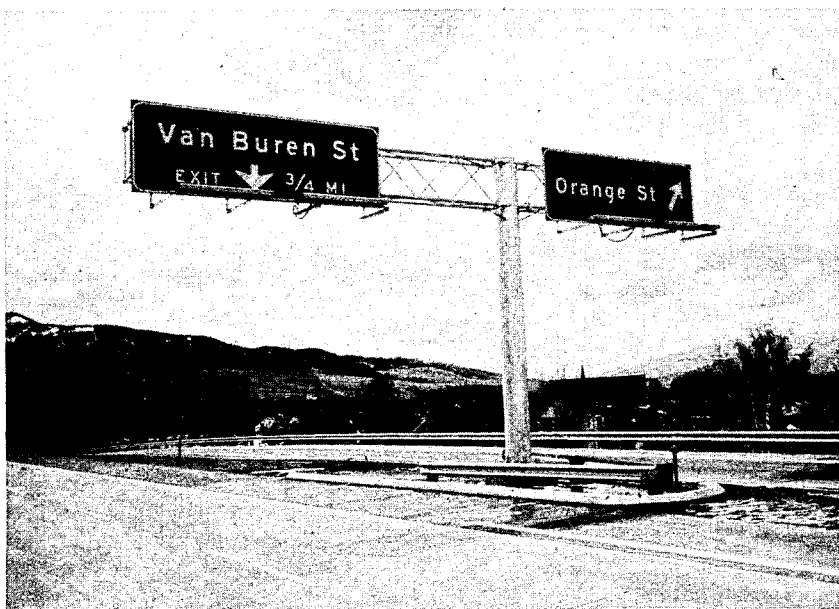
Mr. E. M. JOHNSON. Where it was flared sufficiently?

Mr. CONSTANDY. No. I misunderstood.

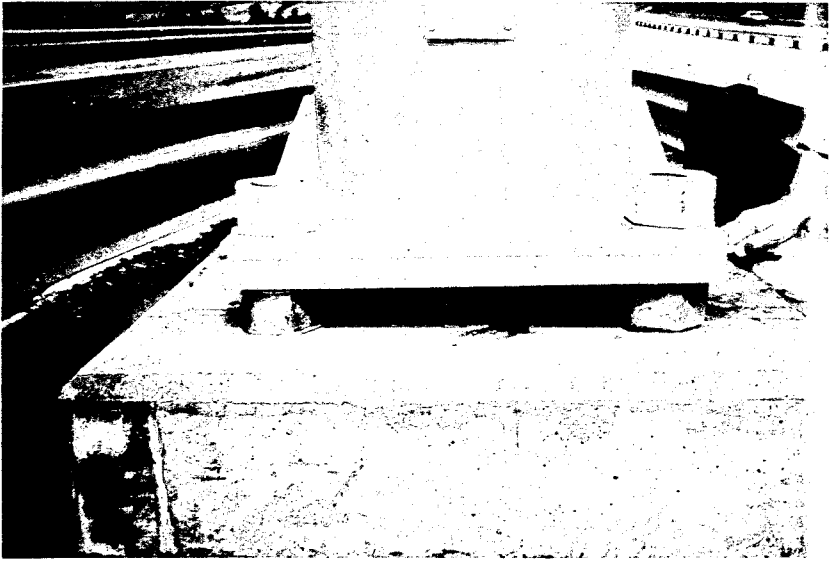
Mr. E. M. JOHNSON. I understood it was not flared. The point I wanted to ask was that if you had made any observations in your studies where flared guardrails without burying had been found to be safe as compared to flared guardrail that is buried according to the Highway Research Board study?

Mr. CONSTANDY. No; we did not have anything on that.

This is a sign installation in Montana. It is one of three intersections at Missoula. Of the three of them, this is the only one that had this type of butterfly sign in the gore.



As you can see from the next photograph, the sign is substantial. It is mounted on a concrete base. The nut there is 5 inches wide. This is not a breakaway-type sign.

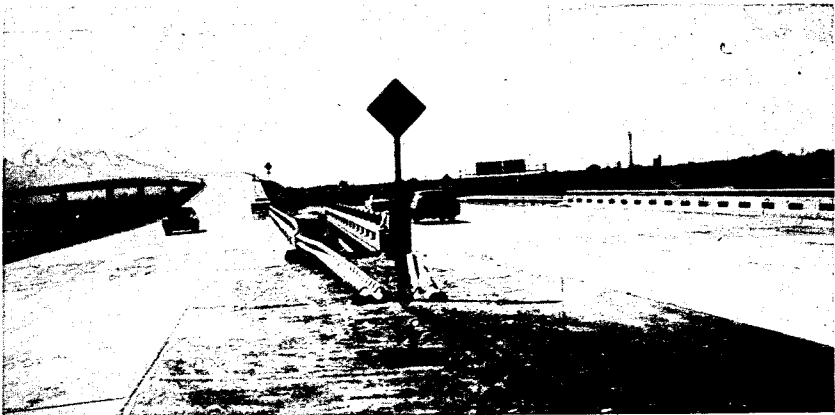


This is a twin bridge in Salt Lake City, Utah.

Mr. ZION. On the other slide, we presume it would be virtually impossible to make a breakaway sign that size?

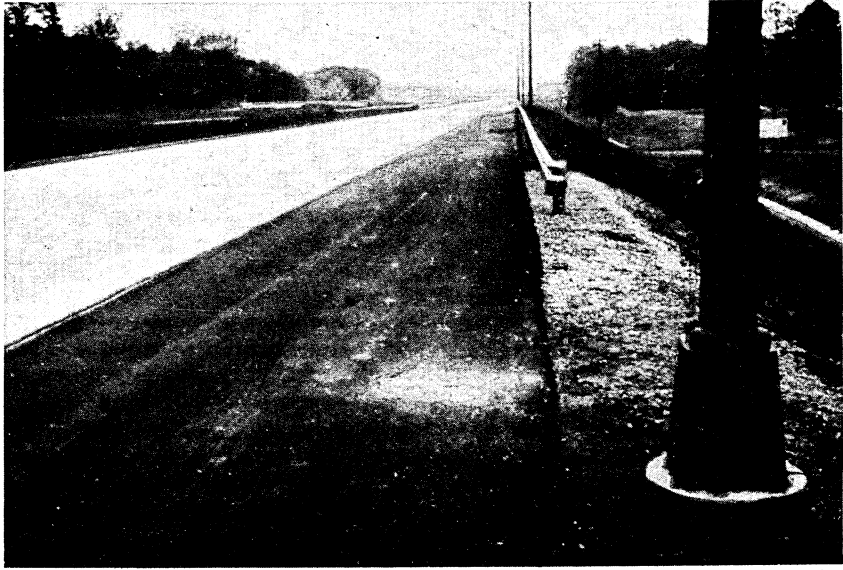
Mr. CONSTANDY. I do not know if it is impossible. According to the comments that were made by the panel that attended the hearings earlier, perhaps one solution would be to post this type of sign in advance of the point of decision along the right-hand shoulder behind the guardrail or on an overhead bridge structure. In either case, it should be in advance of that point.

This is, as I mentioned, in Salt Lake City. It is a twin bridge which is unpaved. California's experience would suggest that with a 24-foot medium it would be possible to pave between the two structures at no additional cost. I do not know if it would follow, then, where you have

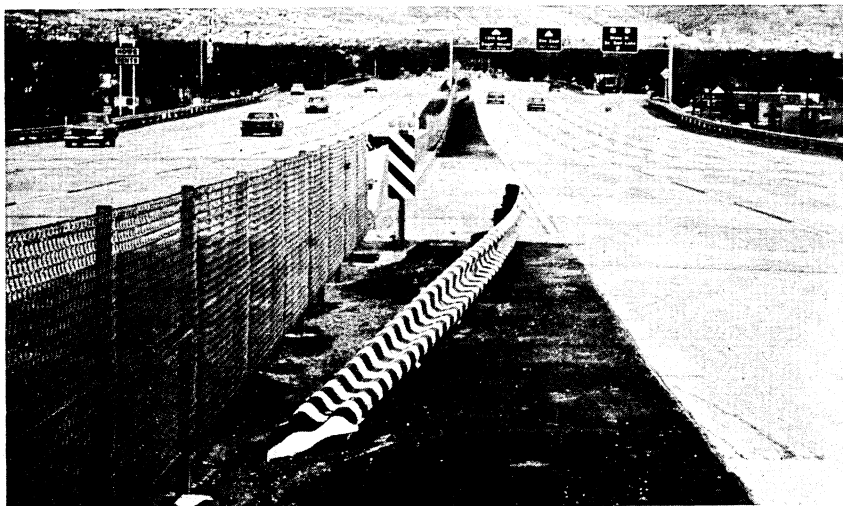


an opening which is 6 feet between the two structures, and something in the area of 8 or 10 feet at the other end, it was not more expensive to do it this way than to provide the additional safety, and to have the area cleared.

This is a light standard on a project north of Atlanta, Ga., that is mounted on a transformer base. Both the base and the pole are steel. These are lethal when hit.



This is an installation again in Salt Lake City which shows a combination of a chain-link fence combined with cable, and it approaches the twin bridge, which in this case has been paved. The bridge engineer has designed and constructed a concrete parapet between the two roadways, which presented a problem in the transition from the chain-



link fence to the concrete parapet. It necessitated the installation of a third type of barrier, a W-beam, which is flared and buried here, but it almost eliminates the shoulder on the left side.

It comes from within 2 feet of the traveled way. There is some question as to the length of this section being too short.

You have a mixture of all three at one point, any one of which might have been satisfactory had it been properly installed.



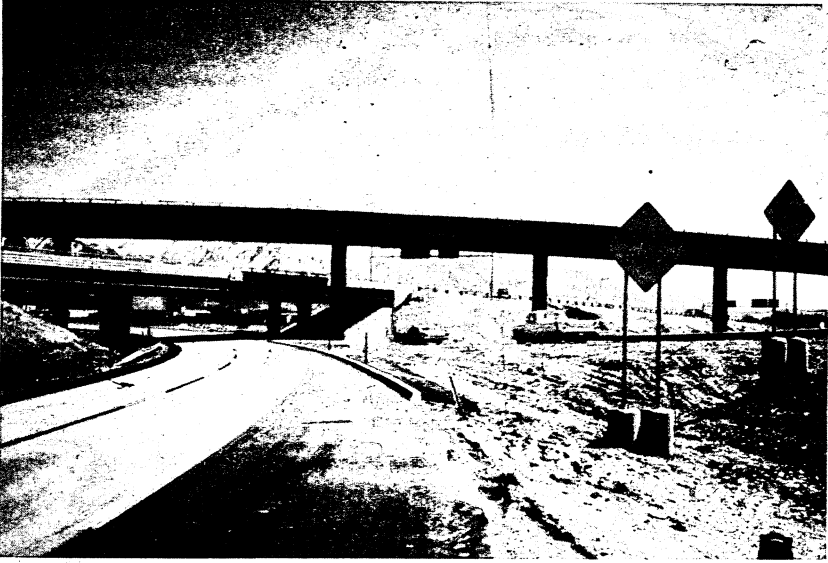
Here is a sign that is not untypical of the nine projects we visited. The right-hand leg is mounted on a concrete pedestal standing over 2 feet high. The sign support is 6-inch steel I-beams. It is 2 feet off the shoulder, the edge of the sign. The sign is otherwise unprotected.

You will note the message suggests that particular sign did not have to be located precisely at this point anyhow.

This is again typical of the Interstate route signs. In this case it was mounted, in Montana, on 4-inch steel I-beam, laid in concrete foundation, placed 2 feet off the shoulder. There is a variation. Some of them use two 4-inch I-beams, as Maryland does. Some of the other States use one. One State mounted this, only a temporary installation, on a piece of channel iron.



Here are two merging traffic signs. And I think the one on the right was projected above the grade on a concrete foundation higher than any we had seen. That is over 3 feet high.



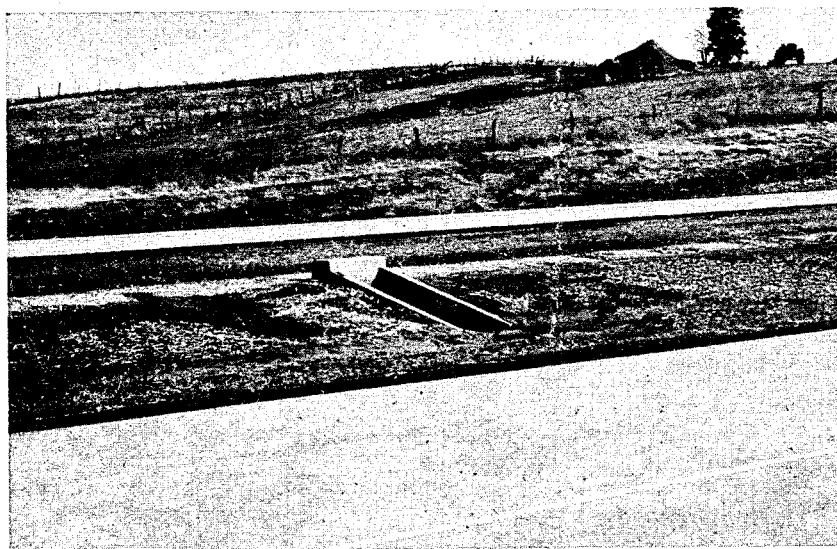
Here is an installation in Montana where the guardrail is placed directly off the inside shoulder in order to protect the driver from the center pier. As you can see, it is not long enough. In this case, not being long enough, it permits the driver to go behind it and still impact the center pier. This condition is true, too, on both shoulder piers.



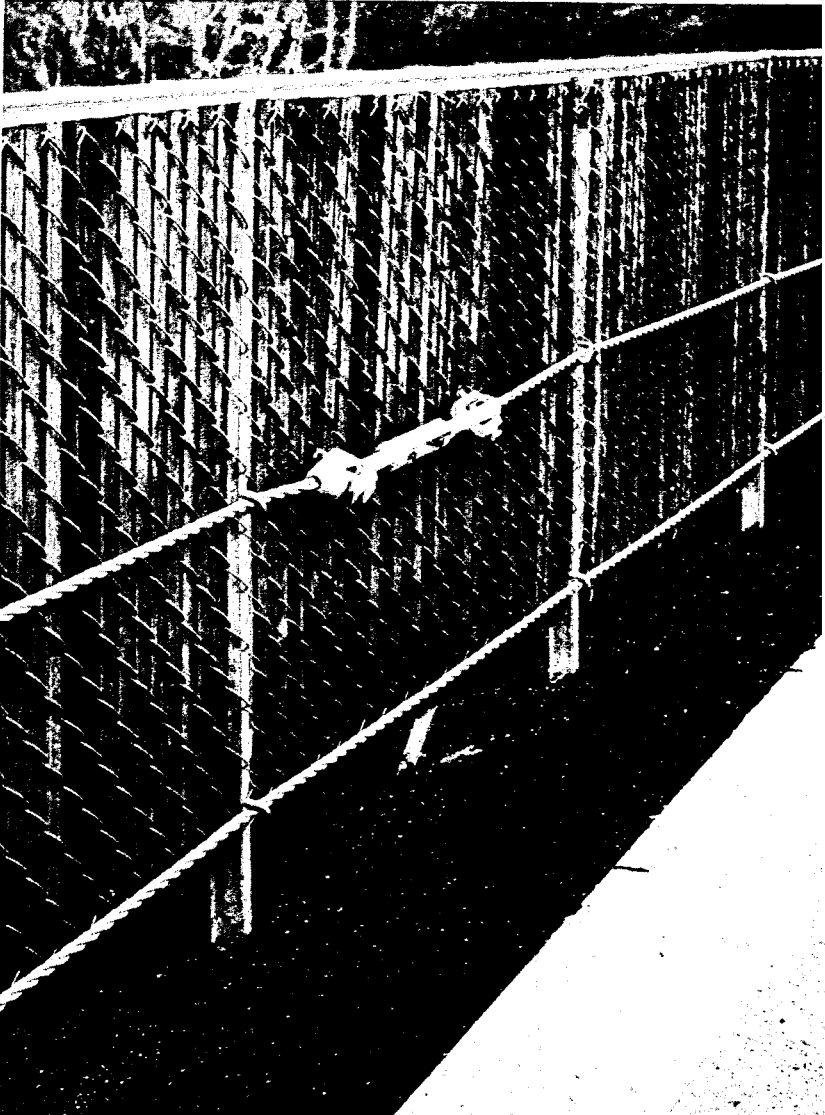
Here is another installation in Salt Lake where the guardrail misses coming to the end of the bridge by some 8 or 10 feet. It is enough to drive between without touching either the bridge or the guardrail.



This is a concrete headwall and drainage structure placed directly off the inside shoulder.



This is an installation in Rhode Island where they have attempted to duplicate what California initially conceived was a desirable media barrier, utilizing the cable and chain-link fence on a weak post. However, Mr. Beaton testified they would only use this on wider media than is installed here, inasmuch as there is considerable deflection. They would never use it with curb that close to it. After they installed this, they found that the turnbuckle presents an additional hazard. They have eliminated the lower cable. What happened here is that Rhode Island has installed something California has already discarded.



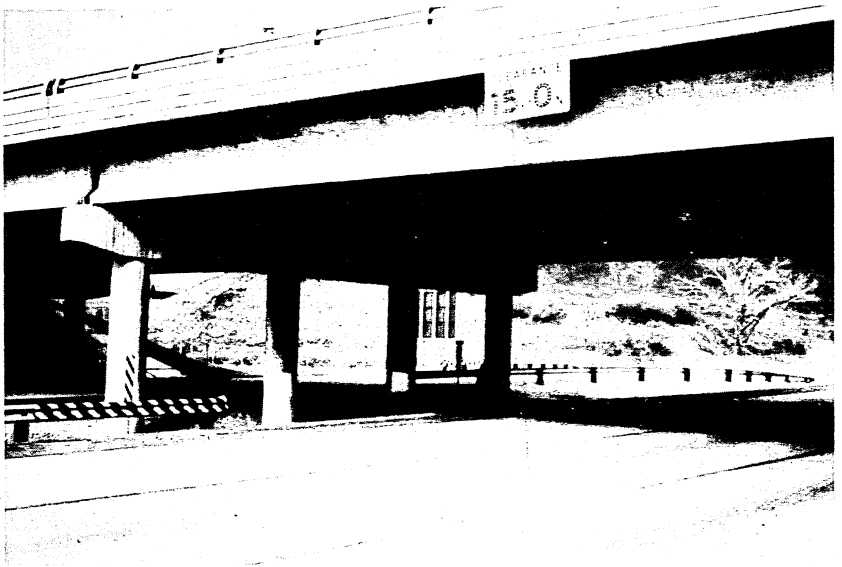
This is another photograph taken in Rhode Island which shows the existence of a formidable piece of rock which was left off the right shoulder at a distance of some 15 feet in an attempt to provide esthetics. This was a common situation on that project.



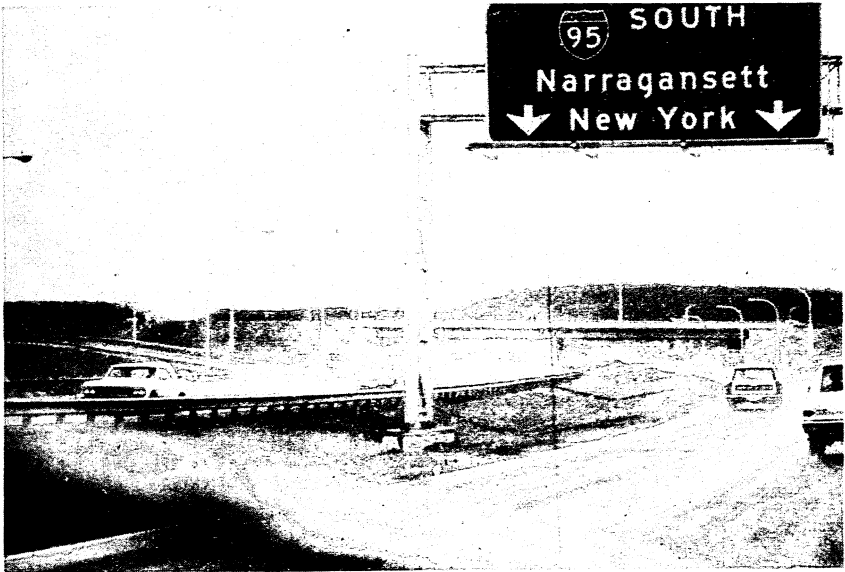
This is again in Georgia. It is a median structure.



Here are the center piers on one of the projects where the guardrail comes up and does make an attempt to protect the driver, and I guess does from the first pier, but the next three are left exposed. You have the paradox there of the guardrail with reflectorizing paint to show they are a hazard.



This is a sign in the median, left totally unprotected.



Mr. W. MAY. Perhaps since we have heard from Mr. Morton, Mr. Snider, did you have some comments on some of those features that we just saw, and give us your observations as to how we can assure ourselves that this type of feature will not be included in our new projects.

Mr. SNIDER. I must say first that the pictures are very convincing that we have not been going all out on the safety features. I will say this, that in most of the States that I know of, most of these features or the design, at least, have been changed; and I will have to confess that although you did not name my State, I saw one picture that I recognized—the foundations for the signs were high. That has been discontinued. It has been some time ago. Probably should have been discontinued sooner.

There are some of these features that are questionable in our minds at least. However, we are going on the guardrail in particular. The buried end of the guardrail, I think, could possibly cause a different type of accident, maybe not as serious. To my knowledge, we have not had a case where the driver of an automobile has run directly into the end of the rail.

However, we are burying our rails, and making the transition, flaring it. We are doing it on construction jobs.

I think it is worthwhile so that the accident may not be as serious.

Now, going back to guardrails, we think that more flaring and longer guardrails probably might be safer. We do not know. We do not have figures on that yet, but we are trying to find out.

Now, I want to comment just very briefly on those rocks in the backslope. We have some of that. That did not happen to be in our State. It has made the biggest hit with the public of anything that I know of in the way of esthetics. We received a letter—

Mr. W. MAY. Did you say hit?

Mr. SNIDER. Yes, sir. We have received a letter just very recently on a job on Route I-44, down the south part of the State, where we had left some of those rocks out in the backslope. And I must say they do look nice.

This lady said that "you have a heart of beauty. I do not see why you do not do more of it."

Now, I do not know that that is a good description. That is what she said.

I was down there after we had been going over these safety items, I was in that particular district recently, and I made mention to the district engineer that it looked like we were going to have to quit that and take such rocks as that out of the slope. And he let that word out, some way or another, and well, I have had a lot of criticism on it since. So it is a matter of education, I think. So are a lot of these items.

I think we can do a better job, and I assure you we are going to do a better job.

Mr. W. MAY. Thank you very much.

Mr. Goodman?

Mr. GOODMAN. Thank you. I would like to tell you how much I appreciate being here. Being chairman of a bridge committee, it puts a severe responsibility on one's extra curricular duties.

The bridge committee not only covers bridges per se, but we also have the responsibility for the design of the sign supports, light sup-

ports, the culverts and such as that. I am real happy to report that most of the bad things I saw have been under discussion by the bridge committee for some time.

To the best of my knowledge steps are being taken to correct them. We are making a sincere effort to eliminate the curves and be sure that there is no obstruction there for the car to hit. We are also looking at our bridge rail design to be sure that we have a rail that is somewhere between one that stops you so cold that you die and so weak that it lets you go through so you die. There is a medium there someplace that we are trying to achieve.

Our new sign manual will be out the latter part of this year. That sign manual is being updated to incorporate all the latest safety features that we can think of. It is very easy to alibi some of those pictures.

The people who drew them and built them, I understand they were building for permanence, and they wanted to place supports up out of the ground so they would not rust. They wanted to make them strong enough so they did not have to replace them. But in retrospect, maybe we can see maybe they overdid it. Some of the critical faults I noted were simply caused by the fact that the bridge spans were too short. Some of the rails did not continue through and protect the intermediate columns. To do so would have infringed on the very narrow clear space that we were trying to achieve.

What we are going to have to do, and we are recommending to the bridge committee, is that these spans be longer so there is plenty of room for the guardrail, either being long enough to not require guardrail, or if we do have to require guardrail, for goodness sake, make them long enough so the guardrail does not infringe on the safety area.

We are doing this by a series of task subcommittees. It all goes back to cost. Bridge engineers can design almost any type of bridge that is required. He is always controlled by the amount of money.

We have an everlasting trying time to design a beautiful safe bridge within the money we have. So to take care of these, we have some subcommittees that are continuing to work on new materials, new designs, in an effort to so we can build safer bridges and more beautiful bridges.

It may be of some interest to know that there was a contest sponsored about a year ago—some bridge engineers were judges—and they chose as a winner, not the most economical bridge or the bridge with the cheapest span, but they chose as a winner the bridge which did offer the most pleasing appearance and safety features.

I think that is a new trend in bridge engineers' thinking. I was a bridge engineer many years ago and grew up in the school of frugality. And I am glad to say that some of the new schools are looking a little further in the future and are trying to get new safer bridges for the benefit of all.

Mr. W. MAY. Thank you very much.

Mr. McCARTHY. Mr. McEwen.

Mr. McEWEN. I would like to ask Mr. Goodman, as chairman of AASHTO Committee on Bridges and Structures, are you giving consideration, Mr. Goodman, to the elimination of these large concrete abutments on the ends of your bridge rails? We have had quite a few

slides here and testimony relating to this. We found, and I noticed myself, that in many of the photographs we have had, you can say the abutments are esthetically rather attractive. There are three or four levels tiered up. I said earlier in these hearings, personally going by at 65 miles an hour on an Interstate highway, the esthetics escaped me until I saw it captured on a still slide on this screen. We have seen photos of a number of accidents, where vehicles have either freely gone into the abutment or have been guided there by guardrail. Is there thought being given to eliminating these large ornamental concrete abutments?

Mr. GOODMAN. Right. Traditionally many years ago when a bridge was built it had to have some sort of elaborate monument to dedicate it to someone or something. To my knowledge those have not been built in a long time; and even the most conventional bridge abutments are being replaced with just a flare turned down, so there is a straight line to get in the bridge and not have to come in and meet some sort of obstruction.

Mr. McEWEN. One other feature on bridges has concerned some of us, and that is, I believe, commonly referred to as the safety walk.

Mr. GOODMAN. We have differences of opinion about the safety walk. In my statement I said in general that we are trying to eliminate the 18-inch safety walk and merely have a flush curb. There are some engineers who feel that the 18-inch curb is important on long bridges for the benefit of maintenance people who are out there trying to fix joints and such as that and paint the strip, as a place of refuge. And then in some of the States, in spite of all our warnings and precautionary measures, there are some pedestrians. And although we would like to keep them off of there, some bridge engineers feel that the 18-inch walk is a good idea.

I would say in general that most States have eliminated it and are going to the flush curb. I would like to offer this comment.

I failed to say that another activity of the bridge committee is that for 2 years we have been studying—both in the United States and abroad—these large, wide joints in the bridge. We have had reports of some of the small cars and motorcycles dropping down in these joints and having some fatalities. We have had that on our agenda for 2 straight years, and we are trying to work out some series of expansion device that would not require that kind of a joint.

Mr. McCARTHY. Thank you.

Mr. CLEVELAND. Mr. Chairman, this is not really a question, but it is a comment and an observation. I have noticed in New Hampshire, and I am sure this is true in other parts of the country, when a rain comes up, sudden rain, summer thunderstorm, under these bridges you will find congregated various motorcycles and motorbike people. It strikes me that this is an observation worth reminding ourselves of because there is a great deal of talk here about keeping these wide lanes under the bridges free of any obstruction, and there you have the human element.

I have seen as many as 20 or 30 motorcycles crowded under there to get out of the weather.

Mr. GOODMAN. True.

Mr. CLEVELAND. I do not blame you for the designing of bridges on there. It does show the human element does creep in despite the best thought anybody can give.

Mr. GOODMAN. It is quite common to see on some of our bridges, under them, during the rainstorm, trucks of all kinds in addition to motorcycles waiting for the rain to get over.

Mr. W. MAY. Then that becomes a fixed object.

Mr. GOODMAN. Right.

Mr. W. MAY. Mr. Ives, may we have your comment?

Mr. IVES. I would like to just discuss briefly this matter of roadside obstacles. I think like every other highway department we are working very zealously in order to correct all the deficiencies that we have been made aware of and have been aware of for a long time in the matter of roadside obstacles.

We have been talking primarily about our Interstate System. And it has been brought out here several times that the secondary systems, on our secondary roads, are where the greatest danger is in striking objects. I think many of the States in common with ours have developed a crash program to find out where these obstacles are, what they are, and what we can do about that.

For example, to cite Connecticut, which is necessary in this case, we have charged each district engineer immediately with surveying all of these obstacles within the right-of-way that we have been discussing as to clearances, no matter what they may be, with immediate attention to high-speed highways, and we know that this will take considerable length of time.

So the reports are coming in piecemeal, and we are deciding whether to handle them by contract and remove corrective action or to do it with our own forces.

I think this is most important to the effort to get right after this situation. And I am sure many other States are doing it.

Mr. W. MAY. Thank you.

Mr. Eugene Johnson, you mentioned the Yellow Book in the first page of your statement. You mentioned that it was not valid as an AASHO standard. Why not?

Mr. E. M. JOHNSON. Well, I do not know of any particular reason that it was not; but this tour and inspection was made, as you know, last year. And this committee wrote that report. We were extremely anxious to get it out as soon as possible, and the truth is that the executive committee actually approved it without a draft in front of us, as I remember. But it was approved by the executive committee to be issued as a committee report. We issue a great many publications in that manner.

I think that for all practical purposes, and particularly in view of the fact that the Bureau has used it as a standard, that for all practical purposes, it is having the full effect of a standard adopted by two-thirds vote of the association members.

Mr. W. MAY. You do not consider the effect would be any different if it was adopted as an AASHO standard?

Mr. E. M. JOHNSON. In view of the fact that the Bureau had utilized it as a standard, I do not believe it would make any difference now in this particular case.

Mr. CLEVELAND. May I inquire?

Mr. MCCARTHY. Mr. Cleveland.

Mr. CLEVELAND. When you adopt one of these things as standards, is there not a tendency for it to become fixed? Am I not correct in saying,

as I understand your testimony, there are still some questions or areas of doubt in this general area; so if this was adopted as a standard by a vote, is there not a tendency for it to become fixed and people stop thinking about it?

Mr. E. M. JOHNSON. No, Mr. Cleveland; I believe it is just the opposite way. I do not know of anything that we have put out, whether it be a standard or policy or whether it be a committee report, that does not receive virtually continuous consideration by the various committees interested in those subjects.

In fact, we have a great deal of trouble with so many revisions coming in that it is difficult to handle them and keep the publications current.

Mr. A. E. JOHNSON. The yellow book was issued as a committee report very similar to many of our publications because it was made up of comments and observations by a special committee. It was not a matter worked on over a short period of time, of a committee that had members from all the State highway departments. It is something that went through several years of study, development, study draft, and redraft.

Here is one of the very important policy publications that AASHO puts out, which is called the blue book, which is the bible for rural design. That thing is a very detailed scientific thing that was probably 4 or 5 years in the development.

After it has been developed, then it is sent to the States and it is voted on as a policy, and it becomes actually the bible for designing highways.

There is a difference as to the type of report that is put out, the effort that is put into it, the time, and how many States participated.

Mr. W. MAY. Is there anything particularly new in the yellow book?

Mr. E. M. JOHNSON. I do not think that this is particularly new; but I think it has emphasized the various things you have emphasized in your study and presentation.

Mr. W. MAY. It is a compilation of those best thoughts and various items?

(Mr. Blatnik assumed the chair.)

Mr. E. M. JOHNSON. It puts it in front of all the highway personnel, I think, in a way that has not been heretofore achieved.

Mr. W. MAY. Thank you.

I have no further questions, Mr. Chairman, unless some of the witnesses have additional comments to make.

Mr. E. M. JOHNSON. I would like to make one, if I may.

Mr. BLATNIK. Please.

Mr. E. M. JOHNSON. I believe you are aware that we are as deeply concerned about this situation as anyone and are taking actions to try to correct these things. And I believe you will see many improvements during the next few years, and we do appreciate the opportunity to come here and discuss these things with you, sir.

Mr. BLATNIK. I want you gentlemen to know, too, that we are certainly mindful of the enormity and complexity of this peacetime public work project, the largest public works project ever undertaken by anyone. I think we are all agreed, are we not, there is always room for improvement.

It does require tremendous effort and constant alertness, so as we have gone through these hearings at no time were we trying to look for any so-called whipping boy—the same thing you do on your own staff. We have our respective offices. We travel back and forth from home. We are always finding something we should have thought of in advance.

Again we thank you for your cooperation, for your appearance here.

If there are no further questions from the committee, this will conclude the hearings for today; and we will resume on Thursday, July 20. We will hear testimony from our final witnesses from this phase of our inquiry.

The witnesses will be the Federal Highway Administrator, Lowell K. Bridwell; F. C. Turner, from the Bureau of Public Roads; and Dr. William Haddon, director of the National Highway Safety Bureau of the U.S. Department of Transportation.

If there are no further questions or comments, we again thank you. Gentlemen, the hearings for today are adjourned.

(Whereupon, at 12:30 p.m., the hearings were adjourned, to reconvene at 10 a.m., Thursday, July 20, 1967.)

HIGHWAY SAFETY, DESIGN AND OPERATIONS

Roadside Hazards

THURSDAY, JULY 20, 1967

HOUSE OF REPRESENTATIVES,
SPECIAL SUBCOMMITTEE ON THE
FEDERAL-AID HIGHWAY PROGRAM OF THE
COMMITTEE ON PUBLIC WORKS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:10 a.m., in room 2167, Rayburn House Office Building, Hon. Richard D. McCarthy presiding.

Present: Representatives Blatnik (chairman), McCarthy, Johnson, Cramer, Cleveland, Clausen, Duncan, McDonald, and Fallon.

Staff present: Same as previous days.

Mr. McCARTHY. The Special Subcommittee on the Federal-Aid Highway Program of the Committee on Public Works is now in session.

We have three distinguished witnesses: Lowell K. Bridwell, Administrator, Federal Highway Administration; Frank C. Turner, Director, Bureau of Public Roads; and Dr. William Haddon, Director, National Highway Safety Bureau, Department of Transportation.

Gentlemen, if you would rise please and take the oath.

Do you solemnly swear that the testimony that you will give before the subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. BRIDWELL. I do.

Mr. TURNER. I do.

Dr. HADDON. I do.

Mr. McCARTHY. Thank you, gentlemen, and we welcome you to the committee.

Mr. MAY. Mr. Bridwell, you have a statement that you would like to make at this time?

TESTIMONY OF LOWELL K. BRIDWELL, ADMINISTRATOR, FEDERAL HIGHWAY ADMINISTRATION; FRANK C. TURNER, DIRECTOR, BUREAU OF PUBLIC ROADS; DR. WILLIAM HADDON, DIRECTOR, NATIONAL HIGHWAY SAFETY BUREAU, DEPARTMENT OF TRANSPORTATION

Mr. BRIDWELL. Yes, Mr. May; I do.

Before starting my statement, I would like to introduce to the committee Mr. Frank Turner, the Director of the Bureau of Public Roads,

who I am sure is well known to all members of the committee because of his long association with the Federal-aid highway program and working with the committee; and to my right Dr. William Haddon, the Director of the National Highway Safety Bureau, and as you are aware, he heads the Bureau which has responsibility for both the Highway Safety Act of 1966—which was an excellent product of the work of the House Public Works Committee—and also the Motor Vehicle Traffic Safety Act of 1966 which the Congress enacted and the committee work was handled by one of the other committees of the House.

I will proceed with my statement at this time, if I may. Mr. Chairman.

Mr. MCCARTHY. Please do, Mr. Bridwell.

Mr. BRIDWELL. Mr. Chairman, members of the committee, I am pleased to have this opportunity to appear before you. I have been following the development of these hearings with great interest, not only because of my own concern, but more importantly because of the valuable contribution that the hearings are making to public understanding of the magnitude of the problems you have been studying.

There can be little disagreement that the single most important lesson to be learned from the evidence presented so far is the importance of thorough and detailed attention to the safety aspects of highway design, construction, and maintenance.

The hearings and the information produced have made a valuable contribution in the area of highway safety, and the highway program is indebted for your efforts.

It is appropriate that these hearings are being held at this point in time, when national needs in highway safety are being subjected to concerted action. During the course of these hearings, the initial set of standards for State and local highway safety programs was issued by Secretary Boyd. And, shortly before, the report of the Special Traffic Safety Committee of the American Association of State Highway Officials was published, and its findings adopted by the Bureau of Public Roads in all Federal-aid highway construction programs. These actions were preceded by the promulgation of the initial motor vehicle safety standards.

Taken together, these and other current governmental efforts represent a comprehensive offensive in the area of highway safety—an area which encompasses the highway, the vehicle and the driver, and the environment in one context, and in another the elements contributing to the preaccident, accident, and postaccident problems.

In every facet of highway safety, we have set as our goal the rapid and effective improvement of all factors which can contribute to the reduction of deaths, injuries, and damage.

No one will dispute the fact that the present toll of traffic deaths, injuries, and property losses on our highways presents a grim picture. I do not feel that it should be our role here today, any more than it has been the role of this committee throughout these entire hearings, to downgrade the accomplishments and advances already made in our highway systems. Certainly our Interstate System attests to these advances. On the other hand, so long as we are killing ourselves on our highways at the rate of roughly 1,000 people per week, we can only

conclude that we are not doing as good a job as we can—even with present resources.

I believe the committee may be interested to hear from us about present and planned programs of the Federal Highway Administration in cooperation with State, county, and city officials, and other concerned interests, to meaningfully and comprehensively reduce the incidence of safety hazards highlighted by these hearings.

Mr. Turner, Director of the Bureau of Public Roads, will undertake to do this in some detail. He will discuss past, present, and contemplated programs under the direct supervision of the Bureau of Public Roads in its effort to reduce or eliminate hazards on Federal-aid highways.

Before Mr. Turner speaks to you, I would like briefly to outline some of the broad areas in which we will be working to achieve our safety goals.

As a step in this direction, I have asked the Bureau of Public Roads and the National Highway Safety Bureau to begin preparation of a highway safety design manual—a comprehensive, all-inclusive handbook of highway design practice which will, in one volume or perhaps in a series of volumes, integrate such disciplines as street and highway design, traffic engineering, and maintenance and operations. I fully expect this to be done in cooperation with State highway officials, county engineers, city officials, professional organizations, and others who have a contribution to make.

We do not intend that this manual will be a mere codification of the hundreds of standards, criteria, guidelines, and suggested practices that have been prepared over the years by official, quasi-official, and private organizations. This will be only one of its functions.

But more importantly, the proposed manual will embody truly up-to-date thinking in all areas of highway design, in a form attractive for immediate use and quickly susceptible to improvement as new information and advanced technology become available in the future. Moreover, it should eliminate gaps in accepted criteria that exist today.

Another area that is receiving our immediate attention is the matter of safety research. Our Interstate highways are designed on a 20-year future-needs basis as far as traffic volume capacity is concerned. It is our belief that the same sort of forward vision must be applied to research into highway safety design needs. Research in this area frequently has been a matter of reaction to conditions already developed. Research is needed and has been started to make the driver-vehicle-highway system more nearly compatible, and less subject to failure in the accident situation.

We are looking forward to the planned hearings of the Roads Subcommittee in a few weeks when we will have the opportunity of telling the committee members of our progress in carrying out the Highway Safety Act of 1966, including its authorizations for research.

There is no limit to the value of new knowledge which can contribute to safer highway design, yet all too often there exists a great gulf between research and application. Whether the gulf is due to lack of communication or reluctance to accept new ideas, our responsibility is to build a bridge across this gap. One means of accomplishing that objective will be early incorporation of applicable research findings

into the design manual that I mentioned earlier, at the earliest possible time after these findings have been evaluated and proven to be valid and feasible.

Also germane to your inquiry is the fact that all too often in the past, engineering decisions have been weighted by first or capital cost considerations. However, enlightened engineering practice now dictates that although initial costs may play an important role in such decisions, other factors must also be considered. More and more we will be urging States to use the cost-effectiveness approach not only for operational highway improvements, where it has already proven its worth, but in broader areas of highway design affecting safety. This approach has special implications with regard to safety items such as guardrail, median barriers, signs, and lighting standards. Yardsticks are being developed by which relative safety effectiveness of one design over another can be measured. We believe accident reduction benefits, for example, can be measured on the basis of anticipated deaths, injury, and property damage, through formulas which can be employed equally well for determining either the area to be improved or the method for improving it.

In addition, the other projections involving maintenance demands, durability under actual service conditions, and flexibility to accommodate anticipated traffic growth can be applied to all highway projects in the future. I am convinced that such techniques, founded on reliable cost-effectiveness bases in conjunction with realistic engineering for safety, will reduce the extravagance of too frequent rebuilding and at the same time will result in better, safer, and more economical highways.

I believe it is important to note that the physical plant which is our Nation's highway network is one of the three major safety elements which is most susceptible to consistent and continuing public control. No driver can be trained and policed to perform with the predictability or reliability of a fixed engineered system. The vehicle's dependability is subject to variables not always susceptible to constant and immediate correction. Thus, the highway itself will continue to be a fertile area for total highway safety progress.

Much effort in this direction has already been expended, and some of it has begun to bear fruit. But much more attention needs to be given to this pervasive problem, as well as to other elements of the comprehensive national highway safety programs which the House Public Works Committee helped launch.

We share with you, Mr. Chairman, your concern that "the mistakes of the past are not carried over into our new roads." The consuming interest of this committee will make our work toward that goal a great deal easier, and will stimulate much more vigorous action toward the meaningful reduction of built-in hazards across the Nation's highway system.

Mr. Chairman, that concludes my prepared statement. As I indicated in my statement, Mr. Turner has a prepared statement which deals in much greater depth and detail with some of the issues, most of the policy issues that have been raised in the course of these hearings.

Mr. McCARTHY. Mr. Bridwell, before Mr. Turner commences with his statement, I wonder if I could ask you a question.

Now a number of things struck us. One was that the substance of our findings had been known for a number of years. For instance, General Motors, one organization that comes to mind, has had films pointing out the deficiencies of our highways, particularly on roadside obstacles for a number of years; and nobody—let's say few States incorporated the indisputable findings of General Motors research into the construction of their roads. And the staff selected nine States at random with Interstate highways just built, and only one State had incorporated these findings that were well known.

Now I am wondering why it is that when this information was so widely available, it wasn't incorporated in the engineering of brand-new roads?

Mr. BRIDWELL. Mr. McCarthy, there are a number of factors involved here. First of all I think my statement and by the statement that the committee will soon hear from Mr. Turner, we would agree with you wholeheartedly that the findings of research, testing, and analysis, have not been as widely and as rapidly applied as they either could be or should be.

I do not believe, however, that the situation is quite as dark as—here is all of the information, why are you not doing it?

There are quite a number of factors that go into it. One is the fact that highways that are actually being constructed today in many, many instances were designed 3 or 4 or even 5 years ago on complicated projects. So that is a factor.

Another factor is that there is not a comprehensive manual in the field, which has been highlighted by these hearings with such things as the example of the guardrail in "Highway Research Bulletin No. 81." So that the people in the field, the people who actually design and are responsible for the construction of these projects, do not have easily available to them a lot of material which is completely known now to the committee because it has been presented to the committee.

It has not been presented to these people in the field that have the responsibility.

Another factor, of course, you referred to the General Motors research specifically. One of the overall conclusions of the General Motors research has been the clear roadside concept which we have followed without any question, at least to some extent, to a great extent. There are cost factors involved in this because obviously if you have a clear roadside and you have general clear slopes extending from the edge of the right-of-way for certain increments of distance, 30 feet is the one that we generally talk about, then there are cost considerations in the acquisition of right-of-way.

There are cost considerations in the design and construction of the project and earthwork and structures and quite a number of things.

So I cite these as factors, not as excuses, but only to point out that it really is not quite as simple as just simply saying the knowledge was there, why does it not show up on the highways?

Mr. MCCARTHY. You mentioned that some of these Interstate highways were designed 3 and 4 years ago. Does that mean that we have to wait 3 and 4 years before some of these concepts are incorporated in the construction of future Interstate highways?

Mr. BRIDWELL. No, sir. It will depend on the particular item or portion or facet of a design project as to what point in time it can be incorporated.

If you are talking, for example, about such things as what we popularly categorize as roadside construction, such as signs, guardrail, that kind of thing, as a practical matter these should be reviewed while the construction is going on and change orders made in the design plans if they are not being done properly. So that in that instance a correction can be made as late as today.

However, in laying out the basic line and grade for a highway certain results flow from this. The extent of your fill, the depth of your cuts, the location and length of major structures, once those designs are accomplished, to go and redo those requires a complete reengineering of the whole project.

For example, one of the things that I am very interested in is the extent to which we can have gentle slopes on a fill portion of a project. One of the factors that is the result of recent research is the application of photogrammetric procedures in which you can have a rapid and completely accurate calculation of a number of design alternatives, one of the results of which is a balancing of earthwork.

In other words, you take the dirt from the cut and put it in fill so you do not have to borrow any or you do not have to waste any.

To the extent that a line or grade is changed, then you have to go back and recalculate all of that earthwork, and this for all practical purposes results in a complete redesign of the project.

Now in summary, the answer is on some items you can do it as late as today. On other items it is a basic fundamental part of the design, and once established it almost impossible to undo without starting all over again.

Mr. McCARTHY. Thank you very much, Mr. Bridwell.

Mr. CLEVELAND. Mr. Chairman.

Mr. McCARTHY. Mr. Cleveland.

Mr. CLEVELAND. I just want to ask a question for the record. In connection with the construction by the State highways of the Interstate System particularly, and also the other Federal-aid highway systems, is it not a true statement that all of this highway design is done under standards that have the stamp of approval by the Bureau of Public Roads?

Mr. BRIDWELL. Yes, sir. By statute, the standards applicable on the Interstate System are those developed by the American Association of State Highway Officials in cooperation with the Bureau of Public Roads and are approved by the Secretary of Transportation.

Mr. CLEVELAND. And you certainly have the right to either change or suggest changes or veto any of those standards that you people feel might be conducive to unsafe highways, is that not correct?

Mr. BRIDWELL. Yes, sir; that is correct. Because the statute gives the Secretary final authority in this matter. He can accept and therefore, presumably, modify or reject any standard that he wants to.

Mr. CLEVELAND. Thank you. That answers my question.

Mr. JOHNSON. Mr. Chairman.

Mr. McCARTHY. Mr. Johnson.

Mr. JOHNSON. Thank you, Mr. Chairman. I have just one or two questions here for Mr. Bridwell.

As I understand it, all the money for highway safety that is provided for in your budget comes out of the general fund.

Mr. BRIDWELL. For the carrying out of the provisions for the Highway Act of 1966; yes, sir.

Mr. JOHNSON. Now was there enough money provided for in the budget that was approved just recently in the House? As I understand it there was a cutback in the committee and a further cutback on the floor. Do you have enough money to carry out the highway safety program? During these hearings it seems it was brought out there was quite a deficiency and need for a lot of work in that direction.

Mr. BRIDWELL. In my opinion, no, sir. The amount of funds approved by the House are very substantially inadequate to carry out the program as envisioned by the Highway Act of 1966, which in the final analysis was a product of the House Public Works Committee.

Mr. JOHNSON. As I understand it, if there is any reconstruction of the facilities that you build, that would come out of the trust fund on your recommendation?

Mr. BRIDWELL. Yes, sir.

Mr. JOHNSON. There is ample there to take care of immediate construction that is necessary throughout the Interstate System?

Mr. BRIDWELL. I will have to give you a qualified answer. In the sense of, is the balance of funds in the trust fund adequate, the answer is "Yes." In the sense of, are funds adequate considering the cost of completing the Interstate System by the present statutory deadline for completion, the answer is "No."

Mr. JOHNSON. As I understand it, you could have used more money to bring in the program of highway safety—

Mr. BRIDWELL. Yes, sir.

Mr. JOHNSON. Thank you.

Mr. McCARTHY. I think it might be made clear that most of the features that we dealt with in these hearings were bridges, design of bridges, design of guardrail, breakaway signs and the like, and they would come out of the trust fund.

Mr. BRIDWELL. That is correct.

Mr. McCARTHY. Mr. Turner, would you like to deliver your statement to the committee?

Mr. TURNER. Thank you, Mr. McCarthy.

As Mr. Bridwell has indicated in his statement, we believe your hearings are making a significant contribution to the future safety of highway travel.

The Bureau of Public Roads wants to contribute to that safer future on the highway and in that capacity, representing the Bureau, I am pleased to be here today.

As I understand your schedule, you have been directing your attention appropriately to the problem of roadside hazards largely on the Interstate System. This is a serious problem, major in its importance, because it concerns our principal highway network for interstate and defense travel; highways being designed and constructed for the highest quality of service to users. We in the Bureau are keenly aware of and are giving appropriate recognition to the fact that structures alongside the roadway must be given different treatment in future design of our Interstate System.

In a way, the situation is rather unique because all of the other types of hazards are substantially less on the Interstate System than on older roads. With most types of accidents eliminated or at least

markedly reduced by the Interstate System design features, I suppose we should not be too surprised to find that single-vehicle, run-off-the-road type accidents are the major type of accident possibility remaining on our Interstate highway facilities.

Obviously, something must be done, and we have no doubt that something much better can be done than what you have seen here. We already have taken the necessary actions in that direction.

During the course of these hearings you have observed, with considerable repetition, examples of roadside features—signs, light poles, bridge piers, guardrails and the like—which present serious hazards to vehicles which leave the roadway out of control of the driver.

It is obvious that these items were not deliberately placed in such a manner as to create hazards.

The rather large directional sign is designed specifically to convey information to the high-speed passing motorist in a manner which will reduce to a minimum his distraction from his driving chores and give him information needed to safely maneuver his vehicle. Standards for this particular type of signing have been developed only within the last 7 to 8 years. Prior to that time we did not use such large signs requiring the heavier mounting poles and foundations which have been discussed throughout this hearing.

The justification for lights is also premised on providing a safer environment for the driver. However, the pole which supports the light is necessarily, in many cases, an additional safety hazard and so we may properly raise the question about whether the added safety from a lighted roadway exceeds the hazard introduced by the pole mounting.

The bridge piers and abutments support structures permitting the separation of cross traffic for the purpose of eliminating the hazards of at-grade intersections; but while they eliminate one set of hazards, their very presence at the same time introduced other hazards not previously existing.

Guardrail is one of the best safety devices we have to lessen the chance of serious damage to a vehicle out of control and running off the paved roadway and shoulder, but in its use, we often introduce another hazard.

So while many of our newer design features have been introduced to reduce major hazards, their very presence also produces a set of new hazards of a different type, hopefully of a relatively lesser magnitude. It is our purpose to reduce both sets of these hazards to the lowest possible level. I believe the measures we are now taking will do this.

There is no simple answer to offer for the question you have asked as to why these roadside obstacles have been erected as seen by you in numerous pictures. The administrator has mentioned some of the causes. The principal cause is clearly that our previous judgment in designs dated 7 to 8 years ago did not anticipate the degree and frequency with which drivers would run off these new roads. It took some time to observe that a dismaying pattern of run-off-the-road accidents was occurring and an equally long time to develop the appropriate corrective measures and to get these into the stream of planning and construction. While some observed defects are still being included in recent construction, I believe that the focus of attention on these items by this subcommittee and the Bureau has served to force the