REPORT ON FORMATION OF SPECIAL COMMITTEE ON CAUSES AND PREVENTION OF HIGHWAY ACCIDENTS

H C Dickinson

Highway Research Board, Washington, D C

At a recent meeting of the Executive Committee of the Highway Research Board, it was voted to organize a special committee to consider one aspect of highway research, namely, the problem of safety. It is not necessary to emphasize the importance of the problem of highway safety Facts brought out at the National Conference on Street and Highway Safety, called by Secretary Hoover, have sufficiently established its importance The probable loss of some 25,000 lives annually, not to mention several times that number of injuries, cannot be taken lightly

On the other hand, it may not be well to look too much on the dark side of this picture The loss of life represents about one fatality per 1,000 years of automobile operation, or perhaps one per 15 or 20 million passenger miles of travel These figures include not only the occupants of vehicles, but also all other users of the road, the latter represent in fact roughly 65 per cent of the total number of fatalities

Comparing this with the records for the railways of the country, the figures are 18,000,000 passenger miles per fatality It may be said by way of encouragement that the figure of one fatality per thousand years of driving represents an improvement of nearly 50 per cent within the past ten years on the ratio of accidents to vehicles, notwithstanding the fact that the total number of fatalities has increased enormously This improvement is due to various causes, notably the nation-wide attention focused on what we may term the abstract idea of safety The minds of drivers and the general public have been insistently assailed by the safety idea, often with much emphasis on the more spectacular sources of danger in contrast to the commoner and more important ones

It is safe to say that the average citizen not familiar with the facts would rate fatalities at railroad grade crossings as one of the most important hazards of the highway As a matter of fact, however, such accidents represent about 4 per cent of the fatalities and a far smaller percentage of injuries

A brief survey of the relative importance of different causes of accidents as gathered from recent statistics (Table I) may suggest what part a committee of the Highway Research Board can best

take in helping toward a solution of this grave problem of national concern.

TABLE I

DISTRIBUTION OF BLAME AMONG FACTORS INVOLVED IN ACCIDENTS

Factor causing accidents	Per cent of total cases in which factor is blamed					
	All accidents		Fatal accidents		Average	
	Conn, 1924	Mont-Ore, Wash, 1924	Mass, 1924	Nat'l Auto Chamber of Com Jan 1924 May1925	St Louis, Mo, 1924	Five sources
Operator	77 7	63 5	62 0	40 4	59 2	60 6
Non-operator	15 4	11 9	26 3	46 7	36 7	27 4
Human factor	93 1	75 4	88 3	87 1	95 9	88 0
Vehicle	5 6	11 3	11 2	5 8	3 1	7 4
Highway	1 3	13 3	0 5	7 1	1 0	4 6
Physical conditions	6 9	24 6	11 7	12 9	4 1	12 0

Taken at their face value, these statistics seem to indicate that accident causes attributed directly to defects in the highway or the vehicle are of small relative importance A little further thought on the subect, however, may lead to a modification of this conclusion

In the first place, in reporting the cause of an accident the immediate object is usually to fix responsibility if possible The highway is there, as are any natural or permanent obstructions, and such inanimate things are not likely to appeal to the average person as responsible for an accident so long as there is an animate cause to be found The legal side of responsibility is naturally uppermost in most people's minds, and perhaps more particularly in those of enforcement officers or other officials charged with the duty of reporting accidents

In point of fact, whenever any accident occurs there are usually contributing causes and it is often difficult, if not impossible, to fix the main or primary cause Perhaps there is none Indeed, it seems probable, if not certain, that the design and condition of the highway as well as of the vehicle have vastly more to do with

accidents than one might conclude from the bare statistics as they are available

The fact, if it be a fact, that most accidents occur on tangents rather than on curves has been cited as evidence that it is reckless speed rather than highway condition which causes accidents But has any estimate been made of the miles of tangents compared to the miles of curves?

The State of Ohio has a rather gruesome but very instructive, warning device which should afford much information in a very tangible form This is the planting of a little white cross on the site of each fatality on the main highways While there are no statistics available as to the distribution of these crosses, a trip of several hundred miles in the State last summer left the definite impression that one could predict almost with certainty where one or more of these gruesome reminders would be found While there are occasional crosses on the straight stretches there are almost invariably crosses at the points where obvious dangers exist Even on the tangents there are bad culverts, bad shoulders and bad fills which are conspicuously marked by these little white reminders

One fruitful cause of accidents is skidding on abnormally slippery stretches of road It was a discussion of this hazard which led to the action of the Executive Committee of the Highway Research Board to provide for the appointment of a special committee to study the whole problem of highway safety More will be said about skidding later, but suffice it to say here that the construction of the highway surface appears to be a very important element in this cause of accidents It seems evident, therefore, that the responsibility of the highway engineer in the matter of safety is very much greater than bare statistics would indicate

Consideration of what has been done and is being done in the interest of highway safety suggests that the various causes of accidents have been very well summarized, that much has been done toward the formulation of uniform legislation, and that education and propaganda have received much attention, but that much less has been done in the way of research into the basic and less obvious causes of accident and into the possibilities of their elimination

The Highway Research Board is in a peculiarly fortunate position to accomplish important work along this line, because of its contact, on the scientific side with the National Research Council, and on the practical side with the highway departments of the several States, assuring that any results of scientific research will receive prompt consideration by those who may be able to apply them

Some problems of highway design which may call for further technical research are given for illustration

It has been found that wet roads are usually as safe as dry as regards ability to stop, but sporadic cases occur when this is not true, when the holding power of tires is reduced to a tenth or less of its normal value These occasional conditions probably account for most wet road accidents

The coefficient of sliding friction between tire rubber and clean hard road surfaces, dry or wet, is usually 0 7 or 0 8, but instances are found on apparently clean wet roads where this coefficient is less than 0 1 This statement refers only to cases where there is no apparent reason for this abnormal value of the coefficient of friction Under such conditions even a very moderate application of the brakes might lead to a dangerous skid

These occasional slippery road conditions seem to present a safety problem which the highway builder alone can solve, and in order to arrive at a solution he will need accurate data on the causes which produce these conditions

Among other features of highway design and location which affect safety in ways not fully analyzed are banking on curves and their relative width as compared with the width on the tangents, dangerous shoulders, type of curvature, etc With reference to type of curvature, running a tangent into an arc of a circle obviously produces a curve which can be only approximated by a vehicle, since to follow the curve would require the instantaneous shifting of the steering wheel from the position of a straight line motion to that for the constant radius of curvature for the circular arc This is evidently impossible Doubtless a study of the traffic lines on a stretch of new concrete would show how nearly the average driver can approximate this instantaneous shift

Another factor of recognized importance is that of visibility Just how many accidents may be due to failure to see other vehicles or danger spots doubtless will never be known However, the distance which the driver must see ahead and on either side of the road for safety at any given speed is a matter of arithmetic and plane geometry with a few simple assumptions, as has been shown by the writer in a brief paper entitled, "What is Safe Speed?" [1] The application of this type of analysis to the problem of obstructions and blind spots would certainly show up danger spots which could be corrected

In this same connection we should mention also the general subject of warning signs, signals and safety devices of this class as applied to the highway This subject has, of course, received much atten-

[1] Journal of Society of Automotive Engineers, July, 1925

tion, but it is doubtful if the possibilities of scientific research into the mechanical and human factors involved has received the attention which it deserved

Closely related to this is a subject which may be termed the mechanics of driving The functioning of a vehicle involves a very complicated set of mechanical actions, how complex one hardly realizes, because vehicles on the whole are themselves so very good. Safe equipment, such as brakes, steering gear and general mechanical parts are, of course, essential, but the reaction of brake capacity and uniformity and of the accuracy and reliability of steering on the safety and on the traffic capacity of highways has been only partially determined

Headlighting is one of the most important elements in safety There seems to be an almost universal opinion that present types of headlighting are most unsatisfactory, not to say intolerable. Whether strict enforcement of existing laws (assuming such enforcement were feasible) would increase safety, seems to be open to question There is no question, however, that a truly scientific research to determine what is needed to remedy this fault is most urgent. Recent developments in headlight design appear to have opened the way to very important improvements in the safety of headlighting

Not only the visibility of the highway, but also the visibility from the vehicle, calls for study In many designs of closed cars there are totally unnecessary "blind spots" behind which highway obstructions may be hidden from view Accurate knowledge of the relation between poor visibility and accident hazards would be certain to increase safety

Much has been said as to the need of a study of the psychology of drivers Driving a vehicle on the highway is a privilege, not a right, and the privilege should be granted only to competent persons The scientific study of psychological and physical demands upon the driver is urgently needed, in order to discover those drivers who are essentially incompetent The importance of this line of research hardly needs emphasis The National Research Council has already been urged to lend its aid to this project

Another type of psychological study, however, seems not to have been widely recognized This may be termed the psychological effect of laws and regulations While most laws and regulations concern very few of the population, and those mainly the lawless, traffic laws and regulations must now be known and consciously kept or broken by perhaps one-half of the total population Where only a few potential law breakers are concerned, laws can be pref-

aced "Thou Shalt Not," without much regard to whether the prohibition fosters the right or wrong mental reaction on the part of those concerned We may not have to consider very carefully the psychology of the prospective criminal, because he is the exception

On the other hand, when the law in question may concern intimately the everyday life of half the population, its indirect effects may be more important than its direct effects Suppose, for example, a law requires that a vehicle stop before entering a boulevard The driver may obey the law and stop, if he does, it is quite likely that in his mind the fact that he has stopped relieves him of further responsibility, which it should not The intent of such a sign is not really to make the driver stop, but to make it clear to him that he is entering the boulevard at his own risk, and that the boulevard traffic has the right of way in both directions The question is whether the sign accomplishes this purpose of making the driver who enters the boulevard responsible

Again let us consider the conventional speed limits, and the regulations enforcing them If the limit is set low enough to be a real protection at crossings or on slippery roads it has at least two secondary effects

(a) The driver knows that the speed limit is absurdly low most of the time and either breaks the law, "watching for the cop", or

(b) He resents the unnecessary constraint which it involves, or both

These things all tend to distract the attention of the driver from the prime essential of safety, which are the conditions of his own vehicle, of the highway, and of the traffic thereon, not such incidentals as speedometers, signs and officers

Fortunately this and other faults of arbitrary speed limits have been quite generally recognized and better regulations substituted But it seems to be a problem for the psychologist to determine beforehand whether any proposed type of regulation affecting a large part of the population will have the net effect which it is intended to accomplish

In conclusion, it is necessary to state that the annual loss of 25,000 lives on the highways must be stopped This will be accomplished through various agencies working together Among these the Highway Research Board is the one most directly concerned with the entire broad problem of highway transportation from the research side It is believed therefore that a committee of this Board is the logical agency for starting and correlating a research program for the promotion of highway safety

E L CLARKE, Clemson College, S C One of the minor causes of accidents is the failure of a driver to stay on his own side The usual device for keeping a vehicle on the right side of the road, is a white line painted along the center of the pavement This white line is efficient, but not sufficiently so, a vehicle can cross it too easily I have noticed, that where a street contains a car line, the roughness of the pavement on the car track, is decidedly effective in keeping vehicles on the right side My suggestion then is that pavements be built with a rough strip down the center, a strip which a car can cross without danger if emergency demands, but which by its roughness will be an ever-present deterrent against driving thereon

C J TILDEN, Yale University, New Haven, Conn The suggestion made by Mr Clarke has been tried Commissioner Greene, of New York, built a number of miles of road in that State in which the two paved sides were separated by 6 or 8 feet of cheaper construction I do not know that he put cobblestones down, but at least it was such that the driver much preferred to use the concrete pavement I have not seen it myself, but it would be interesting to have the testimony of someone who has actually driven over those roads

There is one other point in connection with this question of safety It seems to me that the multiplication of signal lights which is going on so rapidly in a great many of our cities, especially the use of three different lights, is thoroughly dangerous We had an interesting case in New Haven a short time ago which illustrates one danger if the lights do not work as planned It happened that something went wrong with the automatic machinery at a busy corner and all four green lights came on, opening both streets to full speed Now, of course, the public is very quickly educated to the fact that the green light means go like sin—it means open her up full and get past to the next green light before it turns red if you possibly can Fortunately, no lives were lost, but there was some damage and overheating of tempers

Instead of having the red light mean stop, the yellow caution, and the green go just as fast as the engine will work, it would be better to have one color only—the red When the red light shows it means *stop,* as it should, when there is no light it means proceed with caution When changing traffic, that is opening the avenue and closing the street, or vice versa, the red light would show in all four directions for 3 or 4 seconds, thus performing the function of the yellow light as used at present The public would be quickly educated to this, and the greater simplicity would make for greater

safety and less delay Still greater satisfaction would undoubtedly result if the signals were operated by hand rather than automatically Then the officer could use his judgment in opening or closing the streets

E H Lockwood, Yale University, New Haven, Conn The thing that occurred to me in this connection was the desirability of formulating some kind of a safety handbook for use of the public I believe the outcome of the Committee's activities might include the preparation of such a pamphlet, to be circulated by the State and municipal automobile associations to their members, reaching drivers throughout the country, informing them of ways to promote safety and practices that produce accidents

L I Hewes, U S Bureau of Public Roads, San Francisco, Calif There was one accident in the West this summer which killed eight people and which I think would offer some suggestions The accident occurred in September to a machine coming out of Crater Lake There is a tangent of about 2,300 feet approaching a bridge over the Canyon of the Rogue River There is a drop of 150 feet to the river At the end of this tangent it was necessary on account of the topography to have 100-foot radius curve, then a short tangent and another curve of 110-foot radius to a straight crossing of the bridge The machine carrying these eight people to death was following a very fast moving machine The people who were killed had stopped at the gasoline station and remarked that they would be in Medford in an hour That is almost a two-hour drive—something over 50 miles The records show that this machine was wrecked at this curve when following another machine, the driver of which admitted that he was going 50 miles an hour and he threw up such a dust that the driver of the fatal machine behind him probably could not see this curve, and in addition it was about an hour before sunset and the sun came through the windshield These eight people were instantly killed by plunging over the cliff The ground showed that the driver for 200 feet skidded in an endeavor to bring the machine back on the road Now what caused this accident?

I think we have to be very careful in analyzing the causes of accidents The road at the curve was 50 feet wide There were posts set up along the edge of the bluff and it is probable the driver went between two of them, but he was moving so fast that he struck a log that was laid along the edge of the road and that log followed his machine down and crashed into it There were several contributory causes First, the man was going too fast There was sunlight

and dust and a bad combination of alignment. I think that as far as our designing and locating engineers are concerned we learned this lesson We must not bring a long tangent up to an abrupt curve But when this road was built it was necessary to reduce the span of the bridge crossing the Rogue River at this point by putting in a curve to take the line up stream to a narrow crossing at less expense A straight crossing would have cost several times as much but would, of course, have been safer

With reference to the point raised by Professor Clarke, from South Carolina, about putting a rough strip in the center of the road Of course, the effect is either to widen the road or to narrow the traffic lanes If the road is widened the expense is increased It is well known among highway engineers that you cannot insert an actual obstacle between the lanes of moving traffic without great danger You can widen the road but there is the increasing expense There is in Massachusetts a road, I think, running from Fall River toward Boston where there has been introduced a center strip of bituminous pavement between two strips of Portland cement concrete and this strip in contrast with the two concrete traffic lanes provides one of the apparently most successful through way roads I have ever seen Where the traffic sometimes is given two concrete strips with bituminous macadam shoulders, the bituminous material here had been brought from the shoulders to the center with corresponding widening but this center strip of bituminous macadam is not made to obstruct traffic in any way, it is merely a traffic zone for passing vehicles In contrast to this type of construction there is a similarly built road in the Franklin Canyon, near Berkeley, California, where the engineer designed a strip undesirable for traffic He produced the effect by making the bituminous center of excessive crown The result is that nobody uses that center strip and it adds considerable expense

J S CRANDELL, University of Illinois, Urbana, Ill Professor Tilden has asked for comment from someone who is familiar with the dual type of pavement of which he spoke This pavement, as laid in New York State, consists of two strips of concrete with a penetration macadam between them I have driven over these roads many times, and I have found that accidents seldom occur on them Except during the winter, traffic invariably keeps on the concrete unless one car wishes to overtake another, in which case the overtaking car uses the bituminous strip until it has passed the slower car. In winter there is an element of danger. When snow and ice cover the road it will be found that they melt much faster from the black center strip Traffic then crowds to this part of the road

causing ruts to be formed along the edges of the concrete strips in the snow Traffic gets caught in these ruts and cannot get out in time to prevent collisions However, during the rest of the year these dual type roads are very pleasant to ride on because you are certain to be separated from on-coming traffic by the black strip eight feet wide The sense of security that these roads bring to the driver is heightened at night, because the usual blinding glare of headlights is absent.

C E GRUBB, County Engineer, Wilmington, Del . As a result of the National Conference on Street and Highway Safety many of the States already have held local conferences and no doubt other States will follow Those conferences have been productive of very excellent ideas and opinions in regard to matters of safety. They have, as a result of the National Conference, also given very definite lines of thought in regard to safety I believe any committee of this body will have as its greatest problem the assembling and analyzing of such information as those conferences have produced No doubt the National Conference will meet again and do likewise, but as the matter of safety in its last analysis is one of education of the people (and it is a matter that reaches every individual down to the youngest child who goes to school alone), the problems require careful thought by all and the suggestions for improvements, wide publicity

In regard to legislation which, of course, will control traffic, I believe that most of us will agree that there is already a multiplicity of legislation and that the study of safety should result not in more legislation but more uniform legislation,—that the laws that are enacted should be very reasonable and generally enforced

With the rambling of traffic today, not confined within a State and not within a Nation, there is need of uniformity I might liken it to travel on the seas Whether a man speaks the language of Spain or the language of America he can sail the seas without confusion and without danger We need to devise some uniform traffic legislation which will be without State or national boundaries but will be generally observed and recognized by men from wherever they may hail.

L I. HEWES May I ask just one more question as to whether or not grade crossing eliminations must wait for permanent types of construction? It seems to me that in the history of railroad construction throughout the country we have evidence of the usefulness of temporary types of construction of culverts and bridges Now everybody admits the desirability of grade crossing elimination con-

struction The great obstacle to the accomplishment of it is the expense I would like to raise the point for the consideration of the gathering, as to whether or not we must wait in all cases for permanent grade crossing elimination construction

R W CRUM, Iowa State Highway Commission, Ames, Iowa Dr Dickinson has shown that accidents at grade crossings are a rather small percentage of all accidents On the other hand, because this particular type of accident is well known, there is nothing uncertain about it and a cure or prevention is at hand The necessity for long negotiations with railroad companies in order to get them to pay their share of the improvements is one of the most exasperating sources of delay in crossing eliminations Everyone agrees that the elimination of railroad crossings on our main roads is highly desirable and the process by which this can be accomplished ought to be simplified As a matter of fact in many cases we would be much better off if we did not expect the railroad company to pay a part of the expense Many State highway departments could afford to go ahead and eliminate grade crossings without the necessity of making the railroad pay for part of the improvement There is a chance for some real thought and constructive recommendations, looking toward the end of getting the railroad contribution in some quicker way—perhaps by getting them to make an annual appropriation for the purpose, or perhaps by eliminating it altogether and getting their contribution in some other way than on a specific structure

T K A HENDRICK, New Rochelle, N Y The speaker is very much interested in Dr Dickinson's statement that the coefficient of friction for various pavements, either wet or dry, lies usually in the neighborhood of 0 7 or 0 8 In some cases it drops to a value as low as 0 1 or 0 2, in which case, of course, skidding takes place very easily That there is no qualifying statement regarding the kind of pavement and that wetness or dryness makes very little difference are conclusions that challenge enthusiasm Some European ideas, and not a few American ideas, believed that a wet asphalt pavement was a slippery surface for automobile tires or that the coefficient of friction became very low on account of the surface becoming wet

A film of ice or dirt or a film of oil, perhaps. when interposed between tire and pavement surface, produces a different condition than when there is sufficient water to cause the pavement to be wet,

pure and simple The coefficient of friction at the start of a rain storm might be lower than at the end, finally, of the downpour

Considerable experience in driving down through Westchester County, New York, over the Shore Road, to Pelham Parkway, to Fordham Road, to Fifth Avenue, New York City, has given rise to somewhat desultory observations For the most part this pavement is of asphaltic surface When it is wet the traffic slows down considerably, in other words it automatically serves upon itself a warning signal and avoids skidding When it is dry, on the other hand, few drivers fail to maintain a good steady pace When the pavement is wet, a too sudden application of the brakes may end in disaster even on a straight piece of road On curves of from 100 feet to 500 feet radius, also, on a wet asphaltic surface, it is not advisable to proceed on the basis that the dangerous film of oil has gone and that the pavement is wet, pure and simple

In those local patches of road where it has been found by bitter experience, if not by laboratory device, that skidding obtains easily, perhaps it would be desirable to erect signs, such as "BE CAREFUL—DANGEROUS SKIDDING" The percentage of accidents that have been caused by skidding would justify the use of such a device which, in turn, would tend to diminish this percentage

H C Dickinson (closure). I rather hesitate to repeat any of the definite suggestions contained in my previous paper because whatever suggestion may be made, it is obvious that there are probably some others that are more important in the minds of those present It seems to me that a committee of the kind suggested will necessarily have to study the field pretty carefully and what can be done will depend perhaps not on what is the most important thing to do but what is the most practical thing to undertake at the time Most research is planned along that line—perhaps not the most important thing but the thing that can be done

One point that was raised because it was one that appealed to some of us as having a very close and direct bearing on the responsibility of highway design on the problem of safety, was the problem of excessive slippery conditions that sometimes occur I have personally made observations by using an accelerometer on the dash board of my car for two or three years, and very frequently on a wet road, while the brakes were skidding, measured the coefficient of friction to get information to evaluate the particular relation of this factor If a number of engineers—20 or 30 experienced engineers—would take occasion to secure and mount on their cars an accelerometer of some kind which

will make possible observations of this sort, it might be possible in the course of a few months to get together some really systematic information showing whether or not this problem really is of vital importance, and then it might be possible to decide what further work could be done

The problem of the psychology of the driver has been emphasized very widely, and I believe there is some very effective work going on So far as I know the problem has been attacked from the purely psychological side rather than from the practical side Some sort of correlation between the efforts on that problem would be very desirable

One suggestion which I would like to make is that the entire question of the psychological effect is one of regulation—one which has been worked upon from what one might term an empirical point of view I believe that some thorough research from the psychological effect—rather than the ultimate effect—rather than the immediate effect—of the light system situation, might yield some very valuable results These are only a few of the several points that were just touched upon