MECHANICAL TRAFFIC DEFLECTORS

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SYNOPSIS

With a growing recognition of the need for medial and marginal protection of traffic lanes, there has arisen the collateral problem of the proper design of such protection

The Bureau for Street Traffic Research at Yale University has attempted a contribution toward this problem of design through the creation of two types of mechanical deflectors These designs have been aimed at several specific objectives (1) a device that will occupy a minimum of roadway width, (2) a device that will restrain and redirect the course of motor vehicles within the normal range of attacks without injury to the vehicle or its occupants, (3) a device that does not create related or secondary hazards, and (4) a device that can be installed economically

The first of these has been designated as a "Channelled Traffic Deflector Plate" This is designed to redirect the course of vehicles impinging upon it, but under conditions which do not preclude a safe crossing of the deflector at the will of the operator

The second has been designed as a "Parabolic Traffic Deflector" This is designed to accomplish the objectives set forth above, but under circumstances where it is impossible for the driver to cross the deflector It is therefore applicable under those conditions where traffic operations require the prohibition of passage beyond the area where the device is installed

Both of the above devices have been submitted to tests in cooperation with the Highway Department of the State of Michigan and with the collateral cooperation of the General Motors Corporation

Under normal operating conditions a roadway must make provision for the performance of four basic traffic functions, (1) *stream function* or the movement of traffic along the length of the roadway, (2) *directional function* or the simultaneous movement of traffic in opposed directions, (3) *intersectional function* or the movement of traffic across the roadway at required places, and (4) *marginal function* or the channelizing of traffic with respect to roadside conditions

If each of these functions could be performed with complete freedom there would be no congestion and there would be no accidents Conversely congestion and accidents arise from interferences in these functions which interferences may be expressed respectively as (1) internal stream friction, (2) medial friction, (3) intersectional friction, and (4) marginal friction

The problem here projected deals with the directional function of the roadway and the related problem of medial friction though it will be observed, as the discussion procedes, that an adequate solution of the medial problem has direct implications with respect to the marginal problem

An ideal solution of the medial problem with its concomitants of mutual interferences between opposed streams and its more violent results in head-on collisions would be achieved if roadways were one-way, in other words if opposed streams could be insulated by adequate space To a degree this ideal solution is approached in modern, multi-lane, divided highway construction Here the designer substitutes for the more hazardous medial friction a less hazardous marginal friction

While this type of roadway construction is highly desirable and will undoubtedly become standard design for major rural routes it must be recognized that there are many places where it is not feasible. In general these include all of those locations where the designer is confronted with definite restrictions in width of right of way, an almost universal condition in urban areas, and most acutely experienced in bridge construction or in elevated or depressed way design Under such restricted width conditions the problem of a physical separation of opposed streams resolves itself to the substitution of suitably designed elements requiring relatively little space, for the insulating elements of space itself In addition, even where unlimited width is available, there is the ever-present problem of a suitable treatment of the residual marginal frictions which the dividing strip has substituted for the otherwise active medial frictions Furthermore there is the very practical problem of obtaining maximum efficiency from an existing street and highway system much of which need not, and most of which could not be rebuilt

Progressive protection against medial frictions would appear to fall into three logical steps, (1) the visible definition of the medial area to orient drivers in opposed streams, (2) a medial mechanism which will add a sensory warning to the already present visual warning and which will tend to deflect or redirect the course of a vehicle impinging upon the medial area but of such a character as not to take control of the vehicle nor to preclude a safe accidental or intentional crossing of the medial area, (3) a medial mechanism providing both visual and sensory warnings which will positively deflect and redirect the course of an impinging vehicle, precluding an accidental or intentional crossing of the medial area, and without creating hazards for the vehicle or its occupants under any normal conditions of attack

Great progress has been made toward a solution of the first of these steps This is to be found, of course, in the wide and rapidly increasing use of the center line of paint or other material It is probable that it is the most thoroughly valuable traffic aid afforded American motorists today, and highway officials should be praised for their recognition and use of its values It deserves standard universal application, and there is an urgent, present need for a much more general use in urban areas

There are some who conscientiously believe that the duty of the street and highway designer should end with this step They hold that having given due visible warning of a hazard the responsibility for avoidance is shifted to the operator, and that enforcement should remove those who fail. There would be logic in this position were it not for the almost universal fallibility of the human machine for which no satisfactory predetection methods have been developed, and were it not for the fact that unoffending persons are too frequently the victims of errors on the part of others At any rate no substantial harm can arise from an exploration of the possibilities of providing added guidance or even control for those situations where an error in judgment may prove critical

Attention is directed to step two in the progressive protection against medial frictions here restated. "a medial mechanism which will add a sensory warning to the already present visual warning and which will tend to deflect or redirect the course of a vehicle impinging upon the medial area but of such a character as not to take control of the vehicle nor to preclude a safe accidental or intentional crossing of the medial area" A proposed solution for this problem has been projected by Professor T. M. Matson of the Yale Bureau for Street Traffic Research. As its basic operating principle he has utilized the well known action of tires popularly referred to as "cling" or the tendency of a tire to follow the line of a depression in which it rests in whole or in part It is most commonly experienced in a mild form in the action of tires on street car "U" rails. The Matson principle takes practical form in a so-called "channeled deflector plate." The plate used in the tests later described had a total width of 25-in. and was formed of $\frac{9}{64}$-in. structural steel corrugated so as to form channels approximately 4-in. center to center and $1\frac{3}{4}$-in. deep, tapered or skewed to the longitudinal center line of the plate and the roadway at an angle of 42 to 1 (Fig. 1).

medial area, and without creating hazards for the vehicle or its occupants under any normal conditions of attack."

The author obtained the basic principle for a proposed solution of this problem from a very humble source. He observed in the operation of roller coasters that lateral curvatures far too severe to be controlled by rails or banking were safely accommodated by guiding guard rails on the outer sides of the curves against which the rapidly moving cars

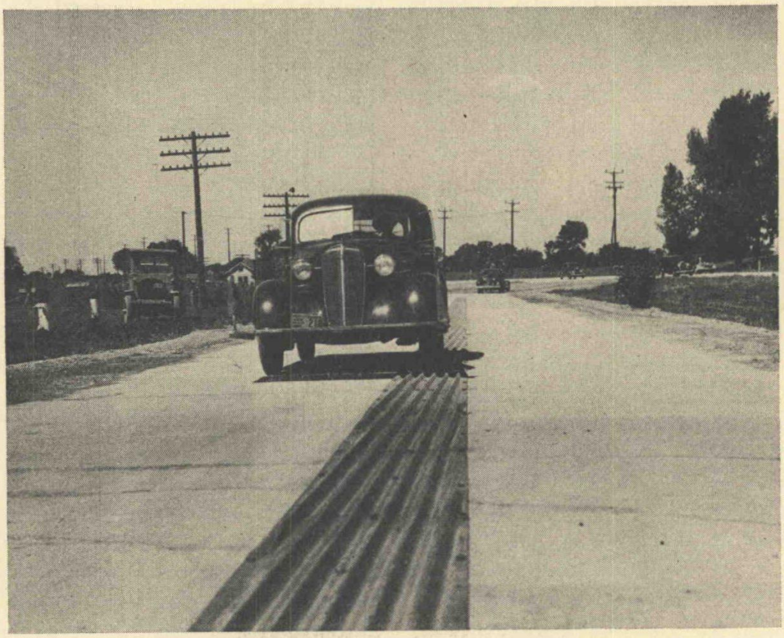

Figure 1. Channeled Deflector Plate

Subsequently a plate with corrugations 8-in. center to center and approximately 3-in. in depth with steeper channel sides was developed.

Attention is now directed to step three in the progressive protection against medial frictions restated as follows: "A medial mechanism providing both visual and sensory warnings which will positively deflect and redirect the course of an impinging vehicle, precluding an accidental or intentional crossing of the

made contact through side rollers. There was thus created a rolling contact which, while resulting in some severity of action, made it possible for the car to negotiate exceedingly sharp curves at relatively high speeds.

Since it appeared to be impracticable to provide side rollers upon motor vehicles for rolling contacts with guard rails, he conceived the idea of so tilting the vehicle that the normal wheels would serve not only to carry the vehicle but to provide a rolling contact with the guiding element. Through various stages of development, this principle took ultimate practical form in a so-called "parabolic deflector." As submitted to the test hereinafter described, this parabolic deflector was fabricated from $\frac{1}{4}$-in. structural steel sheets into a modified "A" section approximately 30-in. at the base and approximately 18-in. in height. The "A" section was designed to straddle the middle line of the highway, the sides accommodate more than moderate loads.

The "parabolic deflector" produces several complex functions more or less simultaneously under attack. It redirects the impinging front wheel as this wheel attempts to climb the curved and sloped surface of the deflector thus resulting in a rotation of the vehicle on its horizontal axis. This, of course, is no more than is accomplished by a direct contact between a moving vehicle

Figure 2. Parabolic Traffic Deflector

or legs of the section being flush with the pavement and arising by curves and tangents to the peak of the structure (Fig. 2).

The test structure was a modification of the fully developed design of the parabolic deflector which provided for a height of $4\frac{1}{2}$-ft. on a $4\frac{1}{2}$-ft. base. This larger structure was designed to absorb the full impact of critical attacks. It was not anticipated, therefore, that the test structure of smaller size would and a fixed vertical barrier except that in the "parabolic deflector" the rotation is a progressive one, initially mild on the lower slope and increasingly severe on the upper slope, thus providing a less violent transition in the rotation.

Concurrent with the horizontal rotation, there is a vertical rotation. The front impinging wheel is raised progressively and the following rear wheel is successively raised as it impinges on the sloped sides of the deflector. This latter vertical rotation of the vehicle counteracts the overturning moments in the mass of the vehicle and provides, through a very short but ample transition, for what is equivalent to a substantial superelevation of the surfaces upon which the vehicle is operating.

There is a third and highly important function in addition to the purely mechanical actions described The "parabolic deflector" is so designed that no portion of the vehicle other than the tires can at any time be in contact with the structure The tires thus serve as rolling pneumatic bumpers to absorb a substantial proportion of the thrusts created by the rotary transitions described and to materially soften the impacts

The "channeled deflector plate" and the "parabolic deflector" have been submitted to exhaustive tests as a cooperative project between the Bureau for Street Traffic Research in Yale University and the Highway Department of the State of Michigan The Highway Department, through the cordial cooperation of Commissioner Murray Van Wagoner and his staff, assisted materially in structural design and through the construction, placement and testing of the mechanisms [1] The tests also had the valuable cooperation of the staff of the General Motors Testing Ground and particularly the advantage of special instrumentation

A 300-ft section of each type of deflector was installed medially in an abandoned two-lane concrete roadway east of Weberville, Michigan The tests were conducted August 22 to August 25, 1938 inclusive

Test vehicles were selected to give a wide range of vehicle reaction They included a Model A Ford Coupe, a 1936 Plymouth Coach, a 1936 Chevrolet Coach, a 1936 Oldsmobile Coach, a $1\frac{1}{2}$-ton Dodge truck, a $3\frac{1}{2}$-ton Dodge truck, a 7-ton Federal truck and a 15 ton water truck, the latter being employed to test the static strength of the deflectors

With these vehicles, a series of tests was run upon each of the deflectors through all of those ranges of speeds, angles of attack and surface conditions likely to be encountered in normal traffic operation In the passenger car classification speeds were employed from ten miles per hour to sixty miles per hour and in the truck classification, from ten miles per hour to the maximum speed of each test vehicle For all vehicles, two angles of attack were employed, one series being 1 in 10 and the other 1 in 20 Conditions of pavement and deflector surface were varied from normal dry to saturated wetness and some tests were conducted with the pavement and barrier greased to simulate glare ice conditions The majority of the tests were conducted with a drifting attack so far as steering was concerned, the driver releasing any pressure on the steering wheel once the angle of approach had been established Some special tests were conducted with violent steering into or away from the structure at the time of contact

Complete photographic records were made of the test both with still cameras, with normal motion picture cameras and with high speed motion picture cameras In addition, the General Motors Corporation made a very great contribution through the operation of a test car (1938 Chevrolet Coach) fully instrumented to measure precisely vehicle reactions Many of the above technical results are yet to be fully analyzed and, in conclusion, attention is directed therefore to the more obvious and immediately practical results

The "channel deflector plate" provides a very substantial increase in the potential visibility of medial marker, the chan-

[1] Mr Fred Taylor, Director, Highway Planning Survey, was in charge of the tests for the Department

nelled slopes affording maximum visibility for paint The skew of the visible channels being continuously toward the right side of the roadway establishes an optical illusion and a psychological reaction to steer away from the medial line of the highway, a reaction experienced generally by the test drivers The plate provides a definite and sharp sensory warning to the driver of a vehicle impinging upon it It was impossible, however, to obtain any violent vehicle

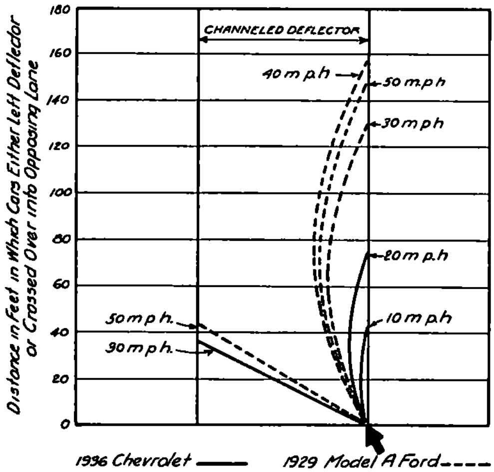

Figure 3. Comparative Performance on Channeled Deflector. The angle of contact was 2°52′ in all cases except that of the model A Ford at 50 m.p.h. which was 5°43′. The arrow indicates the point at which the left front wheel drifts into the deflector.

reactions at any speed or angle of attack with the plate and the pavement either wet or dry.

Drivers were able to cross the plate freely with intention at any speed or angle of attack This held even for the short section of 3-in channel plate which was installed to test exaggerated problems

The deflector plate definitely tends to redirect the course of freely impinging vehicles as was the result in the majority of the tests However, this deflection and redirection is by no means positive and could not be depended upon with certainty at higher speeds and with comparatively sharp angles of attack (Fig 3)

The performance of the "parabolic deflector" was rather surprising considering the fact that it was of junior size and did not have a computed capacity to absorb full impacts The full series of tests resulted in no damage to any vehicle or occupant [2] Most tests were run with a driver and one or more passengers In each test the vehicle automatically

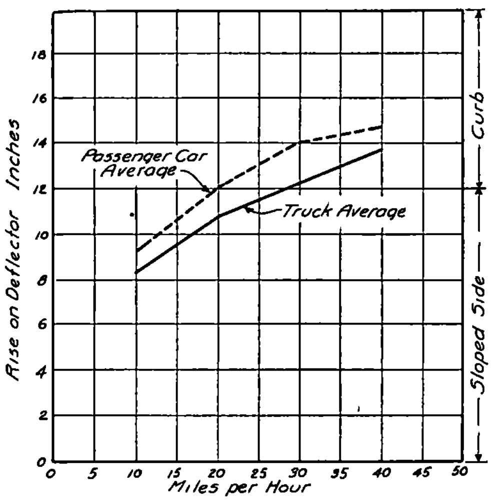

Figure 4 Average Performance of Passenger Cars and Trucks, Drifting Approach, Deflector Dry, Angles of Contact 2°52′ and 5°43′.

left the barrier at approximately the same angle as the attack No violence in steering was noted at any speed At speeds up to 40 miles per hour, there was little recorded violence in the movement of the body of the vehicle Body movement increased in general with speed Each of the passenger vehicles, however, attacked the barrier repeatedly at the lower angle of approach at speeds of

[2] Some rubber was worn from the running board of one test car and one vehicle required slight wheel re-alignment

60 miles per hour It should be noted here that even on a 4-lane highway acute angles of attack at high speeds are normally impossible The high speed tests showed some violence in car reaction but this violence did not extend to the point of resulting in damage to the vehicle, in hazard to the occupants and, in no case, in a result affecting the full control of the vehicle (Fig 4)

It was the concensus of the observers and drivers that the "parabolic deflector" would absorb impacts substantially above those imposed but that the full values from the test had been derived without the necessity of proceeding to a point where critical reactions might be approached

It is the intention of the Yale Bureau for Street Traffic Research to continue its research work in this field looking toward refinement of the structures described and the design of related types of structures

DISCUSSION ON TRAFFIC DEFLECTORS

Mr G. W Davis, *District of Columbia* What is the pedestrian's relation to the parabolic deflector at points between intersections? The big problem in Washington is pedestrian control So far we have not had very much luck controlling them and I should like to know what, if any, results you have had in handling the so-called "jay-walker "

Dr. McClintock. This test installation was on an abandoned piece of rural highway; there were no pedestrians and we hopped back and forth over the barrier. If the senior deflectors were used they would preclude any pedestrian crossing other than at designated places

Prof J. T Thompson, *Johns Hopkins University:* Are there any estimates of cost of the deflectors?

Dr. McClintock We know of course the costs of the two types of deflectors as used in the tests, but that cost would not reflect the ultimate cost of production in mass after dies were constructed for that purpose The parabolic deflector can also be constructed from steel plates or from pre-cast or cast in place concrete and as you can readily see by rather simple forms Costs will vary according to prevailing local conditions, but I can assure you they will be quite low.

Prof. Thompson What were you able to observe with respect to approximate driving distance from the deflectors?

Dr McClintock The normal driver will drive closer to the deflector than he will to a vertical barrier. High speed drivers will drive materially farther away from the parabolic deflector than they would from the center line itself

Prof Thompson Would it be three feet?—four and one-half feet?

Dr McClintock· I question if normal practice would show a three foot clearance except at very high speeds It is not contemplated however, that the parabolic devider could be used without a compensating widening of the roadway