THE UNIVERSITY OF MICHIGAN

Michigan Univ. Engineering Research Institute

AUTOMOTIVE SAFETY REPORT

Final Report On
Project 461 - Problem 1124

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TABLE OF CONTENTS

I INTRODUCTION AND SUMMARY

Members of the Engineering Research Institute like most people in the United States have for years been aware of the danger exhibited by the ever increasing number of cars. We worried and thought about this problem as pedestrians, as passengers, as drivers, and as parents. Professor Folsom encouraged us to worry about this problem as scientists and engineers. We immediately started thinking about designing radar, acoustic, and infrared devices to protect each other. We realized unless we understood the meaning of the statistics of the problem, none of us really know for what we should design. We decided that a study should be made to see what the statistics were and to see if sensory devices were really being investigated.

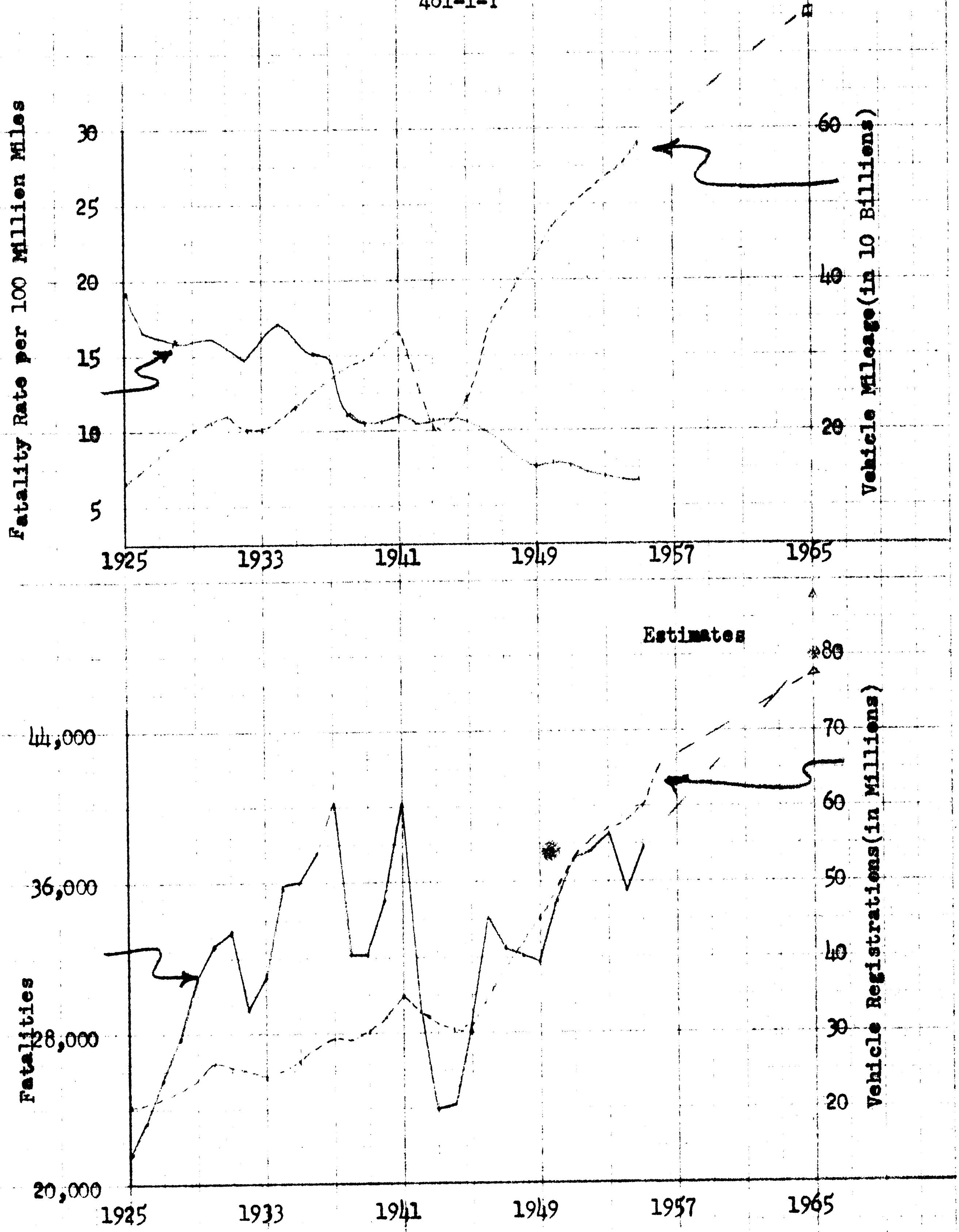
We now know what the statistics say and we are now convinced a research program should be begun concerning sensory devices to give the driver more information at night or in bad weather, at further distances on dry clear days, and about his position in traffic in complex traffic situations. We feel that accidents which occur during the day are the primary concern of psychologists and psychiatrists and driver education programs but with increasing speed and numbers of cars we must also give the driver an increased amount of information. In other words during the night or at dusk or in bad weather the driver does not have nearly enough information and we should try to give him more. During the clear day, mental states of mind control many of the causes of accidents and we feel we should leave these problems to the Medical College. Daytime clear weather causes drivers to speed and this requires them to "guess" or to overdrive their available information. Increased information should cut down on the guesses which might have death associated with them.

Traffic safety is now recognized as one of the most serious and complex problems facing the people of the United States today. Its seriousness is evidenced by the many lives lost and injuries suffered by the American people each year with the associated loss of manpower and money. For 1955 there were 37,800 deaths and 2,158,000 injuries due to the automobile with total costs estimated at over $4,500,000,000 (Ref. 1). The complexity of the problem lies largely in the multitude of tasks confronting the driver requiring excellent coordination, split-second timing, and continual alertness on his part. An excellent analysis of the driver's duties is given in a report of the Highway Safety Research Committee of the National Safety Council (Ref. 2).

"The driver must first learn to coordinate both hands, both feet, vision, and hearing. This coordination must be learned to a point where it becomes semi-automatic before he can hope to operate in traffic with any degree of safety. He must operate in close proximity to other vehicles of different sizes and speeds, going in the same and opposite directions, and on crossing courses. He must also learn to make judgments of changing space-time relationships. He must operate on highways and streets which require passing other vehicles with a clearance of only 1 ft or 10 or 20 ft. When the time intervals within which he must react, even at relatively low speeds, are considered, it will be seen that he must learn to anticipate conditions and situations. If two cars are approaching at 30 mph and one driver loses control when they are 45 ft apart, each driver has 0.5 sec to react. This "means in the light of our present knowledge, that he would just have time to get his foot on the brake, but there would be no possibility of stopping the car in time to prevent a collision. Thus the factors of foresight, planning and appreciation of hazards must be involved to a major extent. Actually, it seems probable that more continuous attention from moment to moment is required of the motor vehicle driver than of the operator in any other type of transportation including the airplane."

Much has already been done to help the driver and increase the safety of himself and his passengers. The automobile manufacturers feel that they have added safety features to the automobile as rapidly as the public would accept them. Improvements of headlights, tail lights, steering mechanisms, tires, etc., and the change to safety glass and four wheel brakes have all helped reduce accidents and injuries. The present trend to automatic items such as power steering, automatic transmission, power brakes, etc., are all at least partially safety items in that they tend to relieve the driver of some of his duties or make them easier and simpler for him.

In the thirty-year period from 1925 to 1955 we see from Figure 1 that although the number of automobiles on the road has almost tripled, and the vehicle-miles driven per year have more than tripled, the death rate in terms of vehicle miles has been reduced by about two-thirds. This in itself is a big accomplishment but the magnitude of the accident toll in both people and money continues to increase and much more improvement in traffic safety is required. Vehicles are being added to the roads at about 2.5 million per year and a projection at the 1955 death-rate of 6.4 deaths for 100 million



MOTOR VEHICLE TRAFFIC PROBLEM

Fig. 1

vehicle miles would give for 1965 over 75 million vehicles traveling about 750 billion vehicle miles with about 48,000 traffic deaths.

In learning about this problem we have talked with many people in the traffic safety field including safety engineers of Ford, Chrysler, and General Motors. We have also examined numerous reports and publications. We have found that there are a great number of organizations working in the traffic safety field and that there is a general public awareness of the problem. It seems that every conference involving public administrators sets up a program for traffic safety. Most recently the Conference of Governors adopted such a program and described the situation as a "national emergency". (Ref. 3)

"Among its 30 recommendations for highway safety were these:

> Adoption by all states of a uniform traffic code.
> Increased traffic enforcement activities.
>
> Expansion of safety education programs.
>
> Reduction or elimination of physical hazards through engineering. (Under this recommendation the committee said 'the automobile manufacturing industry should be encouraged to continue to design safer motor vehicles'.)
>
> Greater reciprocity among states. (Such as license suspensions for traffic offenses committed in a state other than that of the driver.)
>
> Greater research into the human factors connected with traffic accidents."

It is our purpose here to describe the traffic safety problem, outline the work which is presently being done, discuss the many suggestions for improving traffic safety which we have collected and then to recommend the type of program we feel should be carried out in the Engineering Research Institute of The University of Michigan.

II THE AUTOMOTIVE SAFETY PROBLEM

A brief comparison of accident statistics (1930 and 1955) will help to show changes which have occurred in the accident pattern in the past 25 years as well as to emphasize those elements which remain about the same. In 1930 (Ref. 4) 32,500 persons were killed and 962,325 injured in automobile accidents while in 1955 (Ref. 5) 37,800 were killed and 2,158,000 injured.

TYPES OF ACCIDENTS	% FATALITIES		% INJURIES	
Collision With	1930	1955	1930	1955
Automobile	20.7	39.3	49.2	70.3
Pedestrian	45.9	21.5	33.3	10.3
Fixed Object	11.0	11.7	5.5	6.2
Railroad Train	5.1	3.4	.5	.3
Non-Collision	13.0	22.3	5.9	10.2
Other	4.3	1.8	5.6	2.7

ACTIONS OF DRIVERS	% FATALITIES		% INJURIES	
	1930	1955	1930	1955
Exceeding Speed Limit	30.9	42.6	21.0	39.9
On Wrong Side of Road	11.9	17.8	16.2	7.0
Did not Have Right-of-Way	15.0	12.1	31.5	25.2
Drove Off Roadway	33.5	10.0	13.4	6.5
Reckless Driving	-	12.1	-	10.1
Cutting In	4.1	.5	7.2	2.9
Failure to Signal or Improper Signal	1.8	2.1	7.6	4.0
Other	2.8	2.8	3.1	4.4

TYPES OF VEHICLES	1930	1955	1930	1955
Passenger Car	78.5	78.1	76.9	85.1
Commercial Vehicles	15.2	17.4	11.0	9.8
Other	6.3	4.5	12.1	5.1

	% FATALITIES 1930	% FATALITIES 1955	% INJURIES 1930	% INJURIES 1955
CONDITIONS OF VEHICLES				
In Apparently Good Condition	88.9	96.3	94.9	97.6
Other	11.1	3.7	5.1	2.4
WEATHER CONDITIONS AT TIME OF ACCIDENT				
Clear	85.8	84.7	88.1	81.3
Fog, Rain, Snow, etc	14.2	15.3	11.9	18.7
ROAD CONDITIONS AT TIME OF ACCIDENT				
Dry	79.9	78.6	80.7	72.5
Wet, Snowy or Icy	20.1	21.4	19.3	27.5
DIRECTION OF TRAVEL OF VEHICLES				
Going Straight	85.5	78.4	78.2	64.6
Skidding	6.5	6.3	5.5	3.6
Slowing or Stopping	.8	1.2	4.3	12.2
Other	7.2	14.1	12.0	19.6

These figures show several obvious changes in the accident pattern:

1. Collisions between two automobiles have greatly increased. This may be almost entirely due to the increase in the number of vehicles.

2. Non-collision accidents have increased.

3. Pedestrian accidents greatly decreased. This probably represents the result of additional years of living with automobiles. Both drivers and pedestrians are more aware of the limitations of the automobile. Another factor may be that there are very few pedestrians on our expressways, turnpikes, etc.

4. More drivers in accidents are exceeding the speed limit and fewer have driven off the road. Detroit accident figures for 1955 indicate that many more drivers exceed safe driving speeds than exceed the stated speed limit. For Detroit 1,794 exceeded

the speed limit while 27,007 exceeded a safe driving speed but not the stated speed limit (Ref. 6).

5. There appears to be a slight tendency for more 1955 accidents to involve cars turning, stopping, etc., but around 70 percent of all cars in accidents are still traveling straight.
6. There is no apparent change in the types of vehicles in accidents (passenger cars in about 80 percent of all accidents*), the condition of the vehicles (about 90 percent or more in apparently good condition), the weather conditions (about 85 percent clear weather), and in road conditions (about 80 percent dry roads).

From these we can see that most accidents in these two sample years, 25 years apart, involved ordinary drivers with good cars traveling straight ahead on dry roads in clear weather. In 1955 80 percent of the fatalities and injuries occurred as a direct result of driver error (Ref. 5). In 1930 this was about 68 percent with the difference being largely due to the large number of fatalities (7000) and injuries (150,000) directly due to pedestrian error that year (Ref. 4). It seems obvious that 25 years of living with the automobile has educated both the pedestrian and the driver a lot but that driving complexity has increased over the same period to where

*This is about the same as the proportion of passengar cars to commercial vehicles. If however we consider that the commercial vehicle regularly travels many more miles per year than the passenger car it is seen that the commerical or professional driver has less accidents than others.

the driver needs help such as some additional mechanical or sensory aids to assist him in his job. He drives on a straight road in clear weather and dies because he cannot see far enough ahead or is not alert enough.

Further insight into this problem can be found in the discussion of Dr. McFarland (Ref. 2) on the accident repeater. He shows a table of an accident distribution among Air Force pilots over an eight-year period which he points out is similar to the findings for several groups of automobile drivers which have been studied.

TABLE 1

CHANCE AND OBTAINED DISTRIBUTION OF 7288 ACCIDENTS FOR 17,952 PILOTS DURING AN EIGHT-YEAR PERIOD

Number of Accidents	Number of Pilots Associated w/Number of Accidents	
	Chance	Obtained
0	11,962	12,475
1	4,856	4,117
2	986	1,018
3	133	289
4	14	53
5	1	14
6	0	8
7	0	2

The chance distribution here is the well known Poisson distribution of the occurrance of events each of which has a very small but equal probability of happening but which also has a very large number of opportunities of happening. Dr. McFarland points out that the fit is close here but obviously something besides chance is operating in distributing these accidents. It seems more likely that the assumption of equal and small probabilities is not justified here and that there are some pilots who make errors having larger probabilities of causing an accident.

If we analyze our own driving habits, we will find that we make numerous small mistakes which are relatively unimportant in themselves but which if a particular one occurred at a specific instant could cause an accident. How many times have we looked in our rear-view mirror and then turned into the left lane in traffic without looking for a car in the left side blind spot. This causes no trouble unless a car is in the blind spot and we are also meeting another car so that the one in the blind spot has no room to swing over out of our way. If each of these little errors are added to those of the other 75 million or so drivers in the United States and if all of these errors have very small but nearly equal probabilities of occurring, then we would expect the accident distribution to be Poisson. The fact that we do not get a good fit to the Poisson from accident statistics probably shows that in addition to billions of driving errors committed each year with very minute probabilities of producing an accident, there are a few million of high accident probability errors. The driver needs help in preventing these errors.

Some of these driving errors, such as dozing while driving, always have a large probability of causing an accident. Others such as lighting a cigarette become high accident probability errors only if they are done in particular road, traffic, or driving situations. Such a situation might be following too close to the car ahead, passing another car, meeting another car, driving too close to the centerline, going off the road, etc. These "danger situations" (Ref. 30) are situations in which the driver needs to do his job better than ordinary. He must be especially alert. Many times in his driving he needs help in the form of information beyond that which his own senses can give him to warn him that a danger situation is developing or already exists.

A second point shown by the closeness of the fit of our accident statistics to the Poisson distribution is that unless we can make all drivers perfect we will always have some accidents. This automotive safety problem then is twofold.

A. The prevention of accidents by eliminating the high accident probability errors and reducing the over-all number of driving errors.

B. The prevention of death and injuries when an accident occurs by improving automotive design and including additional safety features in the vehicle.

III RESEARCH ORGANIZATIONS AND GROUPS ENGAGED IN SAFETY PROGRAMS FOR AUTOMOBILE DRIVERS

Reference 7 gives the following key agencies in the traffic safety field which work closely with or can provide guidance to more than 100 groups specializing in particular aspects of this complex problem.

American Automobile Association, 1712 G Street, N.W, Washington, D. C.

American Bar Association, Traffic Court Program, 1155 East 60th Street, Chicago 37, Illinois

Automotive Safety Foundation, Ring Building, Washington 6, D. C.

Highway Research Board, National Research Council 2101 Constitution Avenue, Washington, D. C.

National Educational Association, National Commission on Safety Education, 1201 16th Street, NW, Washington 6, D C.

National Highway Users Conference, National Press Building, Washington 4, D. C.

National Safety Council, 425 N. Michigan Avenue, Chicago 11, Illinois

The work of a few of the research organizations and agencies working on phases of traffic safety is summarized below.

The University of Michigan Transportation Institute

Professor J. C. Kohl, Director of the Transportation Institute of The University of Michigan is supervisor of a project which began in July 1956. The State Legislature provided The University with a $23,000 grant to make a thorough study of all phases of automobile accidents that occur in Washtenaw County. The researchers will visit the scenes of significant accidents to gather detailed data on road and weather conditions at the time of the mishap. Using questionnaires prepared by The University of Michigan statisticians and psychologists, they will interview accident victims in an attempt to learn as much as possible about the driver's pre-accident behavior attitudes, mental and emotional states, and his reaction to the highway. This is a pioneer study in which the group is trying to find the real cause of most traffic accidents. Generally the driver is blamed and road and vehicle conditions are more or less ignored. They hope to gain a basis for constructive suggestions as to how accidents may be prevented in the future or to point the way to those phases which warrant further study. They would like to find out what the driver is thinking about the road and weather, when he decides to slow down or accelerate, and how highway engineers can most effectively reach him with warnings on changing conditions.

The University of Michigan Medical School

A special committee has been formed to concern itself with the automobile accident injury research. They will try to answer questions such as how much of a road hazard is a medically or physically handicapped person, the amputee, the person with tunnel vision, the diabetic and others. Members of the committee are Dr. Wilfrid T. Dempster, Dr. A. James French and Dr. Paul E. Hodgson.

The University of Michigan Vision Research Laboratory

Professor H. Richard Blackwell, head of the Vision Research Laboratory of The University of Michigan is directing work on hazards of lighting, both in the automobile and on the highway. Much of his work is centered on the present use of optical filters and their effect on night driving (Ref. 8). This group is also interested in better highway lighting and vehicle lighting. They feel accidents could be lessened if the driver could see the rear of the car in front of him, especially in fog. Their work also deals with the problem of stray illumination in snow and fog.

Mental Health Research Institute

This group at The University of Michigan is concerned with the study of the human reactions themselves. They refer to the biological and social fields involved as "Behavioral Sciences". Participants in this group have been from the fields of history, anthropology, economics, political science, sociology, social psychology, psychology, psychiatry, medicine, physiology and mathematical biology. Heading this group is Dr. James G. Miller, Professor of Psychiatry. In connection with their study, they are working on the effect of drugs on driving, reaction time of the driver, effect of Milltown Tablets, etc.

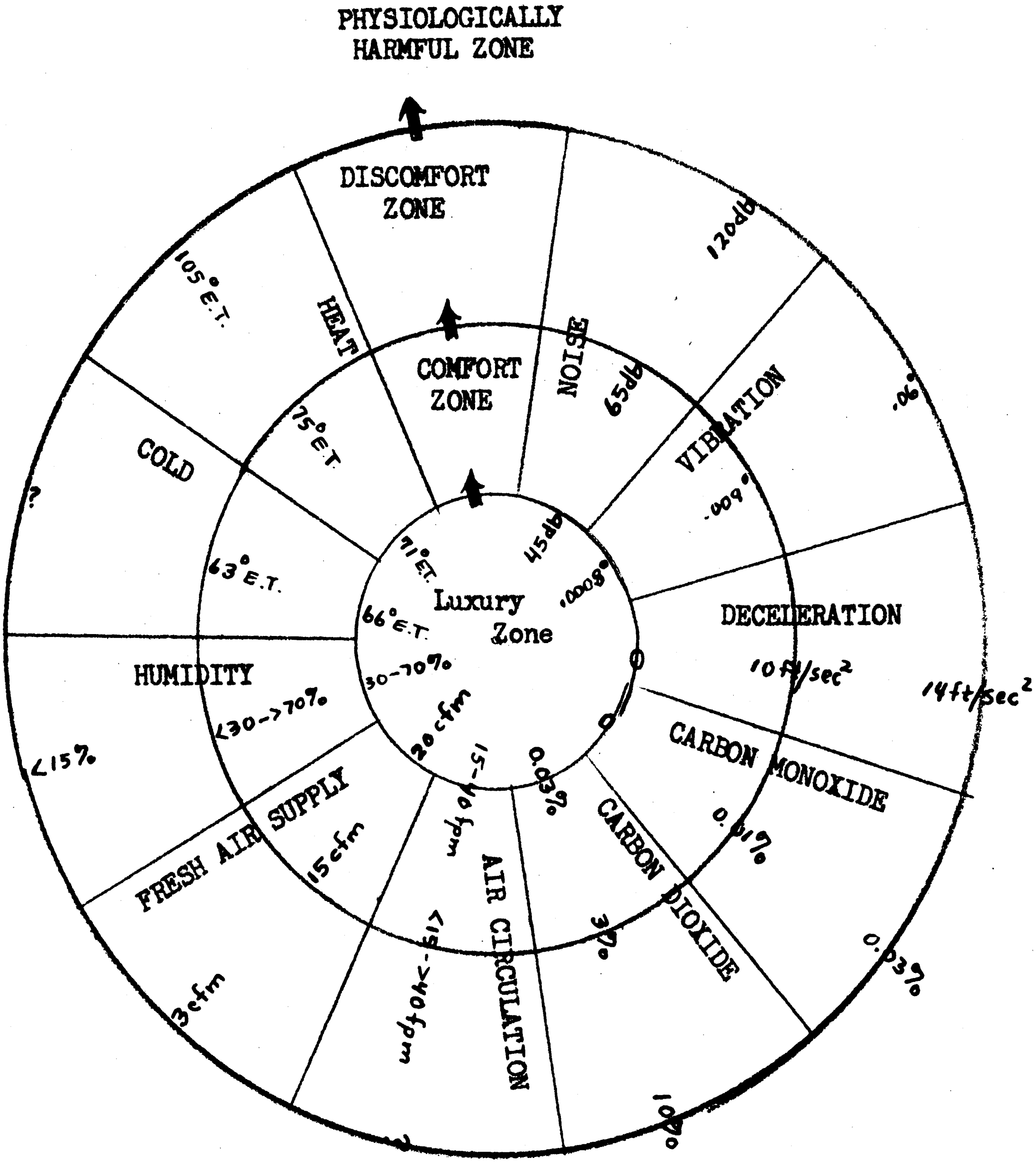
Harvard School of Public Health, Harvard University

"A broad research program in the field of highway safety has been in progress at the Harvard School of Public Health during the past eight years.

These studies were initiated by the American Trucking Associations, Inc., the National Association of Motor Bus Operators, and the National Association of Automotive Mutual Insurance Companies. The facilities of the Harvard medical center are being used by a team of scientists representing various engineering, medical, and biological sciences to study the most important human variables and their relation to accidents.

"Since 1951, the Commission on Accidental Trauma of the Armed Forces Epidemiological Board, Department of Defense, has sponsored research on the human factors in vehicular accidents at Harvard and at a number of other universities and research institutions. Thus far the research program has stressed basic causes in the areas of 1) identifying traits of personality and behavior which lead to repeated errors, 2) defects in the design of equipment (human engineering), 3) injuries and fatalities resulting from vehicular crashes, and 4) mathematical studies of the various interrelationships of contributory causes in accidents." (Ref. 2)

In studying the above, this group has studied accident repeaters, psychological characteristics and physical defects, driver selection and training, and the influence of alcohol, fatigue, emotional disturbances and drugs and medications. The human engineering phase considers the designing of the driver area to fit the driver. "Many errors can be prevented if controls are designed and placed so that rapid and accurate movements can be made." Also considered here are driver-environment interrelationships which may contribute to accident causation. These are illustrated graphically in the following chart.



Physical variables of environment influencing driver comfort, health, and safety. These values must be considered approximations, since each variable is interdependent on one or more additional factors.

Joint Safety Research Group (Ref. 9)

Members of the Joint Safety Research Group are; American Institute for Research (see page 17), Union Switch and Signal Division of Westinghouse Air Brake Company, and the Pennsylvania Turnpike Commission.

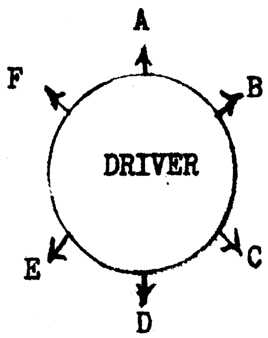
This group has two primary objectives;

1) make a systmatic and comprehensive analysis and evaluation of the fundamental causes of accidents on the Pennsylvania Turnpike System, and

2) make a critical analysis and evaluation of means or methods available or to be invented to combat causation as determined by 1).

The Pennsylvania Turnpike Commission gives general aid and consultant service with full knowledge of the turnpike operation. The Union Switch and Signal Division supplies project administration, environment studies, surveys, and engineering. The American Institute for Research analyzes human factors, surveys, and remedial research.

The following figure gives a graphic breakdown of the basic factors and the inherent problem as given by the Joint Safety Research Group. The driver is seen as the central figure in the accident problem. The following broad elements, both aiding and hindering him are not necessarily listed in order. They actually form an external sphere of influences. The driver is faced with a set of environmental and vehicular conditions. The great majority of the time he succeeds in his driving task - at times there is failure. The problem is to determine the relative importance of the main factors and the full scope of each factor's role in the traffic picture and the actions, interactions or failures of these factors which are basic to accident causation



A - TURNPIKE LEGISLATION & ADMINISTRATION - All acts regulating traffic; maintenance policies, inspection campaigns, police policies, E and E programs, meetings with commercial patrons, weather reports, etc.

B - EQUIPMENT - The vehicle (weight and braking distance, vehicle stability under sudden change); condition of tires, brakes, steering, general maneuverability, etc.

C - ENVIRONMENT - Light conditions, weather conditions, roadway conditions, roadway element, sudden changes.

D - TRAINING - Sudden change in (traffic pattern, equipment, visibility, roadway, environment).

E - TRAFFIC PATTERN - Single vehicle, multivehicle, fixed pattern (number of vehicles, type of vehicles, spacing and relative positions, speed); changing pattern (number of vehicles, type of vehicles, spacing and change in location, relative speed), etc.

F - EDUCATION AND PUBLICITY - Newspapers (editorials, accident coverages, accident prevention articles); magazines, automobile club campaigns, insurance company campaigns, weather reports, etc.

American Institute for Research

The American Institute for Research (AIR) is a member of the Joint Safety Research Group which is under the sponsorship of the Pennsylvania Turnpike Commission. AIR has applied human engineering methods to the efficient and safe operation of highways and to the solution of problems in traffic engineering. Its activities include

1) Studies of driver actions and their results in relation to car, highway, and environmental factors. The effects of combinations of critical combinations and critical behaviors are given special emphasis.

2) Development of recommendations for improvement in highway design. These are based on both findings of special research studies and on known perceptual, judgmental, and muscular response functions.

3) Analysis of near-accident data in evaluating the adequacy of vehicle control features, driver training, and highway engineering.

The first study of this program was analysis of driver behaviors and other factors in causation of highway accidents. They analyzed driver behaviors which, with other items were coded from police accident reports on the rapid-analysis punch cards. They obtained supplementary data from on-the-spot interviews with drivers involved in accidents or near-accidents. This obtained information was then compiled and analyzed to provide a comprehensive picture of accident patterns in Turnpike operations.

A paper presenting the results of a two-year study (1952-53) of accident causation on the Pennsylvania Turnpike is given in Reference 10. These results show that the turnpike statistics are quite similar to the overall statistics shown previously in that most accidents occur on straight roads and are the result of driver failure rather than vehicle failures. The accidents are classified into nine behavior categories.

"1. Failure on the part of the driver to cope with the road conditions was important in 22 percent of all accidents. These failures, by and large, resulted in skids on wet, snowy, or icy road surfaces. Unfortunately there was not enough information available to determine what manipulations the operator went "through to produce the skid. If this fact were known many of the accidents under this category would quite likely appear under the category of deficiencies in routine driving skills, or under illegal or unsafe actions.

2. Drivers commission of illegal and unsafe actions, were involved in 21.5 percent of all accidents. These behaviors ranged from parking on the slow speed lane to entering the pike from the exit lane and pulling out into the high speed lane in the face of a passing vehicle.

3. Driver inattention appeared to have been primarily responsible for 17.2 percent of all accidents. This inattention ranged from falling asleep to reading a road map while driving.

4. Vehicular failures which were not successfully handled accounted for 13.8 percent of all accidents. Blowouts, loss of steering, failure of brakes, trouble with hitches on tractor house trailer combinations, etc., constitute the category of vehicle failures not successfully handled.

5. Deficiences in routine driving skills accounted for 11.7 percent of all accidents. These driving skills are exemplified by the driver who, detecting that he has a wheel or wheels off the pavement cuts back sharply rather than making the correction gradually and safely.

6. Misperception was the primary factor in 8.2 percent of all accidents. Misperception as it is used here is two-fold in nature; 1) loss of vision because of snow, slush, mud or rain deposited on the windshield and 2) ambiguity of cues resulting in the driver doing such things as following in behind a vehicle ahead of him which has gone to the berm to park. This driver follows the one preceding him onto the berm with the impression that the leading vehicle has actually taken a turn in the roadway.

7. Failure to avoid objects in the road accounted for 3.6 percent of all accidents. While everything from a fallen rock to a deer in the road was hit the most frequent objects causing this traffic obstacle were animals in spite of the fact that the roadway is isolated by a fence.

8. Intoxication or drunken driving accounted for only 1.2 percent of the accidents on the Pennsylvania Turnpike.

9. Miscellaneous behaviors or failures accounted for the remaining 0.8 percent of all accidents."

Cornell Aeronautical Laboratory, Incorporated

As a result of its broad background in aircraft safety research and the similarity of aircraft and automotive safety design, the Cornell Aeronautical Laboratory, Inc., is active in research on automobile safety. The Laboratory's studies of kinetic behavior of bodies during crashes started in 1949 and led to the recent auto-crash program under the sponsorship of the Liberty Mutual Insurance Company. In this program the crashes were simulated with a late-model vehicle, enabling engineers to determine time and motion characteristics of the occupants. About three dozen tests were conducted in which the automobile was run down a test track and brought to a controlled stop by means of a snubbing device. This device could be varied to simulate different crash decelerations. Slow-motion photography provided data for time and motion studies of the dummy occupants enabling engineers to determine where, how often, and how hard a human would hit the various obstructions in the automobile in an actual accident. Past efforts in automobile safety research have included evaluations for United States Rubber Company of various padding materials, development of automobile door safety locks and design and development of a seat belt kit for the Hickok Manufacturing Company. CAL recently published under internal research funds, an educational booklet covering the proper design, installation, and use of auto seat belts.

Cornell University Medical College

The Automotive Crash Injury Research Program was initiated to identify, in passenger cars, those items which are causing injury or death of the occupants in accidents. Prior to initiation of this research program, causes of accidents were thoroughly investigated. The causes of injuries were ignored. An interstate cooperative research program has been established with departments of public health, medical societies, motor vehicle departments, police and traffic enforcement agencies in ten states (North Carolina, Virginia, Indiana, Connecticut, Maryland, California, Arizona, Texas, Vermont, and Minnesota). Using Cornell's specially designed research forms, these state groups submit specific injury and accident damage details on all injury-producing passenger car accidents in administratively selected sample areas. Data are analyzed and evaluated and recorded on IBM cards for biometrical and engineering research on the causes of these crash injuries.

Sponsorship and financial support comes from the Commission on Accidental Trauma of the Armed Forces Epidemiological Board with funds provided by the Surgeon General of the United States Army. Further support comes from the Division of Research Grants and Fellowships; National Institute of Health, United States Public Health Service, Ford Motor Company and the Chrysler Corporation.

The Cornell studies on injuries sustained by occupants of vehicles being thrown out of the car when the doors pop open in a crash showed convincingly that the chances of injury were much greater than when the occupants remained in the vehicle. This study was largely responsible for the adoption of the new safety door latches by the major automobile manufacturers and helped in proving the effectiveness of the seat belt in preventing injuries. (Ref. 11)

National Safety Council

The National Safety Council, chartered by Act of Congress, is a non-commercial non-profit cooperative organization furnishing leadership in the safety movement under the banner of the Green Cross for Safety. It provides services to meet the safety needs of industrial concerns, insurance companies, associations, traffic, home, farm and community safety organizations, government departments, schools and individuals. They publish yearly analyses of accidents in booklet form (Ref. 1). This is made possible by cooperation of the following organizations and of many other companies and individuals. Vital statistics and traffic authorities of cities and states, workmen's compensation authorities, United States Census Bureau, National Office of Vital Statistics, Interstate Commerce Commission, Public Roads Administration, World Health Organization, and community safety councils.

"Since the traffic toll is interwoven inseparably with the flow of traffic, the National Safety Council has recently announced a safety program based on engineering, education, and enforcement.

1. Convince every individual to drive and walk safely through organized efforts.

2. Give communities facts on how their traffic program compares with recognized standards.

3. Quickly build many miles of safe, modern accident-resistant roads.

4. By using traffic engineering and law enforcement, make existing highways more fool-proof and safe.

5. Obtain uniform vehicle laws so one set of traffic rules can be followed and enforced coast to coast.

6. Require driver education in schools.

"7. Tighten regulations so only completely qualified persons can obtain driver's licenses.

8. Revoke the license of anyone not driving decently and sanely.

9. Back traffic courts to the limit.

10. Encourage automobile design improvements for easier safe driving." (Ref. 12).

Citizens Traffic Safety Association - Detroit

This group is included as a notable example of the work the citizens' groups are doing for traffic safety. This Detroit group was formed in 1941 as a direct result of a conversation between Edsel Ford, Charles E. Wilson and K. T. Keller. It hires a director, Don Slutz, and operates on a budget of about $100,000 a year contributed by 100 industrial sponsors. Its job is one of education and support of police and traffic courts. The "Drunk Drivers Go To Jail" signs came from it. It was responsible for originating the TV Traffic Court program. It supports new legislation and in general coordinates public effort (Ref. 13).

In addition to the afore-mentioned organizations, there are a large number of educational institutions engaged in some form of traffic education or research. Usually these are in connection with their engineering departments and a few are set up as separate groups. Some of the more prominent of these are given below (Ref. 7).

Bureau of Highway Traffic, Yale University - Works primarily on planning of the geometry of road design and studying the basic characteristics of traffic on existing roads.

The Traffic Institute of Northwestern University, Evanston Illinois Police administration, traffic training, short courses in traffic engineering, motor fleet operation, driver license administration and traffic court conferences..

The Institute of Transportation and Traffic Engineering, University of California at Berkeley and Los Angeles - At Berkeley; engineering phases, planning design and operation of traffic. At Los Angeles; human factors, driver behavior, accident problems, safety and psychology.

Center for Safety Education, New York University - Safety education, driver training and safety teachers, truck fleet supervision and traffic safety coordination.

Driver Training Programs - The driver training programs have been enrolling more student drivers every year. In 1955-56, 10,000 of the nation's high-schools enrolled 994,212 in these programs. This was 62 percent of all eligible students (Ref. 14). We have seen no specific evaluation of the job these programs are doing but they are strongly supported by police and safety groups. In some states (including Michigan) passing a driver training course will soon be a requirement for getting a driver's license. The Michigan law becomes effective 1 February 1957 and requires that persons under 18 years of age must pass an approved driver training course in order to get a driver's license. The law also provides free training courses for every youth under 18 years whether he is enrolled in public or private schools or is out of school. Thirty hours of classroom instruction and six hours of driving practice are required (Ref. 15).

Federal Activities (Ref. 16) - The Federal Aid Highway Act of 1956 authorizes and directs the Secretary of Commerce "to make a full and complete investigation and study for the purpose of determining what action can be taken by the Federal Government to promote the public welfare by increasing highway safety in the United States." This will probably be delegated to the Bureau of Public Roads. A report will be made to Congress not later than 1 March 1959. Items which will be considered are

1) The need for Federal assistance to state and local governments in enforcement of necessary highway safety and speed requirements and the form it should take.

2) Advisability and practicability of uniform state and local highway safety and speed laws and steps to be taken by the Federal Government.

3) Possible means of promoting highway safety in the manufacture of vehicles used on the highways.

4) Educational programs on highway safety.

5) The design and physical characteristics of highways.

6) Other matters avisable and appropriate.

Also investigating traffic safety is a Special Subcommittee on Traffic Safety of the House Interstate and Foreign Commerce Committee. Its chairman is Representative Kenneth A. Roberts of Alabama. Five general areas will be considered by this subcommittee - human factors, legislation, private vehicle design, highways and law enforcement.

IV THE AUTOMOBILE MANUFACTURERS

Each of the automobile manufacturers visited has a group working on safety problems. The approach and attitude of each of these groups, however, was different. There seemed to be only about two points on which they agreed.

1) That there were too many people offering suggestions on safety items who did not know what they were talking about

2) That developmental research on safety items should either be done by the automobile manufacturers or sponsored by them.

There is no question that the Safety Engineer or whatever he may be called in one of these companies has a difficult job. He must not only do the best he can at developing safety devices which he feels meet the driver's needs but he must convince the sales, cost accounting product engineering, manufacturing engineering, design and purchasing departments that the device will help sell the car. This is usually a very tough job and it is easy for the Safety Engineer to become somewhat disgruntled. It is to their credit and that of the industry that many safety items, as previously mentioned, have been added to the automobile year after year.

Fortunately now we are in a period of great public awareness and emphasis on safety and safety items. Therefore they are much easier to sell both internally and to the public. Such items as safety door locks, safety steering wheels, crash padding, and seat belts have found a relatively wide acceptance (Ref.17). Dr. Moore of the Cornell University Medical College reports that "safety door locks have reduced crash door openings up to 60 percent, crushing injuries to the chest were halved by safety steering wheels, crash padding proved successful and seat belts were effective in reducing injuries by 60 percent." (Ref.17)

The Ford Motor Company

At Ford we talked to Mr. R. H. Fredericks and Mr. W. J. Ruby of the Engineering Staff, Ford Engineering Research Department. They outlined their crash injury program to us and explained that they were only working to prevent injuries when an accident happened. They felt that this was the important approach for them since there would always be accidents. They were working on safety belts, window glass, rear-view mirrors, padded visors, etc. We questioned them about window glass since at the American Medical Association Convention, Dr. Dupont Guerry of the Medical College of Virginia had recently described the wrap-around windshield as a "hazard of the first magnitude and one that cries out for correction". He said that it violated "all basic optical principles" by creating distortion and glare (Ref.18). These Ford people felt that although there is some distortion on the sides the driver did not look through that part very much and it was better than having a blind spot there. We also discussed tinted windshields and the complaints such as those of H. R. Blackwell and Haber (Refs. 8 and 32) that they seriously reduce visual detection capability. Mr. Ruby said that they had proof that for Ford's tinted glass the opposite was true; that one could see better with it than plain glass. He promised to send us some material on it but as yet we have not received it.

This group at Ford was carrying out experimental crash injury studies with the aid of instrumented anthropomorphic dummies. They drive one car into another or into a wall and measure the effects on the dummies (Refs. 19 and 20). In connection with these studies, Wayne University is conducting a Human Force Tolerance Study which is designed to find out just what in the way of deceleration and impact the human body can stand. They are also cooperating with Lt. Colonel J. P. Stapp (Ref. 21) of the United States Air Force and with the Crash Injury Research Group of the Cornell University Medical School.

The Chrysler Corporation

At Chrysler we talked with Mr. Roy Haeusler, their Automotive Safety Engineer. He was very cooperative and was willing to discuss their safety program in detail. They have a realistic and active safety program and are interested in all aspects of automotive safety. This program is well discussed in several talks of Mr. Haeusler's (Refs. 22, 23 and 24) which emphasize their eight point automotive safety policy.

(Chrysler continued)

" (1) To give prime attention to the safety factor in all Chrysler Corporation automotive design, development and production and thus to provide the highest degree of transportation safety possible, consistent with the manner of usage of our vehicles by the driving public.

This means giving adequate attention not only to such special safety features as safety belts and instrument panel pads, but also to all other components of the vehicle, all the way from the tires to the roof. We are concerned with such matters as the location of transmission controls. Our new push button controls have been located to the left of the steering wheel in order to insure freedom from interference by other occupants of the car, particularly children. We are concerned with greater vehicle responsiveness and so we provide additional power -- not in order to increase top speed as some people think, but in order to increase vehicle acceleration, in the interests of safety, particularly in the 30 to 70 mile an hour range. We are equally concerned with the ability to decelerate the vehicle, and consequently are continually and intensively at work providing further improvements in brakes. The new center plane brake introduced in the Chrysler Corporation Imperial, Chrysler, and DeSoto cars in 1956 represents an important step forward in braking ability and in brake endurance. Thus the Automotive Safety Engineer is concerned with the entire car and with all its components, not just with a few safety accessories.

(Chrysler continued)

"(2) To provide all practical safety features that appear likely to reduce the driver's probability of having an accident and also to provide all such features as are likely to reduce the severity of injury should an accident occur. By practical safety features we mean those that are likely to be accepted, used and appreciated by the driving and riding public.

When we speak of practical safety features we also imply that the increase in safety must be a net increase. In other words, an inconvenience or added complexity must be appreciable outweighed by added safety. More specifically, we must be reasonably sure that the items proposed as safety features do not add new major hazards which outweigh any possible gain in safety. For example, governors such as might be used to limit our speed might actually be a new source of danger since they would interfere with a vehicle's responsiveness at a time when it might be very urgently needed. The type of restraint sometimes called a "crash bar" is another example of a type of device that could introduce new and serious hazards. This is a suitably padded bar that would be positioned in front of the passenger to restrain him from forward movement in case of crash or other sudden stops. Col. John Paul Stapp of the U. S. Air Force and others have shown through their researches on human tolerance to deceleration that it is extremely important that the restraint be applied across the

(Chrysler continued)

"proper areas of the body and in the proper direction if the restraint itself is not to produce serious injuries of its own. These requirements are difficult if not impossible to meet with a bar type of restraint."

(In discussing this Mr. Haeusler pointed out that industry must consider the aspect of selling the car along with the advantage of the safety device. As an example he pointed out that if hood ornaments were proved a safety hazard, Chrysler could not just discontinue them and hope to sell their cars. Everything in the safety problem must also be considered from a "consumer interest" point of view. He said if other manufacturers would drop the use of dangerous ornaments Chrysler would also.)

"(3) To provide additional safety features as soon as they can be properly developed and prepared for production. Safety is too important to wait for model changes.

An illustration of this policy in action is the Chrysler Corporation's introduction of seat belts in all our cars in the middle of the 1955 model year. Our announcement in April of last year revealed that we were offering seat belts for all five of the cars in our line, the Plymouth, Dodge, DeSoto, Chrysler and Imperial, and for all of the passengers for which the vehicle was designed. Similar action was taken with regard to another important safety feature, the new Life Guard Safety Door Lock. This lock, intended to keep car doors

(Chrysler continued)

"closed in spite of collision or roll-over forces in any but the most extreme accidents, was introduced into production and first appeared on our cars during the 1955 model year. These locks are now standard on all five of our cars and in all models of these cars.

"(4) To work closely with the medical profession, with traffic enforcement and motor vehicle administration personnel, with insurance company officials, with legislators, and with educational and research groups, in order to get maximum benefit from free interchange of experiences and information.

This means specifically, participating in meetings of the medical associations and other doctors' and surgeons' societies. It means attending meetings of the American Association of Motor Vehicle Administrators and their committees on engineering and inspection. It means entering into informal discussions with insurance company executives, particularly to discuss public information and educational programs. It means studying the various legislative proposals appearing currently in many state and provincial legislatures. It means attending legislative committee hearings and providing comment and explanation at the professional level, especially regarding engineering and production problems that may be engendered by the proposed legislation and the cost penalty with which the ultimate consumer may be faced if such a cost penalty is involved. Many opportunities arise for providing clear and specific illustrative material such as can be made

(Chrysler continued)

"available because of investigations and of tests run by the Chrysler Corporation in connection with the subject of the legislation, whether the subject be exhaust systems, safety belts, headlights, or whatever.

"(5) To give careful, sympathetic, and respectful consideration to all safety suggestions.

We receive a great many suggestions of all kinds from the driving public generally and from members of specially interested professional groups such as safety engineers and from doctors and surgeons. Many of these involve complicated mechanisms of highly questionable practical value to say nothing of the prohibitive cost which would attend their production. There are those who tell us the engine must be in the rear of the car and others who assure us that such a car cannot possibly be as safe as the design we now call conventional. Many of these suggestions appear over and over again, sometimes in slightly different form, sometimes in virtually the same form as before. Each such suggestion is dealt with in a careful and considerate manner but only after a prescribed understanding has been reached between the Corporation and the person making the suggestion."

(It is obvious that the many ridiculous suggestions received by the automotive manufacturers sometimes cause the people working on them to be a little bitter. Mr. Haeusler is much more charitable in this respect than was Mr. P. C. Ackerman, director of engineering for

(Chrysler continued)

Chrysler in his remarks following Dr. MacFarland's paper (Ref. 2) at the 1956 SAE Meeting:

"But we cannot design automobiles that will make up for all the ineptness, carelessness, or selfishness of which human beings are capable. .... I say this mindful of the lay suggestions that continue to arise from people, often competent in other fields, which suggest an incredible lack of information about the technology and economics of automobile design and manufacture." (Ref. 25).)

"(6) To exchange safety information with other automobile and parts manufacturers in order that all vehicles may benefit.

This exchange of information occurs through the committees of the Society of Automotive Engineers, the Canadian Automobile Chamber of Commerce and other organizations and is also carried on directly. At the present time, for example, the Chrysler Corporation is preparing to distribute through these channels a report of its extensive developmental work on automotive seat belts. This is being done in recognition of the fact that a detailing of the many designs developed and tested may indeed be of help to others working in the same field.

"(7) To provide the widest possible circulation of safety information that will aid in the establishment of good driving practices and good maintenance practices.

In pursuance of this policy, we have produced such booklets as

(Chrysler continued)

"'Good Driving Practices'. Another manner in which this portion of our policy has been put into effect is represented by our support of the May Highway Safety Check Program, sponsored by the Canadian Committee for Highway Safety, the Maclean-Hunter Publishing Company and by the Canadian Highway Safety Conference. This program recognizes the importance of periodic motor vehicle inspection in order to minimize the likelihood that lack of adequate vehicle maintenance will contribute to the threat of accident and injury. Some governmental jurisdictions now require such periodic motor vehicle inspection by law. The May Highway Safety Check Program places special emphasis on the vital necessity of getting the active cooperation of the car owner. Without such active cooperation based on a sympathetic understanding of the safety risks involved, any such periodic motor vehicle inspection program will be of much less benefit.

"(8) To provide aid and support for independent safety research programs such as the Cornell University Medical College Automotive Crash Injury Research Project, and the various projects of the Automotive Safety Foundation, such as those concerned with road planning and building, the further training of enforcement officers and the expansion of facilities for training the driver training instructors. Such support of related automotive safety programs simply represents recognition of the fact that these programs must be all carried on simultaneously if we are to make a maximum effort to reduce the highway

(Chrysler continued)

traffic toll."

In discussing possible safety items we mentioned an energy absorbing bumper, rear facing seats, and radar brakes. Mr. Haeusler felt that the problem of styling, if the bumper were to absorb sufficient energy to be useful, would be tremendous and that the public would not accept the rear facing seats. He had watched a demonstration of radar brakes which were of the "on-or-off" type and thought that they needed much more work before they would be feasible. Regarding the tinted windshield, he felt that the comfort aspect of non-glare might override the reduced night visibility. At least until it has been proven statistically that more accidents occur at night involving tinted windshields than clear ones, he was sure the public would demand the tinted ones. This is a problem where the Cornell work will be very useful.

Mr. Haeusler also mentioned that Dr. Harold Elliott at McGill University Veterans' Hospital in Montreal Canada is organizing a program similar to the Cornell Crash Injury Research Program but on a considerably larger scale. Dr. Elliott plans to cover all of Canada with his program.

General Motors Corporation

A meeting was held at the General Motors Technical Center on 14 June 1956 between Mr. Howard K. Gandelot, Safety Engineer of General Motors and the authors of this report. They discussed the safety features of the modern car. The authors of this report were given the impression that GM feels the modern American car is just about as safe as it can be made. It is up to the driver to learn how to avoid accidents. The automotive manufacturers feel they cannot add safety features to their automobiles until the public is ready to accept them. Mr. Gandelot says the public may criticize the way the modern car is built such as the thinness of the metal but this in itself according to GM acts as an energy absorber in the event of a collision. The viewpoint of the automobile manufacturers is not to avoid a collision but to avoid as much as possible hurting the driver. They are not concerned with saving the automobile.

Gandelot would prefer that universities stay out of the automobile accident field. He suggested we work on accidents which occur in the home. He showed us graphs to prove the home accident problem is more important.

This brief review of the safety programs of the automobile manufacturers and the review in the previous section of the work of civic, governmental, and research groups has shown that a large amount of effort in going into automotive safety work. This work is primarily on driver education and training, human variables and their relations to driving, crash injury research, accident causes, etc. There is very little indication that much thought is being given to additional sensory devises which could extend the drivers sources of information beyond his own senses. If the driver is to adequately cope with the "danger situation" in today's complex and tomorrow's more complex driving conditions some such device is urgently needed.

V SUGGESTED ITEMS AND DIRECTIONS FOR AUTOMOTIVE SAFETY RESEARCH

In collecting the material for this report we have accumulated a number of criticisms of and suggestions for improving automotive safety. Some may be the same suggestions as those screened and rejected by Mr. Haeusler's people. This may merely mean that a need exists but that the specific solution offered was considered not realistic by the automotive people. This list is given here only as an indication of areas in which more research is needed.

A. The Prevention of Accidents

Aerodynamic Design* - The wind influence on our present cars is quite pronounced due to their design. This might account in some cases for side-swiping accidents that seem to occur for no reason. Anyone who drives, notices on a windy day how the car will swerve with each gust of wind. If you have had a truck pass you at a high speed (60 - 70 mph) you have notices that your car appears to be pulled toward the truck. This cannot be entirely prevented but there certainly is room for improvement in the aerodynamic design of the car.

Brakes - There has been much discussion on the subject of radar brakes. Tests have been given by automobile corporations. They do work but on the "on and off" principle. If you were on an expressway and wanted to begin crossing over to the exit lane on your right, you would not want the radar brakes to begin braking just because there was a

*Reference 26 contains a very lengthy discussion of what is wrong with the automobile based on the results of many accident investigations. Numerous suggestions are made for improvement and these are listed in this section.

car ahead of you as you crossed over, otherwise you could be hit by the cars behind you.

The suggestion has also been made that the brakes should somehow be tied into the transmission in such a manner that they would brake slowly on snow or ice without allowing a skid.

Wheels (Ref. 26) - Some wheel designers have made provision for five bolts to hold the wheel on the drum and also three additional holes to position the wheel on the drum before the bolts are tightened. All these holes leave little strength in the remaining metal in the small center portion of the wheel. Under fast turns and other extreme conditions this type wheel has been known to leave the car completely with the small metal circle torn completely out.

Another problem is that the lugs are often placed with left-threaded lugs on a right wheel and right-threaded lugs on a left wheel. There is a tendency of bolt creep in some cases and when the creep is sufficient the bolt shears from the drum.

Windshields (Ref. 26) - This is one of the most lethal parts of the automobile. It is also a great problem for the engineers. If they attempt to make it more shatter proof, it tends to become opaque.

Recently there has been a great deal of criticism on the wrap-around windshields. Eye specialists and doctors state that the distortion in the corners of the glass causes serious fatigue, increased glare, double vision from images resulting from reflections exaggerated by the acute curvature. (Ref. 18)

Engineers have stated in answer to this that it might be better to see a distorted image of a pedestrian or automobile than no image at all. They admit there is distortion in the corners and edges but the over-all center of the glass is free of such defects.

Windshield Wipers (Ref. 26) - Automatic windshield wipers have a hypnotic effect on the driver. The steady metronome sweep can lull the driver into a state of semi-consciousness. Why not have them built with a varying cam.

Ventilating Systems (Ref. 26) - At present the air intake of the ventilating system is low in front. In traffic, this does nothing but bring in the carbon monoxide from the car in front of you. This design was all right in the days of the open highway.

Headlights (Ref. 26) - The lighting problem in the car and on the highway is one of the greatest problems in the Automobile Safety Field. The headlamps introduced in 1955 provide a higher intensity low-beam illumination pattern on the road but the problem of glare to oncoming motorists is still great and stray illumination in snow, rain and fog needs more research. It has been suggested by Professor H. R. Blackwell of The University of Michigan that lights be placed low and the beams directed to the right of the road. This would illuminate the portion of the road that is often unseen and also eliminate the great amounts of stray illumination dispersed in the fog, etc. He also suggested the idea of a "cyclops" yellow flashing light in the middle of the grill of an automobile to indicate that the car is passing. This idea would seem feasible in the light of passing accidents that occur on our three-lane highways.

Another suggestion on lighting is to use polarized light in the headlights. This would be expected to do much toward reducing glare and giving better visibility in fog, rain, snow, etc.

Automobile Finish - Minnesota-Mining has developed a spray finish to apply after polishing your car. It gives a luminous quality to the automobile. This enables drivers to see the other cars much easier at night. Perhaps this idea could be adopted by automobile manufacturers and applied with the paint at the factory to form a permanent luminescence to certain parts or all of the automobile.

Tail Lights - These should be larger (that is, emit more light) and emit light at variable intensity to enable drivers of other cars to see them in conditions of reduced visibility.

Speed - A Safe Speed Signal is now being distributed by the All-American Sales Company of Leonia, New Jersey. This connects into the speedemeter cable and attaches to the dashboard. It can be set to any desired speed. Whenever this speed is exceeded a buzzer sounds. It is quickly adjustable for varying speeds. It sells at $14.98. (Ref. 27)

Chicago has started a push-button control for changing speed limits on its super-highways, and expressways (Ref. 28). It has just been announced (Ref. 29) that Detroit is planning to set up an eight-mile test of the use of television for traffic control on the John Lodge and Edsel Ford expressway. This would consist of 33 cameras mounted in towers on bridges over the expressways with an average distance of 1500 feet between cameras. The cameras would be operated by remote control from a monitor room and would also be tied into a system of signs and signals operated from this room.

Electronic Guidance and Control - General Motors, RCA (Ref. 28), and De Hart (Ref. 30) have suggested similar ideas for controlling the car on a high speed expressway. This involves a conductor strip or a series of conducting or magnetic slugs buried in the concrete and an electronic computer of some sort in the automobile which would pick up impulses from these and use the information to control speed, turns, stops, etc. DeHart describes this as:

"Small slugs of a magnetic material (not necessarily permanent magnets) buried in the center of each lane (halfway between the wheel tracks made by an auto) can be made to induce pulses of voltage in a pickup coil. One pulse will be obtained for each slug. Absence of these pulses or substantially reduced amplitude when the auto has deviated from the center of the lane can be utilized to produce a warning to the driver.

"The pulse repetition rate is a function of the auto velocity and the spacing of the magnetic slugs. This dependence could be used in the following manner: Suppose that the local road speed limit is fixed and transmitted as an audio frequency, f, to the auto in some manner, and is compared with the pulse repetition rate, p, due to the magnetic slugs. A warning to the driver will occur when p is greater than f. Since p is controlled by the magnetic slug spacing as well as the auto velocity, the operating speed limit along the road can be varied (by variable slug spacing) in accordance with curves and other fixed road hazards."

Electronic Traffic Control is being studied and tried in several places (Ref. 28). Philadelphia presently has the largest set-up and several other large cities including Chicago, Los Angeles, Vallejo, New Orleans, and Baltimore are working on similar systems. These operate from a system of traffic counters which feed traffic flow data to a central control. A "cycle selector" then controls the lights in accordance with density, direction, and speed of traffic. This "volume density control" system was developed by the Automatic Signal Division of Eastern Industries and is now also produced by General Electric, Eagle Signal Corporation and Crouse-Hinds, Incorporated. (Ref 33)

Relative Position Warning - (Ref. 30) - "For a danger situation involving the auto ahead, knowledge of the range (and probably its derivative) to that auto in addition to the speed of the trailing auto is required for implementation of a warning device. The range, range rate, and road speed must be correlated and a warning sounded if (a) the range is too small, or (b) the closing velocity is too great. The threshold for warning probably would be determined by road speed, and road conditions and is certainly a function of the stopping distance for the hindmost auto.

"The basic problem in implementing this device is connected with measuring range to the auto ahead. Several possibilities immediately come to mind:

"a. measure the angle between two fixed points a known distance apart on the auto ahead. These two points might be active or passive radiators but must be standardized on all autos and available for use at all times. The measurement device may be optical in nature.

b. an optical range finder could be used on a single point on the auto ahead.

c. an acoustic radar could be used. Such a device could produce the range information in a readily usable form for the range, range rate, speed correlating device.

d. some sort of "block signal" type of system built into or beside the road could be used. This device would have to be sensitive to the separation between autos and capable of transmitting range information to the auto concerned."

A possible example of the type of system suggested in (d) above might be the "radar lamp post" idea. This would consist of small radar transmitters placed on the top of posts alongside of the road with a receiving set in each automobile. A row of corner reflectors would be embedded in the center of the road and also placed along each side of the road. These reflectors would be constructed so that energy from the "lamp post" would be reflected across the road where it would be picked up by the receiver in the car. Operating on a doppler principle, the receiver would not show any signal while the car was stationary but would show signals when the car started moving. The strength of the signal from the center strip or the roadside reflectors would be determined by the position of the automobile between them. The frequency of the signals from these reflectors would be a function of the reflector spacing and the automobiles speed. Another automobile in the same lane would give a signal only if going faster or slower than a radar equipped car. Meeting a car in the opposite lane would give a very large signal. Thus with regularly spaced reflectors, vehicle speed and location of the car could be shown at all times along with the relative speeds of near by vehicles.

Medical Reports - It has been suggested that doctors should be required to report to the Traffic Bureau all medical treatments given which might affect the driver's ability to drive. Doctors must report bullet and gun shot wounds. Why not make them report medical "situations" which cause the driver to be a potential killer. Traffic Bureaus could then decide when suspension of Operators' Licenses become mandatory.

Driver Fatigue - It has been our experience that in many cases drivers take long trips by automobile to save money and to have the convenience of a car at special sight-seeing places enroute. The drivers tend to spend too many hours on the road and usually go too fast in order to obtain the accommodations they expect at some distant Shangri La. (The fact that they are often disappointed is beside the point.) Despite the advertisements about flying and then renting a car, this usually cannot be done either because of cost or lack of airport facilities. Toll charges on turnpikes make them cost competitive with trains. The public accepts this and still drives.

Can one overcome the "long trip menace"? The answer to this is yes; as soon as either the railroads or the automobile carriers realize a market in the pick-up of cars with passengers at designated locations and leaving them off at other locations.

For example, such places could be at every 400-mile interval from Chicago to Yellowstone Park or Grand Canyon, etc. No one likes to drive to Yellowstone per se; they want to stop at key places along the way (Mount Rushmore, Badlands, Black Hills, etc). Those interested in speed and saving money would drive during the night and sleep aboard the auto carrier during the day. In this way they are moving around the clock. The carriers could make money just by charging each automobile six cents per mile which is what it would have cost to drive the distance, excluding the cost of the wear and tear on the driver.

<u>Rear View Mirrors</u> (Ref. 31) - "The present rear view mirror, whether inside the car or on the left front door frame, provides only a limited view of the area behind a car, leaving dangerous blind spots which can be observed only by turning the driver's head for a direct view (see Figure 2). As an alternative to the present small mirrors, the arrangement shown in Figure 3 is proposed. By mounting the mirror above the roof, a much larger size can be accommodated and the view is not obstructed by the frame of the car or by rear seat passengers.

Another possible use of mirrors would be to install a forward-looking periscope at approximately the same location as the mirror shown in Figure 3. This would give the driver a view of the road

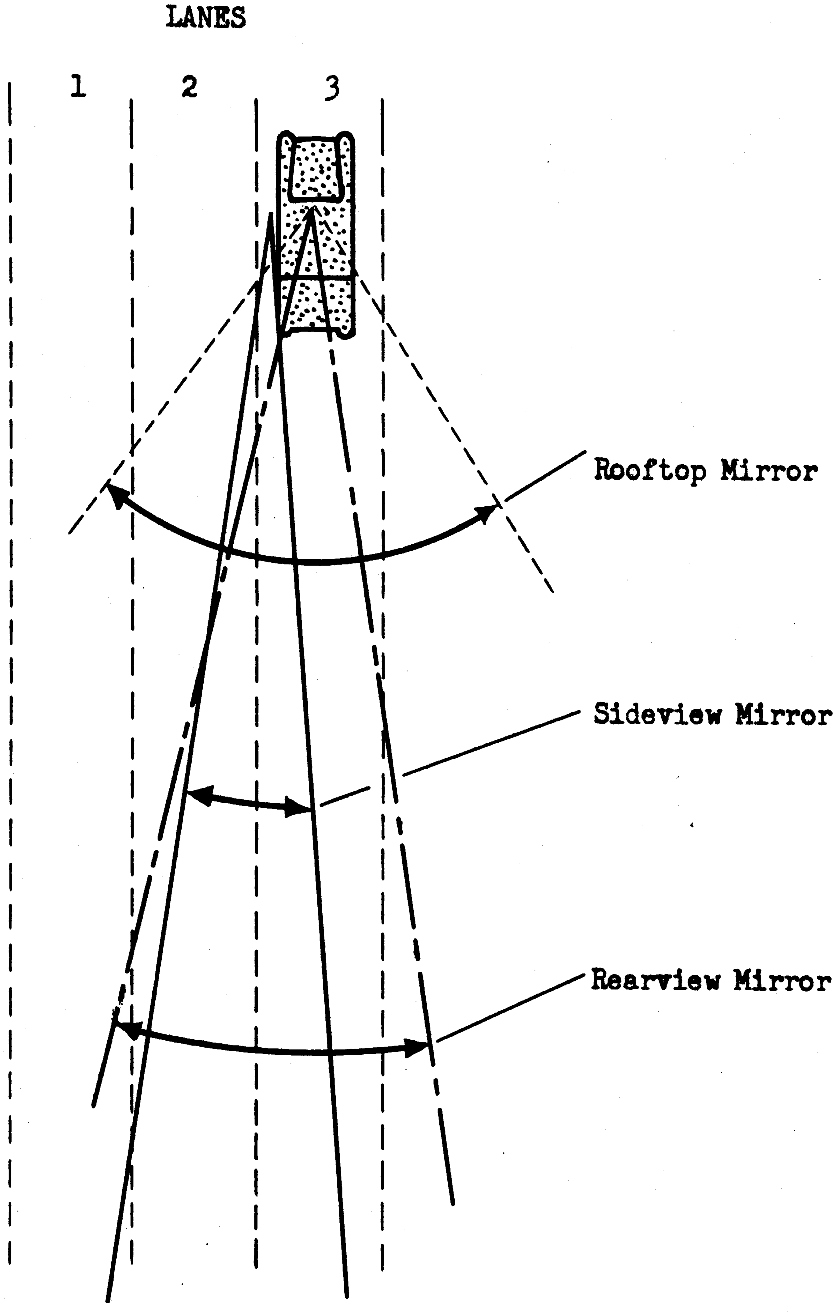


Figure 2 - Visual Angle of Present and Proposed Mirrors

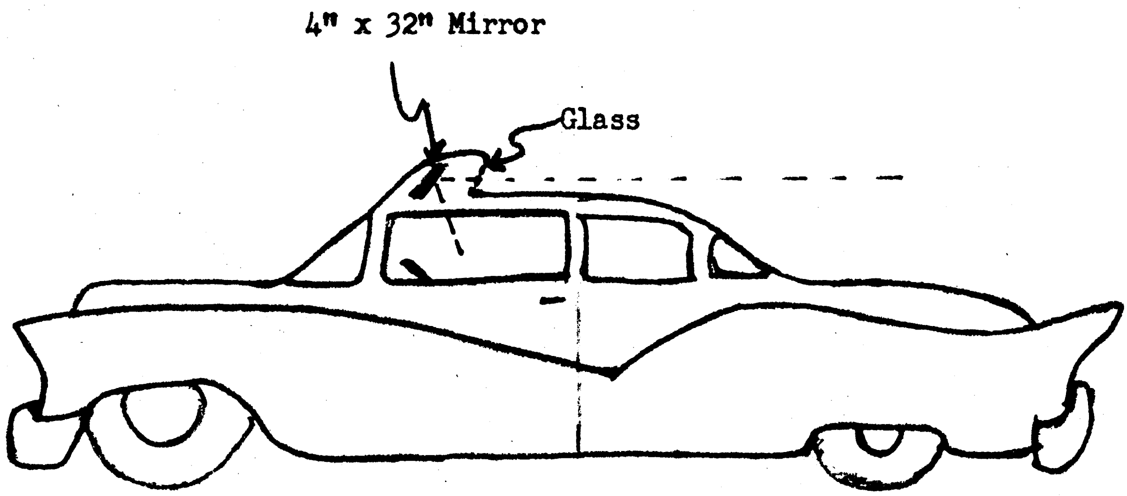


Figure 3 - Rooftop Rearview Mirror

ahead from an apparent height of about 5 or 6 feet and would allow him to see over the top of the car ahead so that he would have a better knowledge of road conditions ahead."

Simulation Techniques in Driver Training (Ref. 31) - "A review of accident statistics indicates that in a large percentage of the cases, accidents are due to a failure of the driver to react quickly, to obey the traffic laws, or to exercise good judgment. Any means of bringing forcefully to the attention of large numbers of drivers their most common failings should be a valuable contribution to safety. It is therefore proposed that automobile simulators be provided for this purpose. These would perform the same function in driver training that aircraft simulators do in flight crew training.

"It is not intended here to give a detailed statement of how such a simulator should be designed but merely to indicate the primary features of the design. To provide the most effective training device, the greatest possible realism is desirable. The driver should have available to him all the controls normally at his disposal in a car and they should have the same feel as they would have in a car, especially the steering wheel. He should have displayed to him a view as nearly as possible like that which he would see through his windshield, side windows, and rear view mirror. The techniques used in Cinerama indicate how realistic this view can be made. Realistic traffic sounds should also be included. Furthermore, his actions should feed back into the simulator system. The application of the brakes should affect his apparent forward speed, and the operation of the steering wheel should modify his position on the road. This feedback can be performed by well-established analog computer techniques.

"The training process would consist of throwing at the driver a variety of dangerous and unexpected situations, for example, operation over slippery roads, cross winds, tire blowout, sudden stop of the car ahead, jaywalkers, and night driving. The value of good driving habits would be emphasized and comparative driving ability of different individuals could be determined."

Other Highway Design Suggestions

1. Reflector buttons could be installed down the center and to the right of the highway. Low-slung headlights could pick these up as guide lines. They could have a different color, say from yellow to red whenever the driver is approaching an intersection or a hill.
2. One highway in existence in New Jersey has a special concrete about a foot wide along the edge of the highway, when one or more tires of a car are on this concrete the tires squeal as if one were turning a sharp corner. This squeal is an audible warning to the driver that he is too near the edge of the roadway.

   This highway also has this concrete strip as a centerline dividing traffic going in opposite directions.

3. Kansas and Ohio have a highway with bumps in the centerline. These bumps are approximately one to two inches high and about a foot wide and spaced several feet apart. It seems that this type of warning device might cause the driver to lose control of his automobile.

4. Design highways with separate lanes for different minimum speeds. Constant communication by radiophone with control towers at set intervals on this highway would give the driver adequate weather and road conditions and would also enable him to inform the control towers when he is in need of service.

5. With the present highway system why not insist that all four-lane highways have the outer lanes for passing. This would cause less "out-of-control" cars to have head-on collisions. This would require a lot of re-education of drivers but the results might be worth the effort.

B. Prevention of Injury

The Automobile Frame (Ref. 26) - Wider bodies have weakened the upper portion of the body and the roof supporting framework. This often provides insufficient protection in cases of roll-over accidents. Although better vision has been afforded by wider windows and smaller posts, it would seem that a stronger car frame without weight increase could be built. Stock car racers have been aware of this lack of strength in cars and have had reinforcing bars installed in their automobiles. In addition to this they have the seats re-anchored and safety belts and harnesses installed. We realize the reinforcing bars installed in these racers are not an attractive device. However, manufacturers have managed to make the seat belts look as if they were part of the car - why not the bars. They could possibly be built right into the frame.

New body design has eliminated what was unknowingly a safety device in the older cars. This was the running board. This may have been an eye-sore but it proved to be an excellent energy absorbing device in the event of diagonal collisions. It should be possible to add a bordering design or side bumper built into the vehicle to accomplish the same results as the old running board.

Rear Window Ledge - There should be some means whereby the automobile designers could do away with the rear window ledge. It is only filled with articles which are harmless in themselves but under impact these same articles may become deadly missiles.

Glove Compartments - Glove compartment doors that open downward are extremely dangerous. These pop open under impact and offer a sharp edge to the passenger in the right front seat.

Seat Belts - There has been some question lately of the safety of the seat belt. There has been a whip-lash effect from some of the collision tests at General Motors that has broken the neck of the anthropormorphic dummies.

Padded Visors and Dashboards - The use of foam rubber to pad the visor and dashboard to give safety to the occupants is of little value. There is no appreciable energy absorbing quality to foam rubber. Tests have shown that the use of plastics is a decided improvement. However, until this is standard equipment on a car, people will often buy the car without the added safety devices in order to save a few dollars.

Hood Ornaments - This is a good example of the "consumer interest" problem. It is a known fact that one car manufacturer (Nash) offered its 1955 models without a hood ornament. (Hood ornaments have been known to impale pedestrians.) Customers buying this '55 model had hood ornaments installed themselves after buying the car.

VI CONCLUSIONS AND RECOMMENDATIONS

The first conclusion we have reached is that there are an extremely large number of people who are attempting to do good associated with the automobile safety problem. These people are primarily spending their time on educating the public on what can happen if they do bad, eg. Holiday Q is a high accident holiday so be careful. Month J was a death month, last year, W people died. The public gets barraged with this information from newspapers, radio, and television.

While these programs are all helpful it seems clear that some of the money and effort going into them could better be used to set up an enforced program of driving simulation tests as a part of driver training and re-training. Yearly tests in a driving simulator (pg. 48) where numerous danger and accident situations were presented to the driver with appropriate vehicle movements and background pictures and sounds should be a great help to all drivers. At the same time the driver is taking his test his car could also be given a thorough check.

Our second conclusion is that although a fringe number of people are working for high profit items and spectacular break throughs on low capital investments there seems to be no noticable effort by capital research organizations to really develop sensory devices for the highway-vehicle-driver combination. One large group is interested in the physical conditions associated with the accident (ie) the weather, straightness of the road, the speed, the mechanical efficiency of the car, etc. Other groups are interested in the people involved in accidents, their injuries, their mental state, etc. It is clear that research on sensory devices is needed today and that such sensory devices will play a role in the car and highway of the future.

We recommend that to help overcome the gap in the present programs involving vehicle-driver-road safety a request be made to the National Science Foundation for $250,000 a year for 5 years to investigate sensory devices and their applications to the automobile. We began this thinking in a proposal for the Radiation Laboratory.(Ref. 34) That request, however, is too restricted for the 5 year program as the 5 year program should include studies in radar, infrared, and ultraviolet means of radiation and reflection. Warning devices should be analyzed and built in terms of the automobile and driver. These devices would probably be accoustical and associated with this study should be a thorough systems approach to making the complex relationships between car, weather, road, and driver a workable team effort. Considerable study must also be made on the component problem so that these will become appetizing to the salesman, artistic to the housewife, and realizable to the automotive engineer. Analysis must be made from the government's point of view to determine desirability of suitable transmitters (lamp posts) being bought by the federal, state and city governments for the type radiation chosen to be most suitable. This is considered an augumentation of and not a replacement of the automobile type transmitters and reflectors which presently are used to govern the visible spectrum. Possible sensory devices could be discussed in detail in a separate report but probably we should obtain financing before this report is completed. We now know there is room and a definite need for the abilities which the

Engineering Research Institute possesses in the automobile safety field and if conditions are right we recommend the submission of an immediate program through the National Science Foundation.

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