HIGHWAY RESEARCH BOARD

Bulletin 142

Accident Analysis and Impact Studies

National Academy of Sciences—

National Research Council

publication 434

HIGHWAY RESEARCH BOARD
Bulletin 142

Accident Analysis and Impact Studies

PRESENTED AT THE
Thirty-Fifth Annual Meeting
January 17–20, 1956

1956

Washington, D. C.

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Automotive Collision Impact Phenomena

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A discussion of what happens to occupants of an automobile during a collision is presented on the basis of findings from a series of controlled car crashes. In order to cover a broader range as well as provide maximum severity of load to components undergoing test, cars were impacted into a barrier in addition to the car-to-car crashes. Items such as deceleration of passenger compartment, seat belt loads, occupant decelerations, etc., are reported graphically as they vary with impact velocity.

THE words "automobile collision" are used repeatedly to describe how approximately 100 people in this country become statistics, and how another 6,000 receive injuries every day. The time, during which the decelerations and forces generated in a collision are of sufficient magnitude to cause a fatality, is very short. In fact, the total time consumed in a whole day involves less than thirty seconds to produce all these fatalities, and only about thirty minutes to inflict this multitude of injuries. It is with these seconds and minutes of impact that the authors have been concerned during the past year, and upon which they would like to shed some light in this paper.

The desire to decrease the injury-producing potential of the present day automobile introduced numerous specific questions and problems. Answers could not be supplied from available data and a study project was initiated in the Ford Motor Company Engineering Research Department to explore and analyze impact phenomena.

Normally, the research engineer can simulate in the laboratory the conditions imposed on a particular system under investigation and with little difficulty eliminate or isolate the effects of selected parameters. The foregoing statement holds true, however, only when considerable information concerning the system is available and its reduction and subsequent analysis can be undertaken without violating the general characteristics of the system. After detailed consideration of possible laboratory collision simulators, it became apparent that the information necessary to design a simulator, largely embraced all the information that ultimately would be gained by its use. Design factors, such as deformations, decelerations, stopping distance and time, could be determined only by staging full-scale collisions.

Since it was impossible to simulate the infinite number of possible accident situations and conditions, two general categories of controlled collisions were studied, car-to-car and barrier. The car-to-car type was selected because it accounts for the largest percentage of injuries. The barrier collision was used to establish the maximum deceleration and force conditions for any given impact velocity.

The purpose of these full-scale crash tests is to study the kinematics of passengers, determine the forces and decelerations acting on both the vehicle and the passengers, and to evaluate various safety features incorporated into the vehicle.

General Description

The full-scale crashes, so far conducted, have been accomplished by towing an instrumented test car toward a stationary car or barrier. The vehicle is towed at the desired velocity and released just before impact. A mobile instrumentation van is driven beside the test car, (Figures 1 and 2). Anthropomorphic dummies are variously positioned in the moving and stationary vehicles. Typical barrier and car-to-car impacts are demonstrated in Figures 3 and 4. Various 1952 through 1955 models of Ford, Mercury and Lincoln vehicles have been used in these tests.

The test car and the towing vehicle are displaced 11 ft laterally and 34 ft in the direction of motion. Towing in this manner is made possible by the use of a bridle on the towing cable (Figure 5) and setting the front wheels of the test car to a negative camber. The steering mechanism is centered by trial towing and then held in a neutral position with spring tension applied to the steering wheel. A quick release mechanism, Figure

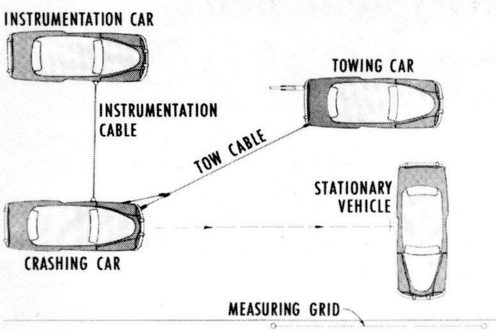

Figure 1. Schematic of vehicle arrangement for full scale crash tests.

6), is actuated manually from the towing vehicle. Table 1 charts towing distance as a function of velocity. These distances are for a Thunderbird, with automatic transmission, operating at full throttle while towing a 4,000 lb test car.

In car-to-car crashes, brakes are applied after impact to prevent vehicle runaway. The brake master cylinder is actuated pneumatically when a valve, mounted on the fender (Figure 5), is opened by a lanyard attached to the towing vehicle.

The 18 ft wide barrier, (Figures 7 and 8), is constructed to 2-ft diameter green logs 12 ft long which are embedded vertically 6 ft in the ground. A ½-in. steel cable ties the logs together near the top, and a 6-in. slab of concrete binds them just below the surface. The logs are backed by a sand pile retained by planking. The front face of the barrier is provided with replaceable oak boards supported in the log crevices with concrete fill.

Four anthropomorphic test dummies have been used in these tests. These dummies

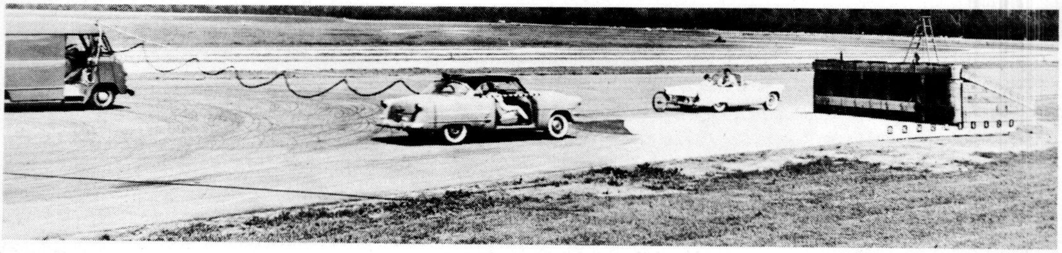

Figure 2. Moving toward barrier.

were fabricated to Air Force specifications and, as purchased, are 6 ft tall and weigh approximately 200 lb. The articulation and weight distribution simulates that of a human being. Representative dummies are shown in Figures 9 and 10. The name FERD is an abbreviation for Ford Engineering Research Department. Table 2 gives the measured weight and size of these test dummies. It will be noted that FERD No. 1 has been modified to provide a size range for test purposes.

Instrumentation

Electronic instrumentation is the primary data source utilized in these full-scale crash tests. To augment this electronically recorded information, additional data is obtained from high-speed, motion picture photography and various mechanical measurements, such as, chassis point-to-point measurements before and after each test.

A multichannel recording oscillograph receives suitably amplified signals generated by accelerometers or other transducers which are mounted in the impacting car or test

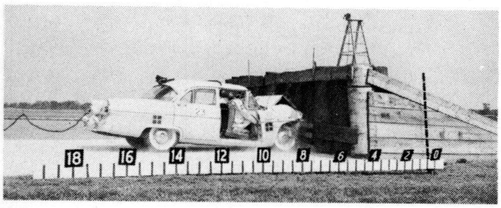

Figure 3. Barrier impact.

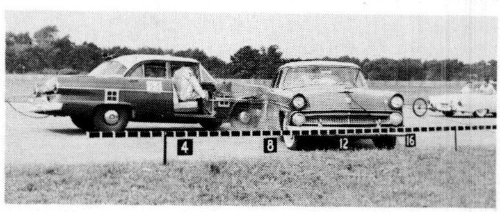

Figure 4. Car-to-car impact.

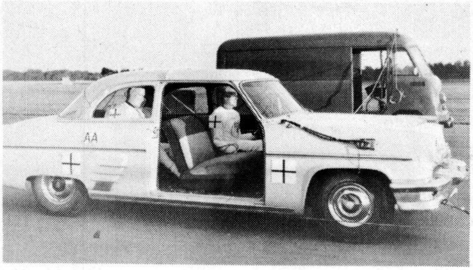

Figure 5. Towing bridle and brake operating valve.

Figure 6. Towing-cable release mechanism.

TABLE 1

APPROXIMATE TOWING DISTANCES FOR VARIOUS IMPACT VELOCITIES

Impact Velocity mph	Towing Distance feet
10	22
20	100
25	150
30	220
35	340
45	615

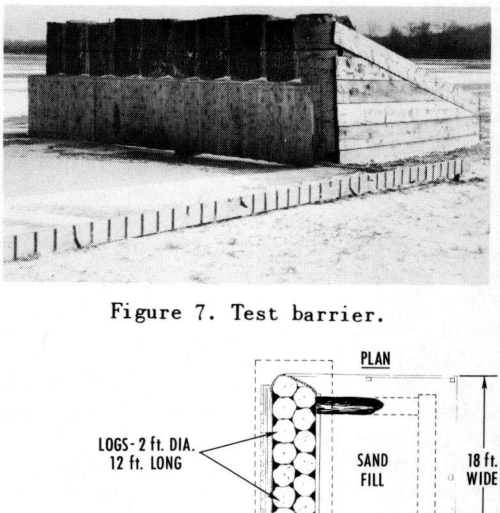

Figure 7. Test barrier.

TABLE 2

ANTHROPOMORPHIC TEST DUMMY PHYSICAL DATA

Dummy No.	Weight lb	Height ft-in.	Seating Ht in.
FERD No. 1	180	5-9½	36½
FERD No. 2	194	6-0	40
FERD No. 3	217	6-0	37½
FERD No. 4	194	6-0	38½

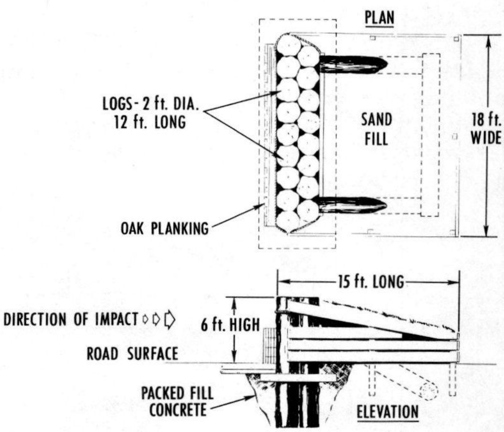

Figure 8. Test barrier construction.

dummies. Except for the transducers, all of the electronic equipment is contained in a mobile instrumentation van, (Figure 11), which connects to the crashing vehicle with multiple circuit cables. Since it is difficult to maintain a fixed distance between the instrumentation van and the test car, the cables which are wrapped together are supported from an elastic line of shock cord, (Figure 2). This arrangement permits a variation of 100 percent in the distance between the vehicles without dragging the cables on the ground or detaching the quick disconnects.

A portable power supply, complete with voltage regulator, is towed behind the van. This provides the power to operate the electronic equipment. However, each channel has its own predetermined bias supplied to the bridge by dry-cell batteries. All channels are balanced and calibrated separately in anticipation of the magnitude expected for each function.

Figure 9. Anthropomorphic test dummies.

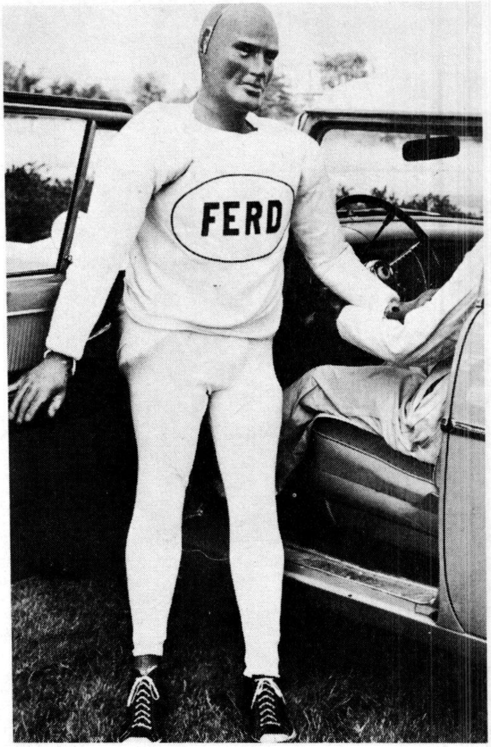

Figure 10. Anthropomorphic test dummies.

The normal photographic coverage for a test consists of two Fastax cameras which use black and white film and operate at 500 to 1,500 frames per second depending on the available light. Color film is taken at 128 and 24 frames per second, and one or more gunsight cameras, mounted on the moving car, take black and white exposures at 96 frames per second. In addition, still pictures are taken before, during and after impact. One or more doors are removed and holes are cut in the roof panel, (Figure 12), to provide adequate viewing and light conditions. Figure 12 also shows a typical mounting bracket for a gunsight camera. The locations of the Fastax cameras and a fixed reference scale are recorded to facilitate the analysis of the high-speed film. Targets, utilizing black on white, are placed on the body of the car and critical areas of the dummies so that displacement-time curves can be prepared.

Two typical transducers, an accelerometer mounted on a frame rail and a belt tensiometer, are shown in Figures 13 and 14 respectively. The exact time of various events is recorded on the oscillograph film record. For example, a bumper switch establishes the zero reference time. Additional time records also are obtained from aluminum foil contacts which cover critical impacting areas both of the car and dummy passengers.

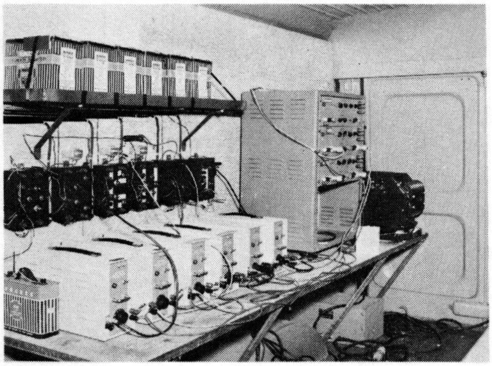

Figure 11. Mobile instrumentation van interior.

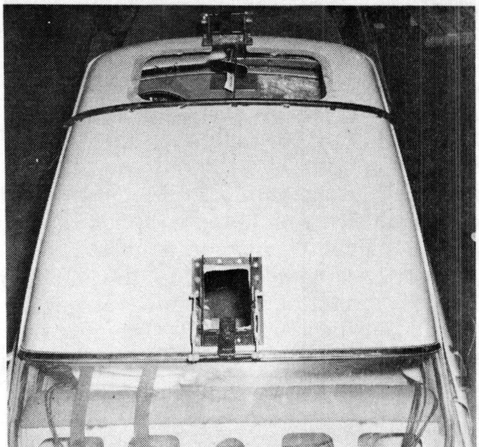

Figure 12. Roof area of test car.

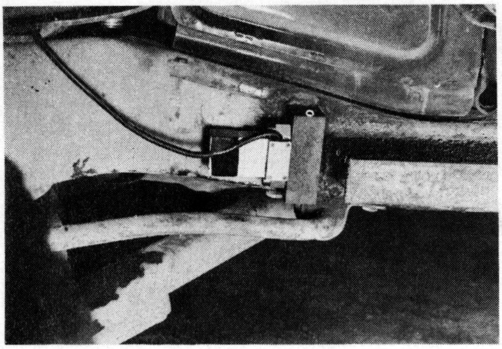

Figure 13. Accelerometer mounted on frame of test car.

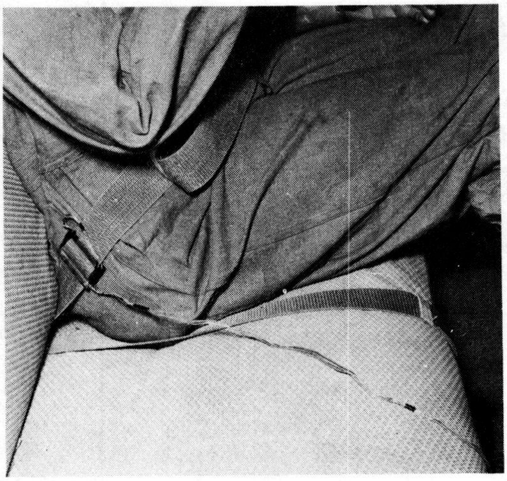

Figure 14. Belt tensiometer mounted on seat belt.

However, it must be realized that there are many variations possible in test conditions which cannot be completely controlled when staging full-scale collisions.

All the data in this paper, with the exception of the permanent deformation measurements, either have been taken directly from, or are a result of, the electronic recordings. Analysis of the high-speed motion pictures is a lengthy procedure for which reason it lags other phases of measurement and interpretation. It is believed that the corresponding measurements of functions by electronic and photographic techniques would not necessarily yield equivalent numerical results. As an example, visualize an accelerometer mounted to the floor structure and a target fastened to the outside of an automobile. The deceleration obtained from the transducer could peak very differently from

Test Results

The results so far obtained have been most encouraging. Of course, they represent only a beginning and a great deal of their worth has been towards the formulation of techniques and appreciation of the problems in this important aspect of automotive engineering. Although the results presented here are considered rather general, they appear fundamental to the understanding of the problem.

It is realized that there are many specific questions which are not considered in this paper, but time has not permitted a more complete study of the subject. As the program continues, specific conditions will be treated in greater detail. The information herein submitted is presented in anticipation that other investigators probably will disagree with certain aspects of the study.

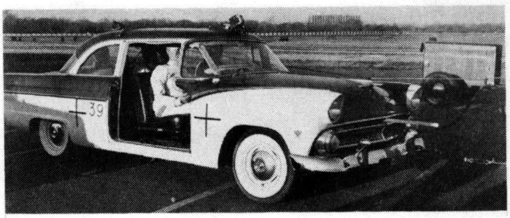

Figure 15. Crash 39 - Over-all view of test car.

Figure 16. Crash 39 - Close-up view of test car.

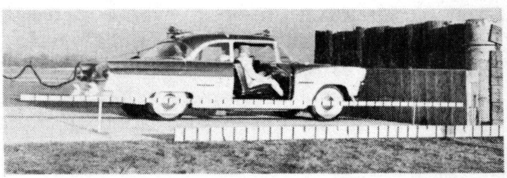

Figure 17. Crash 39 - Just before impact.

Figure 18. Crash 39 - Test dummy kinematics during impact.

that obtained by differentiating the displacement curve of the target as plotted from the high-speed movie film. The correlation of these two techniques would be an elaborate undertaking in itself.

In order to provide a more complete mental picture of automobile collision impact phenomena, a typical barrier test will be described in detail. The test car used was a 1955 Ford Tudor weighing 4,144 lb including four passenger dummies totaling 785 lb. The car was equipped with a 1956 instrument panel complete with pad, safety steering wheel, and padded sun visors. Both the driver and the right front passenger were restrained with lap belts. The left rear passenger was restrained with both a lap belt and an experimental shoulder harness which terminated at the lap belt. The right rear passenger was unrestrained. Mounted on the car were two gunsight cameras to record the movements of the dummies within the car during impact. In the barrier area, four cameras were stationed to film the impact. Two cameras were high-speed black and white and the other two were low-speed color. Attached to the front of the car was a velocity measuring device for accurate determination of the impact velocity. Strain gage type accelerometers were mounted on both right and left sides of the frame front and the floor pan of the passenger compartment to measure the decelerations. An accelerometer was placed in the stomach cavity of the driver and the head of the right front passenger to measure the decelerations at these points. The seat belts were equipped with strain gage transducers to measure the loads during impact. Sheets of thin aluminum foil were placed on the instrument panel, visor, and lower dash as well as the right front passenger's head and knees to record when contact occurred between these areas. Targets were taped on the car for future use in frame-by-frame analysis of the movie films. Figures 15 and 16 show the car after all preparations were completed.

The kinematics of the crash are shown in Figure 18. This is a selected series of

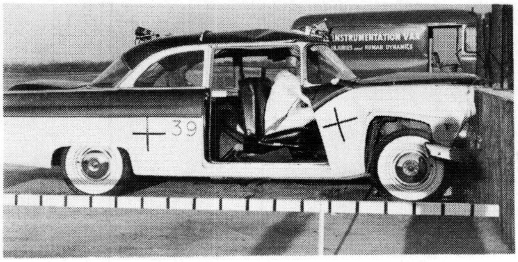

Figure 19. Crash 39 - Right side view after impact.

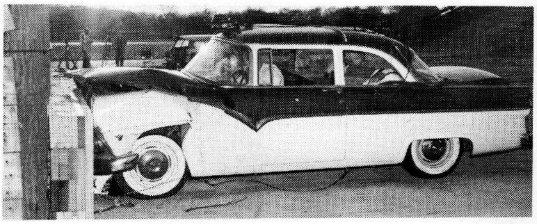

Figure 20. Crash 39 - Left side view after impact.

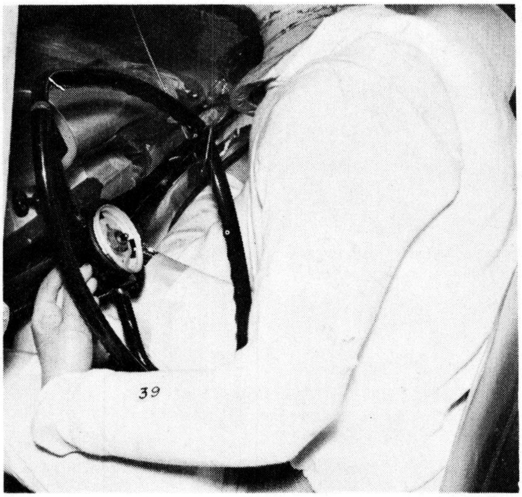

Figure 21. Crash 39 - Steering wheel deformation after impact.

Figure 22. Crash 39 - Final dummy position side view.

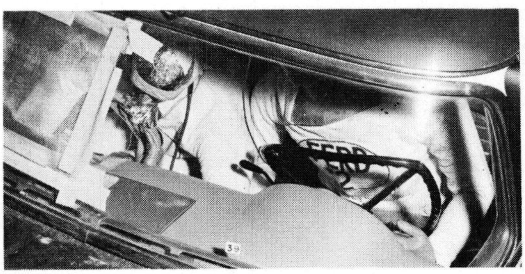

Figure 23. Crash 39 - Final dummy position front view.

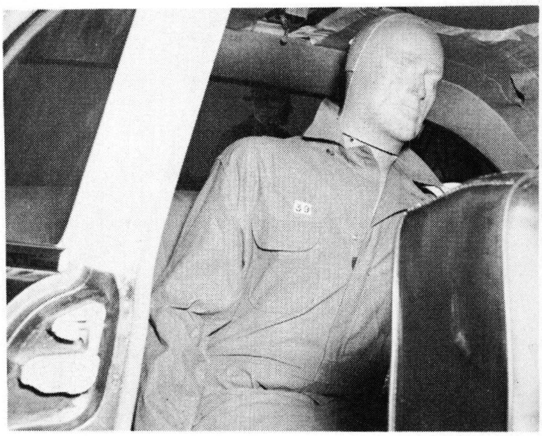

Figure 24. Crash 39 - Final position of rear dummy.

enlargements taken from the Fastax film. This camera operated at 500 frames per second. The time in seconds from "O" reference (contact) is given for each frame shown.

It is of interest to note that the time for maximum deformation of the car is 0.06 seconds from contact. However, at this time the occupants have just started to move forward. At 0. 10 seconds after contact the front seat occupants have attained maximum forward movement and the rear unrestrained occupant is still moving forward. The rear dummy's head hit and dented the roof panel at 0. 14 seconds and reached the farthest forward position at 0. 20 seconds after impact. The total time for the rear dummy to go forward and return was 0. 74 seconds.

Figures 19 through 24 show over-all damage to the car and final dummy positions. The deformation of the energy-absorbing steering wheel can be seen in Figures 21 and

26. It should be noted that the dummy's chest did not contact the hub of the steering column. Figure 27 shows the area and resulting dent where the right front dummy's head impacted the instrument panel pad after jackknifing on the seat belt. This illustrates the necessity for proper design of the panel and pad combination to obtain adequate yielding and load distribution to moderate or prevent soft tissue injury. It will be observed that the seat belt prevented windshield impact. FERD No. 1, with a

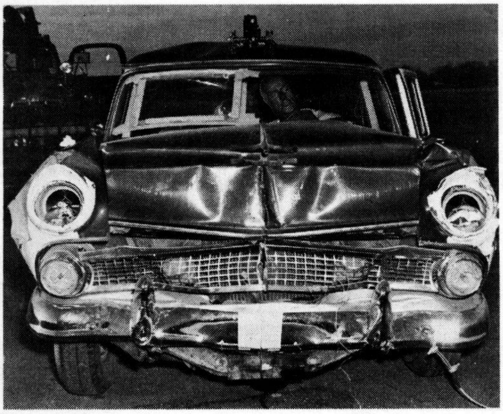

Figure 25. Crash 39 - Over-all damage to front of car.

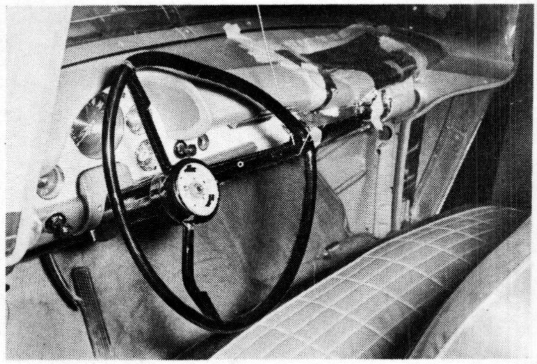

Figure 26. Crash 39 - Steering wheel and instrument panel deformation.

TABLE 3

TABULATION OF DATA FROM OSCILLOGRAPH FILM RECORD - TEST NO. 39

No.	Measurements	Peak Value of Measurement	Time to Peak Value From Start of Impact (Seconds)	Duration of Measurement (Total Time from Start of Rise to End) (Seconds)
DECELERATIONS				
1	Floor Pan Passenger Compartment - Right Side	30.4g	.065	.085
2	Floor Pan Passenger Compartment - Left Side	29.6g	.069	.087
3	Front of Frame, Right Side	88.0g	.022	.057
4	Front of Frame, Left Side	80.5g	.022	.070
5	Driver Chest (Impacting Safety Steering Wheel)	75g	.087	Value After Peak Unobtainable
6	Right Front Passenger Head (Impacting Padded Instrument Panel)	65g	.115	.037
BELT LOADS				
7	Driver Lap Belt	2540 lb.	.087	.070
8	Front Right Passenger Lap Belt	2440 lb.	.088	.110
9	Rear Left Passenger Lap Belt	2900 lb.	.050	Unobtainable
10	Rear Left Passenger Shoulder Harness Belt	2220 lb.	.055	.080
CONTACT POINTS				
11	Windshield and Head (Right Passenger)		NO CONTACT	
12	Upper Dash (Right Passenger)		DID NOT FUNCTION	
13	Lower Dash (Right Passenger)		.063 after impact	
VELOCITY MEASURING DEVICE				
14	14.25 Inches in .03329 Seconds		24.4 MPH	

seated height of $36\frac{1}{2}$ inches, occupied this seat.

The oscillograph film record of this crash is shown in Figure 28, and a tabulation of the results appears in Table 3.

The deceleration that has the first and most significant effect on the passenger is that of the passenger compartment. It is this deceleration which causes the passenger to move relative to the interior of the car. Everyone has heard the expression "It isn't the speed that kills, it's the sudden stop." This of course is true. However, usually the greater the velocity the more violent and consequently the more hazardous the stop.

The curves in Figure 29 are the results of plotting the electronically-measured decelerations which occurred in the pas-

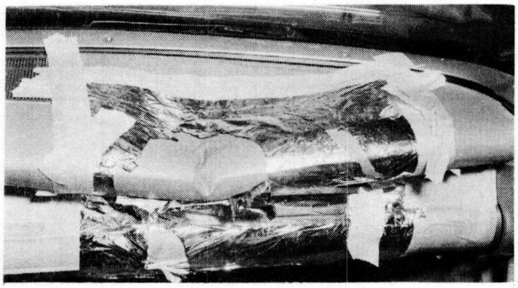

Figure 27. Crash 39 - Close-up view of padded instrument panel deformation.

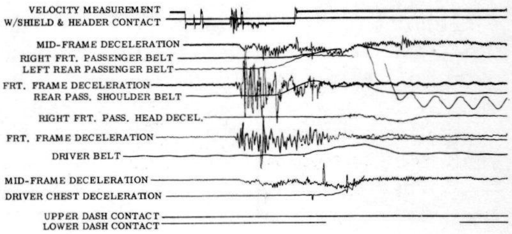

Figure 28. Crash 39 - Oscillograph film record.

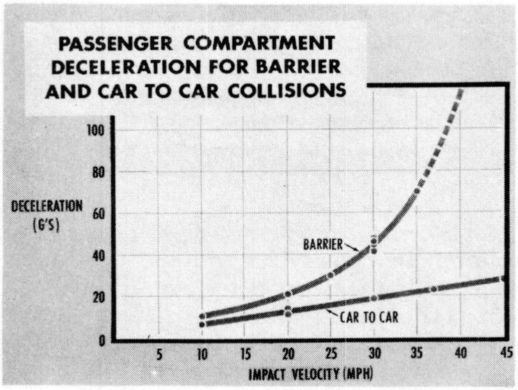

Figure 29.

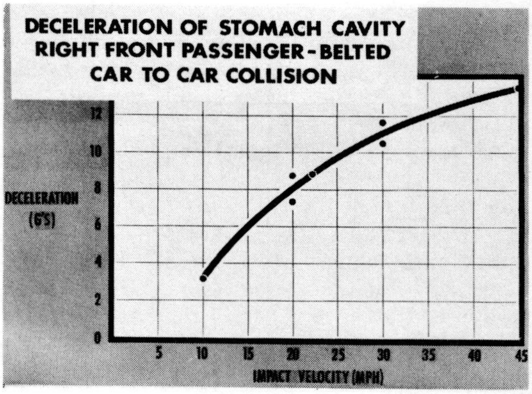

Figure 30.

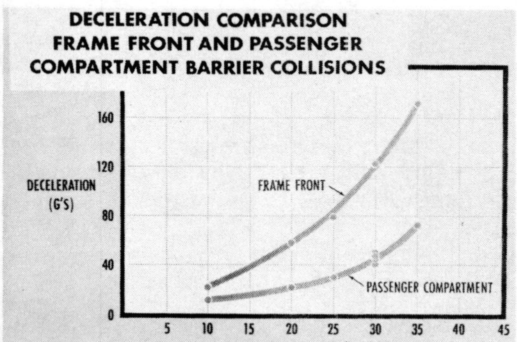

Figure 31.

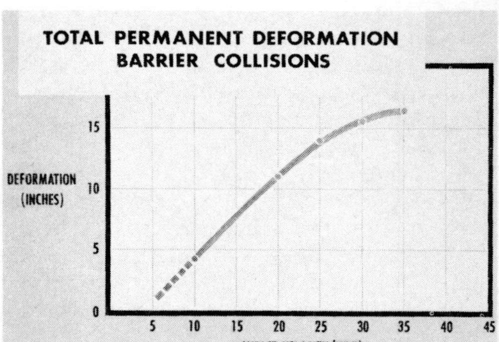

Figure 32.

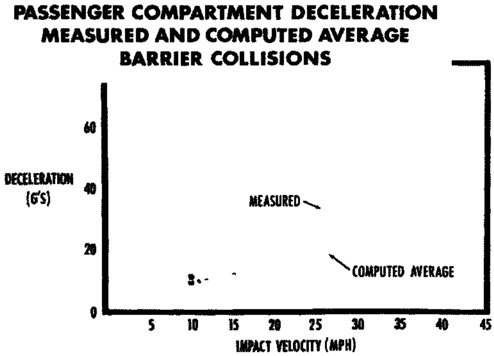

Figure 33.

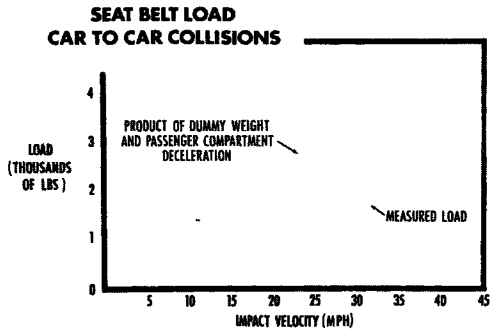

Figure 34.

senger compartment during a series of barrier and car-to-car tests at various velocities. The curve for the barrier condition beyond 35 mph is dotted since it is an extrapolation. All barrier impacts were with the line of motion of the test vehicle perpendicular to the face of the barrier. The car-to-car impacts, reported in Figure 29, were run with the line of motion of the test vehicle 10 degrees off the perpendicular to the centerline of the parked vehicle. The centerline of the moving car impacted the right front wheel of the parked car. The cars used in this series of tests were 1955 Tudor and Fordor Fords with four occupants; a driver, a right front passenger, and a left and right rear passenger.

It is sometimes very convenient to separate an accident into two collisions; the first, when the vehicle strikes another object, and the second, when the occupants strike the vehicle in which they are riding. It may be logical to visualize a situation where, if the passenger was adequately restrained, it might be possible to eliminate the second collision which is the real injury-producing condition. With reference to Figure 29, at 45 mph a deceleration of 28 g's was measured in the passenger compartment, but this resulted in a measured deceleration of only 13. 8 g's, Figure 30, in the stomach cavity of the dummy. It will be noted, in Figure 29, that an equivalent passenger compartment deceleration would be attained at a velocity of approximately 24 mph during a barrier crash. Since no braking is effected prior to impact, the velocities mentioned in discussing any of the figures are the velocities at the time of impact.

In Figure 31, the passenger compartment deceleration curve for barrier crashes, previously shown in Figure 28, is compared to the frame front deceleration. For the full range of velocities tested, the deceleration level in the passenger compartment always has been less than half that observed at the front of the frame. This fact indicates that the front structure of the present vehicle is a substantially effective energy absorber for decreasing the severity of the so-called second collision.

The total permanent deformation, or over-all shortening of the vehicle, which results from barrier impacts is shown in Figure 32, for velocities up to 35 mph. The fact that the total deformation increases at a decreasing rate logically agrees with the data in Figure 29 which shows the peak passenger compartment deceleration increases at an increasing rate. By using the deformation and performing a simple computation, it is possible to plot the average deceleration which corresponds to any velocity. It is evident, from an examination of Figure 33, that this computed average deceleration is less than the measured deceleration for the same velocity.

Measured seat belt loads as a function of impact velocity are shown in Figure 34 for front corner car-to-car collisions. In addition, the product of the dummy weight and the peak passenger compartment deceleration is shown. It will be noted that this computed load is approximately double the measured load.

The subject of Automobile Collision Impact Phenomena covers a tremendous scope. This paper, and all other available information on the subject, constitute only an introduction to this important phase of automotive design.

A Preliminary Study of Speed as Related to Injury-Producing Automobile Accidents

JOHN O. MOORE, Director, Automotive Crash Injury Research and Research Associate, Department of Public Health and Preventive Medicine, Cornell University Medical College

This paper examines accident and injury data on 3,203 automobiles involved in injury-producing accidents to determine effects which speed may have on the frequency of dangerous or fatal injuries.

The examination consists of four substudies: (1) the frequency distributions of the cars according to traveling and impact speeds in progressive ranges of 10 mph; (2) the frequency of dangerous or fatal occupant injury in each of the progressive traveling and impact speed ranges; (3) the extent to which rigid control of traveling speed would reduce the frequency of dangerous or fatal injuries; and (4) the influence which factors other than speed (ejection, seat area occupied, site of impact) have on the incidence of dangerous or fatal injuries.

● MOBILITY and speed seem to have become essential requirements of American culture. A network of new highways is being engineered to carry more and more vehicles farther and faster. Yet constantly is heard the cry: "Speed kills .... Slow down and live!" This poses a dilemma: demand for speed and the opposing dread of it. It is strange that this dilemma should exist, because the contention that speed kills never has been actually proven. It is the purpose of this preliminary study to examine data which may throw light on the subject of the relationship between speed and injury or death.

There is little doubt that the high or excessive speed of a traveling automobile can cause an accident; as the speed increases, so does the rate of closure, thereby reducing visual and physical reaction time. The cause of injury, however, is another matter, for all accidents do not necessarily produce injury.

Realistic examination of the relationship between speed and injury or death requires distinction between traveling speed and impact speed. For example, the driver of a car traveling at 60 mph may observe an imminent accident, apply his brakes, and finally strike an object at 40 mph. Thus, a chain of events leading to an injury is created. A particular traveling speed results in an accident involving a particular impact speed; the injury resulting, although related to both the traveling and impact speeds, is more closely related to the latter, whereas the occurrence of the accident is related to the former. This study, therefore, while examining the relationship between speed and death or serious injury, keeps data on traveling speed distinct from those on impact speed.

Automotive Crash Injury Research data are ideally suited for such study. An interstate cooperative program, involving police, highway patrol personnel, physicians and public health authorities in eleven states and one city, produces data through the use of detailed photographs and specially designed accident and injury report forms. Sampling techniques afford reliable and representative data. State police and highway patrols are specially trained by Automotive Crash Injury Research personnel in reporting and photographic procedures. Hospital emergency room staffs and physicians in the areas being sampled are also briefed on the program, and public health or similar authorities act as a control in securing complete, detailed and accurate medical reports. All persons participating in the program are oriented and motivated to the requirements of a study aimed at obtaining complete accounts of the accidents, as well as discovering the specific mechanical and structural causes of injury.

One of the difficulties in dealing with speed data is that speed reporting is largely subjective. Objectivity in this field of study would require speed recording instrumentation in every automobile, or large-scale employment of radar or similar devices. Since neither of these methods is used presently to an extensive degree — nor promises to be in the immediate future — reliance must be placed on the accuracy of speed reporting by police and highway personnel.

These professional accident reporters have had years of experience in estimating speeds through observation of many thousands of traveling cars; they are trained in the proper methods of interpreting accident details and use such evidence as extent of basic car damage, tire condition, skid marks, types of road surface, weather conditions, and related information in determining accident speeds. Recent years have seen the development of tests to measure and improve the accuracy of police and highway personnel in estimating rates of closure. Thus, although most current speed reporting is subjective, attempts are constantly being made to control and minimize subjectivity. Speed data reported to Automotive Crash Injury Research have the additional advantage of support and confirmation through photographic evidence. Experienced accident analysts at the project headquarters at Cornell University Medical College in New York City used detailed pictures of car damage to confirm reported traveling and impact speeds.

Portions of the report which follow deal with what is termed "excessive" speed. Of course, speed limits in one area of the country often differ from those in another because of variations in terrain, road design, traffic density, etc. Nevertheless, an arbitrary definition of excessive speed can be based on the knowledge that large segments of present rural highway systems employ a speed limit of 60 mph. Thus, for purposes of discussion, this study terms speed over 60 mph as excessive.

BASIC DATA FOR STUDY

Each of the 3,203 passenger automobiles studied was involved in an injury-producing accident during the period from 1953 to 1956 inclusive, and contained at least one injured person. Every type of accident is represented, and the total sample closely resembles national registrations of passenger automobiles in terms of makes, models, and years of manufacture.

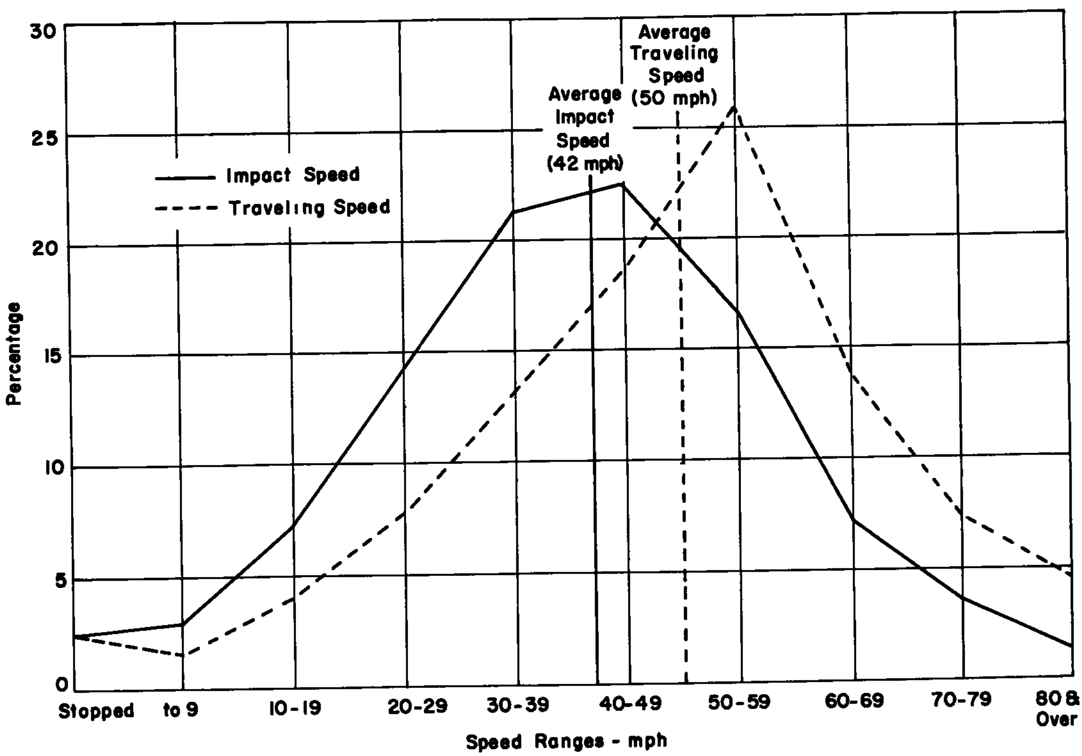

Figure 1. Distribution of reported traveling and impact speeds among 3,203 cars in injury-producing accidents.

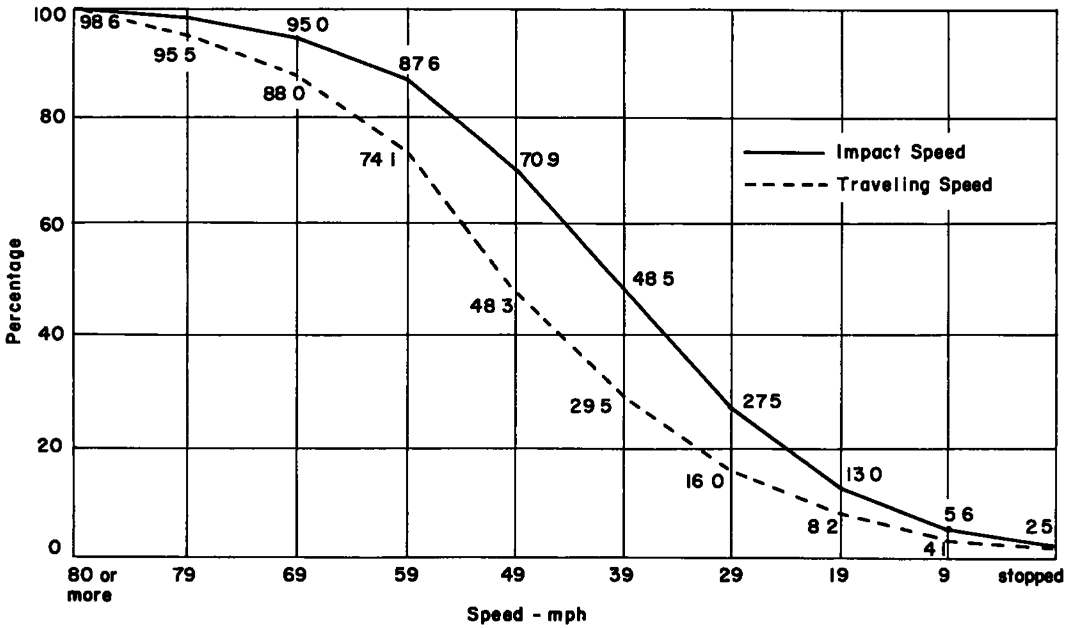

Figure 2. Percentage of cars traveling or impacting at or below a specified speed.

The 3,203 cars carried 7,154 occupants, or 2.3 persons per car. Among the 7,154 occupants, various degrees of injury were sustained in the following proportions:

No injury	25%
Minor injury (bruises, minor lacerations, etc.)	46%
Non-dangerous injury (severe lacerations, fracture, etc.)	20%
Dangerous injury (internal, brain injuries, etc.)	5%
Fatal injury (death instantaneous or within 24 hr after accident	4%

The last two injury classifications (dangerous injury and fatal injury), totaling 9 percent of the occupants, are used in this study as a measure of the effect of speed in injury-producing automobile accidents.

REPORTED TRAVELING AND IMPACT SPEEDS

Figure 1 shows distribution of the 3,203 cars according to both reported traveling[1] and impact[2] speed. It will be seen immediately that the greatest proportion of these cars was traveling at speeds in the 50- to 59-mph range, and impacted in the range of 40 to 49 mph. The average traveling speed was 50 mph and the average impact speed 42 mph.

The basic regularity of the distribution curves in Figure 1 establishes an important fact. The majority of injury-producing accidents are not associated with the higher speed ranges, as popular opinion would have one believe. Cars in injury-producing accidents appear in all ranges of speed and arrange themselves in the typical bell-shaped distribution curve.

In Figure 2 the speed data are presented in cumulative fashion, showing that 16 percent of the cars traveled at 29 mph or less, 29.5 percent traveled at 39 mph or less, 48.3 percent traveled at 49 mph or less, etc. Combining the cars which traveled at

[1] Traveling speed: the speed of the car before involvement in the accident.
[2] Impact speed: the speed at which the major impact occurred between the car and objects or other cars or vehicles.

the most common speed (50 to 59 mph, as shown in Figure 1, with all the cars which traveled at lesser speeds, a total of 74.1 percent of the 3,203 cars were moving at speeds under 60 mph before becoming involved in injury-producing accidents.

Similar consideration of impact speed tells much the same story. The bulk of the cars impacted in the lower speed ranges. The cars impacting at the most common impact speed (40 to 49 mph, as shown in Figure 1), and all the cars impacting at lower speeds, comprise a total of 70.9 percent of the 3,203 cars.

OCCURRENCE OF DANGEROUS OR FATAL INJURIES AS RELATED TO SPEED

Figure 3 shows what proportion of the persons traveling or impacting at successive speed ranges suffered dangerous or fatal injury. Such injuries were sustained by 9 percent of the occupants of cars studied. These two grades of injury (representing trauma which placed car occupants either on hospital "critical" lists or in morgues within 24 hr) are used in this study to measure the effect of speed in automobile accidents; they reflect the severest aspect of injury. Measuring the effect of automobile accidents by the occurrence of fatal injuries only, while dramatic, illustrates merely a portion of the problem. That large segment of the population which is injured to a dangerous degree also represents a major problem. The loss of manpower and dollars through hospitalization, treatment, and often permanent disability has become a critical matter not only to industry, but also to the military services and the medical profession. Injuries of lesser degree — those of a painful, disfiguring, or disabling nature — are, of course, also important, but are omitted from this study for purposes of simplicity.

Analysis of the data shows that as traveling and impact speeds increase, there is a steady and statistically significant increase in the frequency of dangerous or fatal injury. However, as Figure 3 indicates, any increases of injury are small in speed ranges up to and including 40 to 49 mph. From the 50- to 59-mph range, and progres-

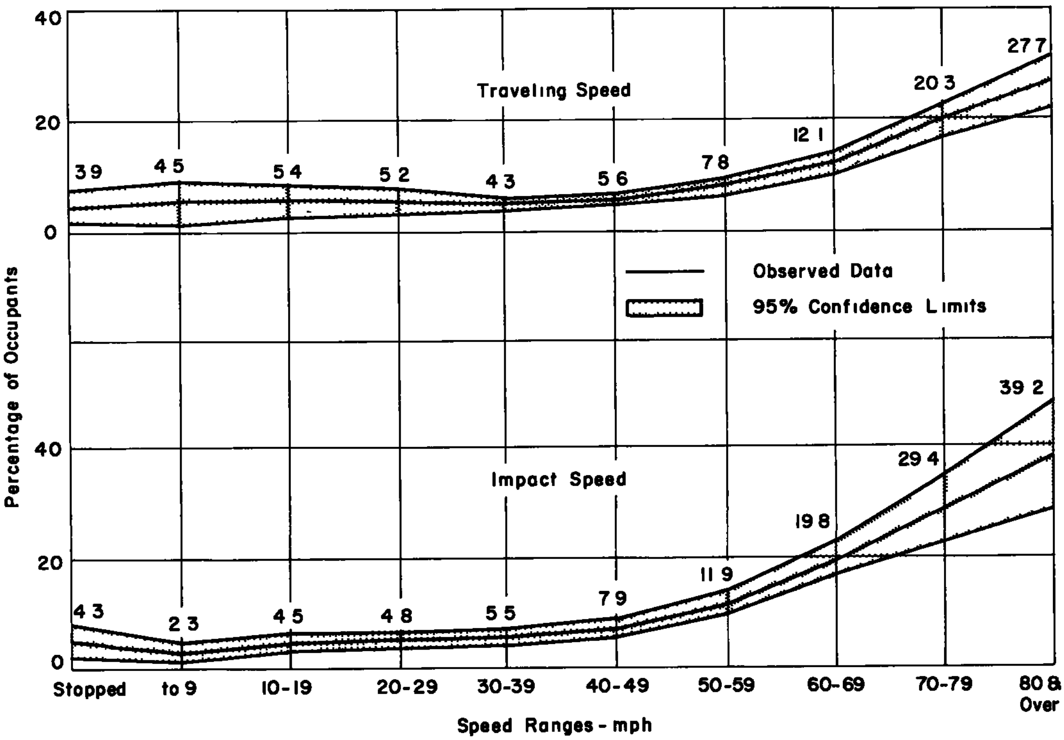

Figure 3. Frequency of dangerous or fatal injury according to progressively higher ranges of traveling and impact speeds.

sing upward through the higher traveling or impact speeds, the increases in frequency of dangerous or fatal injury become more marked. They culminate in an incidence of these injuries among nearly 28 percent of the persons traveling at or above 80 mph, and among approximately 40 percent of the persons in cars impacting at or above this speed.

The finding of correlation between the occurrence of dangerous or fatal injury and increasing speeds must be viewed with caution and interpreted in terms of how many cars or people are involved. For example, only $4\frac{1}{2}$ percent of the cars were traveling at or above 80 mph, and no more than 25 percent were traveling at or above 60 mph.

Ignoring the important fact that high speeds are infrequent, the differences in risk of dangerous or fatal injury can be examined according to whether the speed was above or below an arbitrarily selected limit. In such an examination, impact speed need not be used, since the consequences of traveling at a given speed are being studied.

Because the most commonly reported traveling speed in injury-producing accidents is in the 50 to 59 mph range, 60 mph is used arbitrarily as the dividing line and one can proceed to observe the frequency of dangerous or fatal injury among persons who traveled above or below this speed.

About 6 percent of the occupants of cars traveling at speeds up to 60 mph sustained such injuries; above this speed the toll was in the order of 17 percent. Thus, it might be said generally that traveling above 60 mph may result in more than doubling the risk of dangerous or fatal injury.

The findings at this point must be treated with reservation. What has been discussed has been risk without regard to frequency. Further, there exists a distinct possibility that factors other than (or concomitant with) speed act to create dangerous or fatal injury. Simultaneous consideration of risk and frequency can be accomplished by means of "expectancies."

OCCURRENCE AND EXPECTANCY OF DANGEROUS OR FATAL INJURY AS RELATED TO SPEED REGULATION

For purposes of discussing speed regulation, "excessive" speed, as used in this study, is an arbitrary term referring to traveling speeds of 60 mph or over. Although the findings thus far emphasize the need for public education concerning the hazards of excessive speed, it should be repeated that only 25 percent of the cars in this study of injury-producing accidents were reported to have been traveling at excessive speed before involvement in the accidents. Thus, it appears that efforts to regulate speed cannot be expected to solve the total problem of dangerous or fatal injuries in automobile accidents. Obviously, any reduction in the frequency and severity of injury is immediately desirable, and the data herein presented clearly indicate that speed regulation can produce some improvement in the injury picture. However, speed should not be regarded as the sole and exclusive agent responsible for injury or death – the facts do not justify such a view. Nor should the discovery of a correlation between speed and injury lead to disregard of other factors which may be even more significantly responsible for injury. Although the risk of a dangerous or fatal injury increases markedly at the top speeds, both the risk and the frequency distribution of dangerous and fatal injuries must be taken into account in answering the vital question: "To what extent can rigid control of traveling speed reduce the current toll on the highway?"

To provide an answer to this question, the method of "expected values" has been used. In essence, the purpose of this method is to secure a gross estimate of what would have happened had rigid speed controls been enforced during the time when these data were collected. The procedure entails certain assumptions: (1) every vehicle traveling above the specified "rigid speed limit" would have, instead, been traveling at that speed; (2) the risks for the individuals "moved down" by this rigid speed limit would have been the same as the risks of the individuals actually traveling at this limit in the study; (3) other factors would not have changed. For example, the reduction in speed would not have changed anything about the accident and there would have been the same number of people, cars, types of accident, etc. Under these assumptions, it is possible to gain a gross estimate of the percentage of dangerous or fatal injuries which would

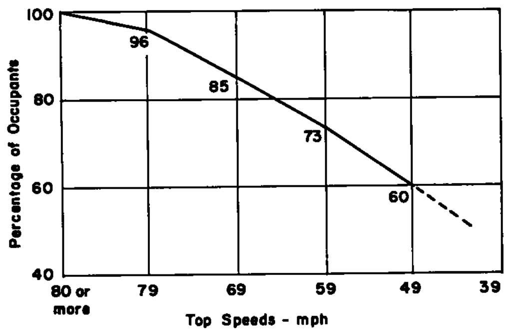

Figure 4. Expected percentage of dangerous or fatal injury at specified top speeds.

have occurred if the speed had been rigidly controlled to a specified limit.

The expected percentages (Figure 4) show that if the speed limit had been rigidly fixed at 79 mph (either by a miraculous 100 percent enforcement or by some engineering device such as a governor), 96 percent of the injuries would still have occurred. If the limit had been set at 69 mph, 85 percent of the injuries would nevertheless have occurred. Lowering the limit to 59 mph, 73 percent would have been involved. Even if the rigid speed limit had been reduced to 49 mph, there would have resulted an essentially limited reduction in the number of dangerous or fatal injuries, for 60 percent of the dangerous or fatal injuries still would have occurred. Hence, although rigid speed control of the top speeds would be expected to produce some improvement in the injury picture, there is a definite limit to the amount of improvement that can be achieved by absolute speed regulation.

OTHER FACTORS INFLUENCING INJURY

The data thus far have clearly indicated that speed is not the sole element in producing dangerous or fatal injuries. Further, speed control offers only partial solution to the problem of these injuries. Of course, there is no injury if there is no accident, and excessive speed does have a bearing on whether or not an automobile accident occurs. Thus, speed control would seem to imply accident rather than injury prevention.

The data make it apparent that conditions other than (or together with) speed act to produce dangerous or fatal injuries. Study of injury-producing accidents has isolated several primary factors as affecting both the occurrence and seriousness of injury in automobile accidents. One of these factors is the phenomenon of ejection, which takes place most frequently when doors open under impact conditions. The consequence of doors opening (front doors open in about 50 percent of cars in injury-producing accidents[3]) is that ejection occurs among approximately 13 percent of the total car occupants. The profound effects of ejection on injury are shown in Table 1, which shows that dangerous or fatal injuries were sustained by five times as many ejectees as non-ejectees; that is, ejection multiplies the risk of dangerous or fatal injury by five.

TABLE 1

RISK OF INJURY AS RELATED TO EJECTION OR NON-EJECTION

	Percentage of Occupants with			
	Mod thru Fatal Injury	Severe thru Fatal Injury	Dangerous or Fatal Injury	Fatal Injury
Non-ejectees	23 9	9 9	5 5	2 6
Ejectees	49 9	36 4	26 6	13 3
Injury ratio, ejectees to non-ejectees	2.1·1	3 7.1	4 8 1	5.1 1

Another factor bearing upon the production of dangerous or fatal injuries relates to the specific areas of the car occupied by passengers. Table 2 shows the frequency of dangerous or fatal injury among the occupants of various seat-areas. Although the problem of injury as a function of seat-area occupied is a subject for further and more thorough study, Table 2 clearly shows that the likelihood of receiving a dangerous or fatal injury is widely different among the occupants of various seats. These differences are statistically significant. Generally speaking, the entire rear seat area is less dangerous than the front seat area. Further, the dangerous or fatal injury potential of the right front seat is somewhat (although not remarkably) greater than that of the driver's seat.

[3] Automotive Crash Injury Research, "A Study of Automobile Doors Opening under Crash Conditions," T. R. 2. New York, Cornell University Medical College, August 1, 1954. Subsequent study with a greater number of cases has confirmed the findings of this report.

TABLE 2

RISK OF DANGEROUS OR FATAL INJURY ACCORDING TO SEAT-AREA OCCUPIED

Seat Area Occupied	Percentage of Occupants with Dangerous or Fatal Injury
	%
Driver[a]	7.5[a]
Center front	4.9
Right front	10.4
Left rear	4.7
Center rear	5.2
Right rear	6.4

[a] Since the Automotive Crash Injury Research sample is one of injury-producing accidents, a driver alone in a car must be injured to get into the sample. To eliminate bias overemphasizing driver injury, this table shows frequency of injury among drivers who were accompanied by passengers.

Another influence on the occurrence of dangerous or fatal injury is the area of the car sustaining the principal crash impact. To examine this influence, it was necessary to study the frequency of injury among occupants with respect to their proximity to the site of impact. Table 3 shows the wide variations in injury frequency occurring according to interaction of (1) the location of the impact, (2) the seat occupied, and (3) the closeness of the seat-area to the impact site. The data show that being near the impact site produces the greatest likelihood of dangerous or fatal injury, regardless of seat-area occupied; further, the incidence of the injury will vary as a function either of the site of impact or the seat-area occupied.

It becomes increasingly clear that injury is concomitant with many accident factors related to engineering and design. Ejection, the force localization dictated by objects in a given seat-area, and the energy-absorbing qualities of various exterior portions of the car are all subject to effective control through engineering. Of course, it should be realized that such factors, controllable by engineering, relate to one another. Similarly, each of these factors is also related, in some degree, to speed. For example, clinical observation shows that ejection increases as speed increases, or that in a given seat-area, the frequency of injury will increase as speed does. However, an all-important reservation is that dangerous or fatal injuries increase appreciably from one high-speed range to the next, starting only at the traveling speed range of 50 to 59 mph. In the lower traveling speed ranges, although there are increases in risk of dangerous or fatal injury, these increases are rather small. Further, although nearly 75 percent of the cars were traveling under 60 mph, approximately as many dangerous or fatal injuries were sustained among the persons traveling below 60 mph as were sustained by those traveling in excess of 60 mph.

Apparently the injuries occurring in lower speed ranges are largely a function of car design, while injuries in the higher speed ranges are a function of both speed and automotive design. Thus, the path for correction is shown by the basic indications of the data: Speed affects dangerous or fatal injury in a relatively small proportion of the cars; design engineering affects this grade of injury in all of the cars and in all of the speed ranges. Efforts to reduce dangerous or fatal injuries in automobile accidents must take both these factors into account.

TABLE 3

RISK OF DANGEROUS OR FATAL INJURY ACCORDING TO OCCUPANTS'[a] PROXIMITY TO CRASH IMPACT SITE

Relation between Occupant and Crash Impact Site	Area of Car Sustaining Principal Impact	Percentage of Occupants with Dangerous or Fatal Injury	
		Drivers	Right Front Seat Passenger
		%	%
Opposite impact site	Front	5 6	7 4
At or near impact site	Side	16 7	20 0
Opposite impact site	Side	2 0	8 5
No strict relationship (car rolled over)	Top	3 1	4 5

[a] Based on non-ejected occupants of cars involved in injury-producing accidents

SUMMARY

A study of the reported impact and traveling speeds of 3,203 cars in injury-producing accidents, and correlation with injury data on the 7,154 occupants of these cars revealed that:

1. Although each car contained at least one injured person, approximately 75 percent of the cars were traveling at speeds under 60 mph and about 70 percent involved impact speeds under 60 mph.

2. There is a statistically significant correlation between increases in both traveling and impact speed and the frequency of dangerous or fatal injury. In each of the 10-mph speed ranges through 59 mph, the increases in frequency of dangerous or fatal injury are slight; beyond 59 mph the increases rise sharply. Traveling above 59 mph (represented by 25 percent of the cars) more than doubles the risk of dangerous or fatal injury.

3. Top speed limits imposed by enforcement or mechanical devices afford relatively limited reduction in the expectancy of dangerous or fatal injuries in injury-producing accidents; a strict enforcement of a top traveling speed of 49 mph would still result in the occurrence of 60 percent of the dangerous or fatal injuries.

4. Many factors other than speed operate to produce injury in automobile accidents. Acting independently, interdependently, or together with speed, are such accident factors as ejection, seat-area occupied, and site of crash impact.

5. Dangerous or fatal injury in low-speed ranges appears to be largely a function of car design, while such injuries in the higher-speed ranges apparently correlate with both speed and car design.

6. Control of excessive speed without simultaneous control of car design imposes limitation on the extent of reduction of dangerous or fatal injuries in injury-producing automobile accidents.

Factors Related to Traffic Death Rates

EARL ALLGAIER and SAM YAKSICH
American Automobile Association

CERTAIN states have low traffic death rates year after year. On the other hand, some states consistently have high rates year after year. This study is an effort, through statistical techniques, to determine the characteristics of the various states that are related to the traffic death rates. In other words what are the characteristics of states with high death rates compared to states with low death rates?

As a first step in this analysis, correlation coefficients were calculated between the traffic death rates for 1952 and 30 factors which it was felt might bear some relationship to the traffic death rate. The seven factors that gave the highest simple correlations with the death rate are listed below.

Factor	Correlation with the death rates
Percent of all roads and highways that is surfaced	-0.5992
Population density	-0.5849
Percent of total state highway mileage that is rural	+0.5710
Percent of population that is urban	-0.5159
Per capita consumption of malt beverages	-0.4785
Percent increase in motor vehicle registration	+0.4460
Percent of high schools with driver education	-0.4439

A multiple correlation coefficient between the death rate and the 12 factors most closely related to the traffic death rate was computed. The coefficient was 0.8800.

Since many of the factors contributed very little to the multiple correlation, another multiple correlation coefficient was computed using the six factors out of the twelve that contributed most to the multiple correlation coefficient. The multiple correlation coefficient using these six factors was 0.8343 indicating that 70 percent of the variability among the states in 1952 could be accounted for by these six factors alone. This same formula with 1953 data was used for predicting the 1953 traffic death rates. The correlation between the actual and predicted rates for 1953 was 0.90. These factors and the weight given each in predicting the traffic death rates are listed below.

Factor	Beta Coefficient	Percent of Total Weight
Percent of total state highway mileage that is rural	0.5215	30.6
Percent of increase in motor vehicle registration	0.3542	20.8
Extent of motor vehicle inspection	-0.2831	16.6
Percent of state administered highway mileage that is surfaced	-0.2597	15.3
Average yearly minimum temperature	0.1447	8.5
Income per capita	-0.1395	8.2
		100.0

From the above it is apparent that states with high traffic death rates also have: (1) a higher percentage of highway mileage that is rural, (2) a greater increase in motor vehicle registration, (3) less motor vehicle inspection, (4) a smaller percent of the state highways surfaced, (5) a higher temperature, and (6) a smaller income per capita.

This study provides a new and better criterion than the simple death rate for evaluating the effect of certain factors on the death rate.

The extraneous effect of these six factors on the death rate can now be eliminated by subtracting the actual rate from the predicted rate. This difference can then be correlated with some other factor, such as normal driving speeds in the various states, to get a measure of the effect of speed on the accident rate. This gives a better criterion than correlating speeds with the simple death rate since the simple death rate is so seriously affected by the six factors previously mentioned.

INTRODUCTION

Traffic death rates (deaths per 100,000,000 vehicle miles) vary widely among the 48 states. This variation apparently is not the result of chance since some states consistently have low rates year after year, while other states have high rates year after year. Four examples are given below:

	High Rate States		Low Rate States	
Year	New Mexico	South Carolina	Massachusetts	Rhode Island
1945	15.1	17.2	7.2	6.6
1946	13.7	16.5	5.5	4.8
1947	11.8	12.4	5.2	4.7
1948	11.4	11.5	4.2	2.9
1949	10.1	11.0	4.2	3.0
1950	9.0	12.3	4.3	3.8
1951	12.9	12.0	3.9	3.0
1952	10.9	12.0	3.7	3.0
1953	11.7	8.2	3.8	2.4
1954	10.3	11.2	4.1	2.9

SOURCE: Accident Facts, National Safety Council

The same information is shown graphically in Figure 1. Further evidence that these differences are not due to chance is indicated by the correlation of state traffic death rates for one year with the rates for the following year. Correlations for several years are given below:

Years	Correlation Coefficient[a]
1949-50	0.9121
1950-51	0.9377
1951-52	0.9389
1952-53	0.9490

[a] 1.0000 indicates a perfect correlation in which the rates for one year would be exactly proportional to the rates for the following year. A "0" correlation would indicate no relationship.

Since the rates vary greatly from state to state and since they are fairly consistent from year to year the question arises: Why do some states consistently have high traffic death rates while others consistently have low rates? This study is an effort to determine those factors whice are most highly related to the state death rates. These factors are generally of two types: (1) physical factors such as weather, population characteristics, etc, over which public and civic officials have little control and (2) education and enforcement programs which are aimed at controlling the driving and walking behavior of the individual.

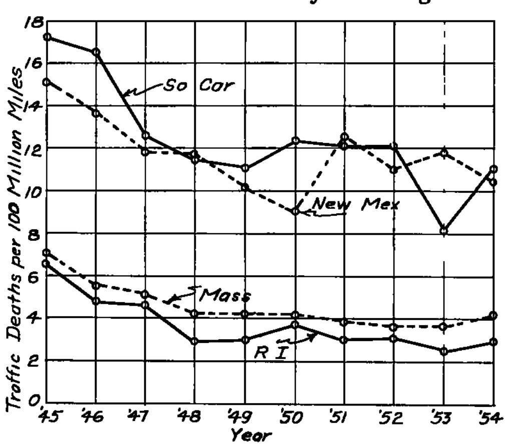

Figure 1. Some states consistently have high traffic death rates while others consistently have low death rates.

FACTORS RELATED TO TRAFFIC DEATH RATES

In this analysis a large number of factors were studied in an effort to determine which were most highly related to the death rate (see Table 1). A second analysis

TABLE 1

CORRELATION OF VARIOUS FACTORS WITH THE TRAFFIC DEATH RATE

Factor	Average	Correlation with 1952 Traffic Death Rate
Non-pedestrian death rate - 1952 (Non-pedestrians killed per 100,000 population - AAA and Accident Facts, 1953)	21.5 per 100,000 pop.	0.7631
Percent of all roads and highways that is surfaced - 1952. (Bureau of Public Roads, Table M-3, 1953)	60.6%	-0.5992
Population Density - 1950. (Persons per square mile)	110.1 per sq mile	-0.5849
Percent of total state highway mileage that is rural - 1952 (Bureau of Public Roads, Table M-3, 1953)	88.1%	0.5710
Percent of population that is urban - 1950	55.0%	-0.5159
Consumption of malt beverages - 1952 (Table 41, Brewer's Almanac, 1954)	14.7 gal. per capita	-0.4785
Percent increase in motor vehicle registration - 1951-52, (Bureau of Public Roads, Table MV-1, Sept. 1953)	3.1%	0.4460
Percent of high schools with driver education - 1952, (Report of Assn of Casualty and Surety Cos., Sept. 3, 1953)	45.4%	-0.4439
Rating of follow-up program on dangerous drivers (Larger figure represents better program. From "Changing Times," Kiplinger Magazine, March, 1951)	2.2	-0.4301
Percent of state administered highway mileage that is surfaced - 1952 (Bureau of Public Roads, Table SM-1, 1952)	93.7%	-0.4230
Pedestrian death rates - 1952 (Deaths per 100,000 pop.) Pedestrian Program, AAA	5.1 per 100,000	0.3949
Income per capita - 1952 (World Almanac) Hundreds of dollars	$14	-0.3911
Quality of driver testing ("Changing Times," Kiplinger Magazine, March, 1951, larger number indicates better testing program)	2.5	-0.3841
Amount spent per dangerous driver on follow-up program - 1950 (Source, "Changing Times," Kiplinger Magazine, March 1951)	$0.047 per driver	-0.3879
Average yearly minimum temperature, (Climatic Guide, AAA, Wash., D.C.)	44.1 degrees	0.3049
Driver education rating - 1952 (Assn of Casualty and Surety Cos, N.Y.C., N.Y. Higher number indicates a better rating.)	100.8	-0.3038
Extent of motor vehicle inspection - 1951 (The Book of the States, 1952-53) 10 indicates states requiring inspection; 7 indicates states requiring partial inspec.; 3 indicates states requiring spot inspec.; 1 indicates states requiring no inspection	4.8	-0.2934

TABLE 1 (Continued)

Factor	Average	Correlation with 1952 Traffic Death Rate
Percent of increase in gas consumption 1952 over 1951 (Bureau of Public Roads, Table G-2, 1952)	5.62%	0.2699
Percent of increase in population 1950 over 1940	14.6%	0.2254
Average annual precipitation (Climatic Guide, AAA)	33.6 inches	-0.2105
State disbursements for safety education 1952, (Bureau of Public Roads, Table SF-4, 1953)	$0.027 per capita	0.2087
State disbursements for highway construction - 1952 (Bureau of Public Roads, Table SF-4, 1953)	$15.81 per capita	0.2316
Disbursements for highway maintenance 1952 (Bureau of Public Roads, Table SF-4, 1953)	$5.54 per capita	0.1858
Total state population - 1950	3,072,910	-0.1839
Wine consumption - (Wine Institute Bulletin No. 710, May 28, 1954)	0.71 gal. per capita	-0.1127
Disbursements for state highway police 1952 (Bureau of Public Roads, Table SF-4, 1953)	0.71 per capita	0.1069
Percent of population that is non-drivers 1952 (Automobile Facts and Figures, 34th Ed., 1954)	53.0%	-0.0863
State highway police per 100,000 population - 1951 (The Book of the States, 1952-53)	10.6 per 100,000 pop.	-0.0837
Consumption of distilled spirits - 1952 (1953 Annual Statistical Review, The Distilled Spirits Industry)	1.18 gal. per capita	-0.0555
Expenditure for Testing for Driver's License - 1950 ("Changing Times," Kiplinger Magazine, March, 1951)	$0.108 per driver	-0.0313

was made to determine the combination of factors most closely related to the death rate.

The simple correlation coefficients in Table 1 do not tell the whole story. If several important factors are put together their over-all relationship to the traffic death rate will be greater than that of any individual factor. Below are listed the factors most highly related to the traffic death rate:

Factor	Correlation with Traffic Death Rate	Beta Coefficient	Percent of Total Weight
Percent of all roads and highways that is surfaced	-0.5992	-0.1075	4.3
Population density	-0.5849	0.1077	4.0
Percent of total highway mileage that is rural	0.5710	0.6061	24.0
Percent of population that is urban	-0.5159	0.1140	4.5
Consumption of malt beverages	-0.4785	0.1560	6.2
Percent increase in motor vehicle registration	0.4460	0.3359	13.3
Percent of high schools with driver education	-0.4439	-0.0023	0.1

Factor	Correlation with Traffic Death Rate	Beta Coefficient	Percent of Total Weight
Follow-up program on dangerous drivers	-0. 4301	-0. 1743	6. 9
Percent of state administered highway mileage that is surfaced	-0. 4230	-0. 3013	11. 9
Income per capita	-0. 3911	-0. 2375	9. 4
Average yearly minimum temperature	0. 3049	0. 1968	7. 8
Extent of motor vehicle inspection	-0. 2934	-0. 1909	7. 6
			100. 0

By the process of multiple correlation it is possible to determine the weight which should be given to each of these factors to obtain the highest correlation with the traffic death rate. The Beta Coefficient represents the relative weight assigned to each factor. If these weights are used then the multiple correlation between these factors and the traffic death rate becomes 0. 8800.

SIX FACTORS ACCOUNT FOR 70 PERCENT OF VARIATION IN TRAFFIC DEATH RATES

In looking over the weights given to the various factors it is evident that a number of factors contribute very little to the multiple correlation coefficient. In an effort to simplify any prediction formula another multiple correlation coefficient was computed, using only the following six factors which are given the most weight:

Factors	Correlation with Traffic Death Rate	Beta Coefficient	Percent of Total Weight
Percent of total highway mileage that is rural	0. 5710	0. 5215	30. 6
Percent of increase in motor vehicle registration	0. 4460	0. 3542	20. 8
Percent of state administered highway mileage that is surfaced	-0. 4230	-0. 2597	15. 3
Income per capita	-0. 3911	-0. 1395	8. 2
Average yearly minimum temperature	0. 3049	0. 1447	8. 5
Extent of motor vehicle inspection	-0. 2934	-0. 2831	16. 6
			100. 0

This information is shown graphically in Figure 2.

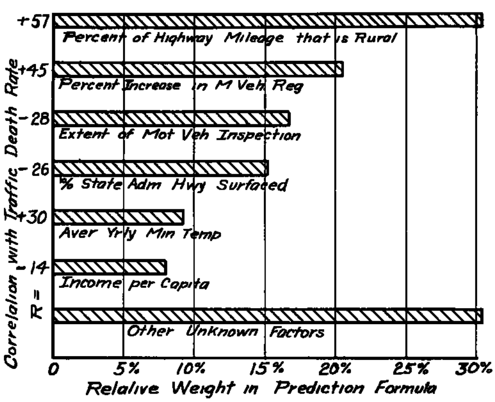

Figure 2. Six factors accounted for 0.70 percent of the variation in traffic death rates among states during 1952.

FORMULA FOR PREDICTING DEATH RATES

From the beta coefficients in the above table a formula was developed for predicting the 1952 traffic death rate using these six factors. This formula becomes:

Traffic Death Rate = 3 481		Sample Computation For Rhode Island
+0 105	Percent of highway mileage that is rural	4 317
+0 274	Percent increase in motor vehicle registration	1 123
-0 0624	Percent of state administered highway mileage that is surfaced	-6 114
-0 000863	Income per capita	-1 381
+0. 03659	Average yearly minimum temperature	1 500
-0 14651	Extent of motor vehicle inspection	-0 146
		2 780

This formula was used to compute the expected rate for 1952. Both the actual and expected rates for 1952 are given in

TABLE 2

INTERCORRELATIONS OF FACTORS RELATED TO TRAFFIC DEATH RATES

Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 Total traffic mileage death rate (1952)	x																					
2 Non-pedestrian population death rate (1952)	7631	x																				
3 Percent of all highways that is surfaced	- 5992	- 6771	x																			
4 Population density	- 5849	- 5414	5654	x																		
5 % of total hwy mileage that is rural	5710	5581	- 5390	- 9137	x																	
6 % of population that is urban	- 5159	- 3292	4893	- 6621	- 7161	x																
7 Consumption of malt beverages	- 4785	- 1371	4070	4205	- 3889	6806	x															
8 % increase of motor vehicle reg '51-52	4460	3626	- 2025	0224	- 0632	0370	- 1548	x														
9 % of schools with driver education	- 4439	- 2092	3682	5149	- 4587	6405	5843	- 0681	x													
10 Follow-up programs on dangerous drivers	- 4301	- 2587	2574	3959	- 3862	4513	2828	0316	5018	x												
11 % of state adm hwy mileage surfaced	- 4230	- 3226	3626	1357	- 1797	2669	3076	- 2129	- 0503	- 1502	x											
12 Pedestrian death rate	3949	2269	0831	0642	- 0912	2979	0722	6138	1370	0562	- 3430	x										
13 Income per capita	- 3911	0138	3203	3744	- 2920	6421	8138	0068	8689	3309	1619	2113	x									
14 Money spent for follow-up on dangerous drivers	- 3879	- 1432	1978	3058	- 1905	2105	2737	- 0012	3665	5964	- 0625	- 1501	2990	x								
15 Rating on quality of driver testing	- 3841	- 3310	2319	3158	- 3542	2342	0349	0404	3485	7647	- 0508	0687	1550	4029	x							
16 Average yearly minimum temperatures	3049	- 0584	0162	- 0329	- 1264	- 0352	- 4528	3974	- 2824	- 1037	- 0217	3473	- 3655	- 2450	1961	x						
17 Driver education program rating	- 3038	- 0627	2508	2809	- 1404	4975	4443	- 1017	8609	4450	- 0397	- 8032	5887	3744	2922	- 2610	x					
18 Extent of auto inspection	- 2934	- 2741	2584	1063	- 0097	0703	0017	- 0456	0191	4615	- 1115	0805	0251	3063	3806	- 1013	0848	x				
19 % of increase in gas consumption 51-'52	2699	2535	- 0326	0159	- 1108	1136	0136	6320	1065	1864	- 2735	5833	0707	0213	2283	4542	0790	0704	x			
20 Disbursements for new hwy construction	2316	5796	- 3900	- 2373	3024	- 1295	1288	3523	1051	0959	- 2074	0539	8581	1566	0031	- 2662	1809	1269	0831	x		
21 % of increase in population '40-'50	2254	3274	- 0399	- 0598	- 1195	3870	2698	5966	2093	2784	- 0745	6533	4206	0624	2899	2617	1336	0321	5685	2963	x	
22 Average yearly total precipitation	- 2105	- 5943	5260	3342	- 3685	0227	- 2415	0135	- 1597	- 0017	0947	- 0435	- 2933	0137	1796	6006	- 2453	1241	0228	- 4183	- 2020	x
23 Disbursements for safety education	2087	3108	- 1116	- 1498	1039	0725	- 0251	0851	- 0031	2985	- 1302	1589	0472	1750	3029	- 1352	1394	2112	0694	- 2646	2272	- 3398

TABLE 3

DATA FOR PREDICTING 1952 TRAFFIC DEATH RATES

State	% of state highway mileage that is rural	% of increase in motor vehicle reg	% of state highway mileage surfaced	Income per capita ($100)	Average yearly minimum temp	Extent of motor vehicle inspection	Traffic Death Rates 1952 Predicted	1952 Actual	1953 Predicted	1953 Actual
Alabama	89	8 8	89	10	56	7	9 9	9 7	10 3	9 5
Arizona	94	12 7	93	14	56	1	11 7	10 6	10.6	9 8
Arkansas	93	1 6	97	9	53	1	8 7	9 1	9.5	8 3
California	84	4 6	98	20	52	1	7 5	7.4	7 8	6 6
Colorado	94	3 8	85	16	37	10	7 6	6.9	7 0	5 8
Connecticut	69	3 5	100	20	41	3	4.8	3.2	5 0	3 6
Delaware	87	4 5	82	22	45	10	7 0	6 0	8 2	7 5
Florida	77	8 4	99	13	64	1	8 8	7.8	9 3	7 5
Georgia	90	6 2	88	11	54	1	10 0	9 1	9.7	7 9
Idaho	96	4 1	92	14	39	1	9 1	8 9	9.1	7 5
Illinois	83	2 1	100	19	43	7	5 5	7 3	6.0	7 2
Indiana	88	1 0	100	16	44	1	6 9	8 0	7 8	7 4
Iowa	91	-1 4	100	15	40	7	5 6	5 2	6 7	5 7
Kansas	94	2 7	97	16	44	1	8 1	7 3	8 6	7 0
Kentucky	94	4 4	99	11	48	1	9 1	10 0	9 5	10 4
Louisiana	86	2 8	100	12	62	1	8 2	9 2	9 5	9 1
Maine	95	2 9	98	13	33	10	6 8	4 5	6 3	5 3
Maryland	86	6 0	100	17	47	10	6 7	7 0	6.4	6 5
Massachusetts	73	2 5	100	17	42	10	4 2	3 7	4.4	4 0
Michigan	87	0 3	99	18	36	1	6 2	7 3	8.1	7 4
Minnesota	90	-0 8	94	14	36	7	6 0	5 2	7 3	5 9
Mississippi	94	2 9	100	8	56	10	7 8	8 4	8 7	7 5
Missouri	89	0 8	100	15	45	1	7 0	6 5	7 8	6 4
Montana	97	2 4	93	16	33	7	7.4	9.3	8 7	8 4
Nebraska	95	1 1	99	15	41	1	7 7	5.8	7 9	5 9
Nevada	98	8 8	86	22	36	1	10 1	11.7	11.4	10 3
New Hampshire	91	1 6	100	15	33	10	5 7	4 4	6.8	4 9
New Jersey	59	4 0	95	19	43	10	3 3	4 7	3.5	4 1
New Mexico	97	5 5	75	13	41	10	9.4	10 9	11 0	11 5
New York	79	1 6	91	20	41	1	6.2	5 9	6.9	6 0
N. Carolina	89	3 5	78	10	51	10	8 5	8.5	9.3	8 2
N Dakota	98	0 7	95	12	29	1	7 9	8 1	8.4	7 6
Ohio	84	3 0	100	18	43	1	6.8	6 8	7.0	6 5
Oklahoma	92	2 7	97	12	49	1	8 5	7 1	8 8	6 3
Oregon	92	3 3	91	17	44	7	7.5	6.8	7.8	6 0
Pennsylvania	84	2 5	90	17	44	10	6 1	5.5	6 4	5.1
Rhode Island	41	4 1	98	16	41	1	2.8	3 0	2.8	2 8
S Carolina	92	4 8	69	10	54	1	11.1	12 0	10 7	11 0
S Dakota	98	-0 6	97	12	35	1	7 7	7 4	8 3	6 5
Tennessee	93	2 4	99	11	51	7	7 6	8 4	10 3	8.3
Texas	88	-0 2	100	14	57	7	6.3	7 2	8.0	6 6
Utah	88	2 5	87	14	38	10	6 7	8 8	7 6	7 3
Vermont	94	1 6	100	13	36	10	6 3	5.1	6 3	5 8
Virginia	92	5 4	93	13	50	10	8 1	8 3	7 9	7 5
Washington	89	1 7	99	18	45	10	5 8	6 2	7.0	5 1
W Virginia	92	0 9	61	12	41	3	9 6	8 1	10.3	8 7
Wisconsin	90	0 3	100	16	39	1	6.7	7 5	7.9	7.1
Wyoming	97	3 4	99	16	30	1	8.0	9.2	8.3	9 1

Table 3. The correlation between these two sets of figures was 0. 8343.

With a multiple correlation coefficient of 0. 83 it is evident that about 70 percent of the variation in traffic death rates among the various states can be accounted for by the six factors considered. A high correlation coefficient does not necessarily mean that one factor is the cause of another. Both factors may be the result of a third factor.

This relationship is further illustrated in Figure 3.

As a matter of interest, the correlation between the predicted rate for 1952 and the actual rate for 1953 was 0. 8475 indicating that factors highly related to traffic death rates in 1952 were at least as closely related to the death rates in 1953.

The death rate for 1953 was also predicted by using the above formula but substituting 1953 information that was available. This included the following: (1) percent of total state mileage that is rural, (2) percent of increase in motor vehicle registration 1952-53, (3) percent of state administered highway mileage that is surfaced, and (4) income per capita.

The correlation between the actual and predicted rates for 1953 was 0. 90 indicating that about 80 percent of the variation among the states could be accounted for by these six factors (see Figure 4).

The use of this formula in predicting expected rates can best be illustrated by taking two extreme cases illustrated in Figure 3. Rhode Island had an actual rate of 3. 0 in 1952, the lowest of all 48 states. The predicted rate based on the six factors in the formula was 2. 8. In other words, Rhode Island had about the death rate that would be expected.

On the other hand, South Carolina had the highest actual rate 12. 0 and the second highest predicted rate, 11. 1. Why are these two states on opposite ends of the scale? This question is answered by comparing the two states on the six factors included in the formula for predicting traffic death rates.

	Rhode Island	South Carolina
Percent of state administered highways that is rural	+41%	+92%
Percent increase in motor vehicle registration	+41	+48
Extensiveness of motor vehicle inspection	- 1	- 1
Percent of state administered highway mileage that is surfaced	-98	-69
Average yearly minimum temperature	+41	+54
Income per capita (hundreds of dollars)	-16	-10

Plus factors are those which tend to increase the predicted rate

In each case, except motor vehicle inspection, Rhode Island has the advantage. Even though the actual death rate of South Carolina is four times as great as Rhode Island both rates are about what you would expect from the character of the two states with respect to the six factors considered. In other words a high death rate does not necessarily indicate that the state is doing a poor job.

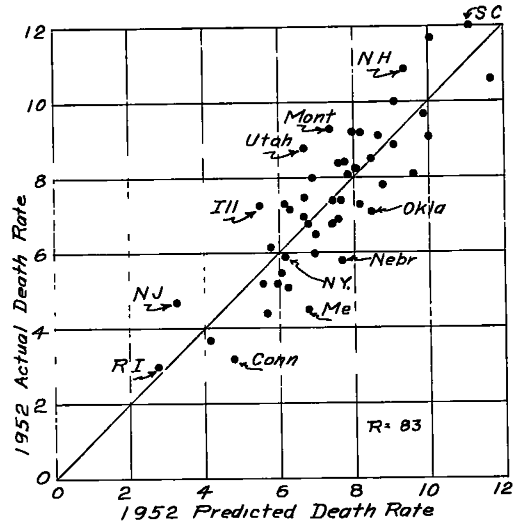

Figure 3. For 1952 the correlation between the actual and predicted traffic death rate was 0.83.

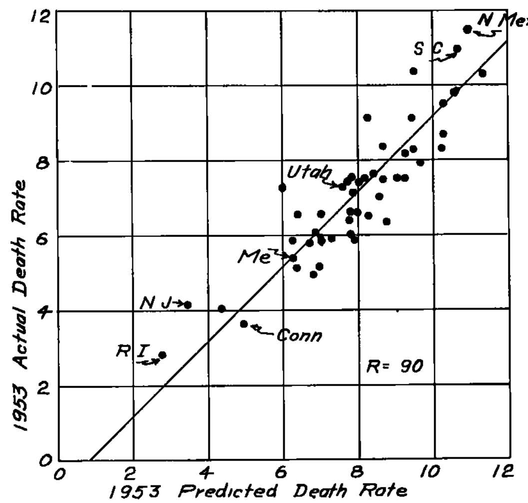

Figure 4. For 1953 the correlation between the actual and predicted traffic death rate was 0.90.

Figure 4 above is based on the following information:

A. Percent of highway mileage that is rural - 1953,

B. Percent increase in motor vehicle registration - 1952-53,

C. Percent of state administered highway mileage that is surfaced - 1953,

D. Income per capita - 1953,

E. Average yearly minimum temperature,

F. Extent of motor vehicle inspection - 1951.

TABLE 4

RANKING OF STATES BY ACTUAL DEATH RATES COMPARED TO EXPECTED RATES

Rank	State	Predicted Rate Minus Actual Rate
1	Maine	+2. 3
2	Nebraska	+1. 9
3	Connecticut	+1. 6
4	West Virginia	+1. 5
5	New Hampshire	+1. 3
6	Arizona	+1. 1
7	Delaware	+1. 0
7	Florida	+1. 0
8	Georgia	+0. 9
9	Kansas	+0. 8
9	Minnesota	+0. 8
9	Vermont	+0. 8
10	Colorado	+0. 7
11	Oregon	+0. 7
11	Oklahoma	+0. 6
12	Pennsylvania	+0. 6
13	Massachusetts	+0. 5
13	Missouri	+0. 5
14	Iowa	+0. 4
15	New York	+0. 3
15	South Dakota	+0. 3
16	Alabama	+0. 2
16	Idaho	+0. 2
17	California	+0. 1
18	North Carolina	0
18	Ohio	0
19	North Dakota	-0. 2
19	Rhode Island	-0. 2
19	Virginia	-0. 2
20	Maryland	-0. 3
21	Arkansas	-0. 4
21	Washington	-0. 4
22	Mississippi	-0. 6
23	Tennessee	-0. 8
23	Wisconsin	-0. 8
24	Kentucky	-0. 9
24	South Carolina	-0. 9
24	Texas	-0. 9
25	Louisiana	-1. 0
26	Indiana	-1. 1
26	Michigan	-1. 1
27	Wyoming	-1. 2
28	New Jersey	-1. 4
29	New Mexico	-1. 5
30	Nevada	-1. 6
31	Illinois	-1. 8
32	Montana	-1. 9
33	Utah	-2. 1

USE OF THE PREDICTED RATES

Death rates are frequently used for comparative purposes. For example, it may by desirable to obtain some measure of the relationship between speed limits and the death rate. Erroneous conclusions will result if the actual death rate only is considered. In such a study all states would be considered, but for illustrative purposes we may compare two states. Oklahoma has a speed limit of 65 and a death rate of 7. 1. Massachusetts has a speed limit of 40 and a death rate of 3. 7. On the surface it looks like a lower speed limit is associated with a lower death rate. Actually, however, by means of the prediction formula, we find that Massachusetts and Oklahoma both had a rate below that expected when the six factors in the formula are considered. Massachusetts has a rate 0. 5 below that expected and Oklahoma, 1. 3 below that expected. Therefore, when other factors are taken into consideration, Oklahoma has a better record than Massachusetts. The data do not substantiate the original conclusion that a lower speed limit is associated with a lower death rate.

In studying other factors to determine their relationship to or affect on the death rate, it seems much more reasonable to use as a basis the amount the actual rate is below or above the expected rate rather than the actual death rate by itself. By doing this the effect of extraneous factors can be reduced and the net effect of the special factor studied can be more accurately determined.

In Table 4 the states have been ranked in order by subtracting the actual rate from the predicted rate. States with a large positive difference are at the top of the list, indicating that their actual rates were much below the expected rates, the expected rates being based on the six factors previously mentioned.

In making an evaluation of the relationship to or affect on the death rate of a given program, it would seem more reasonable to use the rankings of the states in Table 4 rather than the ranking of states based on the actual death rates.

MISCELLANEOUS RELATIONSHIPS

In this analysis 253 simple correlation coefficients were computed (see Table 2).

Some of the relationships are quite substantial and of considerable interest. Some of the more significant relationships are briefly summarized below:

1. A high non-pedestrian death rate is associated with:
   a. a high total traffic death rate
   b. a small percentage of highways surfaced
   c. a low population density
   d. a high percentage of highway mileage that is rural
   e. a high expenditure of funds for new highway construction
   f. a low precipitation
2. A high percentage of the highways that is surfaced is associated with:
   a. a low non-pedestrian death rate
   b. a low population density
   c. a high percentage of state highways that is rural
   d. a high per capita cost for highway construction
   e. a low annual precipitation
3. A high population density is associated with:
   a. a low non-pedestrian death rate
   b. a high percentage of highways that is surfaced
   c. a low percentage of state highways that is rural
   d. a high percentage of population that is urban
   e. a high percentage of schools with driver education
4. States that have a high percentage of state mileage that is rural also have:
   a. A higher non-pedestrian death rate
   b. a lower percentage of highways surfaced
   c. a lower population density
   d. a smaller percentage of population that is urban
5. States that have a high percentage of population that is urban also have:
   a. a greater population density
   b. a lower percentage of highways that is rural
   c. a greater per capita consumption of malt beverages
   d. a larger percentage of schools with driver education
6. States that have a high per capita consumption of malt beverages also have:
   a. a higher percent of the population that is urban
   b. a larger percentage of schools with driver education
   c. a greater income per capita
7. States with the greatest increase in motor vehicle registration also have:
   a. a higher pedestrian death rate
   b. a greater increase in gasoline consumption
   c. a greater increase in population
8. States with a higher percentage of schools giving driver education also have:
   a. a greater population density
   b. a greater percent of population that is urban
   c. a greater per capita consumption of malt beverages
   d. a greater income per capita
9. States with better follow-up programs on dangerous drivers also have:
   a. a higher percentage of schools with driver education
   b. more money spent on follow-up of dangerous drivers
   c. a better driver testing program
10. States with a high pedestrian death rate also have:
    a. a greater increase in motor vehicle registration
    b. a poorer driver education program
    c. a greater increase in gasoline consumption
    d. a greater increase in population
11. States that spend more to follow up dangerous drivers also have:
    a. a better follow-up program on dangerous drivers
12. States with better driver testing programs also have:
    a. better follow-up programs on dangerous drivers

13. States that have warmer climate also have:
    a. more precipitation
14. States with a better driver education program also have:
    a. better follow-up programs for dangerous drivers
    b. a lower pedestrian death rate
    c. more income per capita
15. States with the greatest increase in gasoline consumption also have:
    a. a greater increase in motor vehicle registration
    b. a higher pedestrian death rate
    c. a greater increase in population
16. States that spend more per capita for new highway construction also have:
    a. a higher non-pedestrian death rate
17. States with the greatest increase in population also have:
    a. a greater increase in motor vehicle registration
    b. a higher pedestrian death rate
    c. a greater increase in gasoline consumption
18. States with heavier precipitation also have:
    a. a lower non-pedestrian death rate
    b a higher percentage of highway that is surfaced
    c. a higher average temperature

Highway Accident Analysis Through Use Of IBM Punch Cards

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Traffic Engineering Section, Division of Maintenance Operations
Texas Highway Department

● THE need for more extensive use of traffic accident records by Texas highway engineers has been recognized for many years. Until recently, however, there was no machinery set up which made the records readily available to the engineer, and the size of the job of setting up such machinery was rather formidable. The use of and availability of accident records at the district level were particularly poor, and this is probably the level at which the greatest benefit can be derived from the use of such records. For purposes of highway administration, Texas is divided into 25 districts, each of which includes about ten counties under a district engineer. These district organizations are the backbone of the Department, and it is here that accident records can be used directly and can be applied to specific problems.

The need for providing accident data at the district level was the most important factor to be considered in any accident analysis system that might be adopted. A brief survey of the situation indicated that if any such use of accident records was to be made, it would be necessary to set up a system which could furnish complete data regularly and in a form which lent itself to highway engineering uses. A further study of the situation showed that this would not be a small job, primarily because of the number of accidents, the number of miles of highway, and the yearly vehicle miles to be considered. Since the responsibility of the Highway Department lies primarily in rural areas, the analysis program was limited to rural highways and highway routes within cities of 2,500 population and less. It can be expanded to include larger cities if this is later found to be desirable.

There are about 23,500 miles of rural US and state highways in Texas and about 23,000 miles of rural farm to market roads. Over 16.5 billion miles were driven on these highways in 1954, and there were approximately 30,233 accidents. To handle such large volumes of information efficiently, it was decided, would require some sort of mechanical processing. A study of the methods used in other states was made, but no system was found which seemed to quite fill the need without considerable modification. It was, however, decided that IBM punch cards, which were used by several states, were the most feasible means of handling the data.

The source of the accident records is the files of the Statistical Division of the Texas Department of Public Safety. Texas law requires that a report be filed by each driver involved in an accident in which the total property damage amounts to $25 or more or in which any person is killed or injured. These reports are submitted to the Department of Public Safety where they are processed and filed. Considerable use of the reports and numerous analyses are made by the Department of Public Safety, none of which fills the needs of the highway engineer, primarily because exact location information and collision diagrams are not given sufficient consideration. The reports which the drivers and officers submit are on the standard accident report form recommended by the National Safety Council and are filed yearly by county and date. These records have been available to the highway engineers since 1939, but working with such a great volume of reports made extensive manual analyses extremely laborious. To add to the difficulty, although it increased rural reporting about 85 percent, a safety responsibility law became effective in Texas in 1952. This made it necessary for a large number of accident reports to be removed from the files for long periods of time and rendered the files almost useless as far as the highway engineers were concerned.

These difficulties, which the engineers encountered in trying to use the records as filed by the Department of Public Safety, led to the establishment of the Accident Analysis Section of the Division of Maintenance Operations of the Highway Department. It consists of a traffic analyst and four junior traffic clerks. After the reports have been

TEXAS POLICE OFFICERS' CONFIDENTIAL ACCIDENT REPORT — *MAIL TO Department of Public Safety, No Austin Sta, Austin, Texas*

LOCATION

PLACE WHERE ACCIDENT OCCURRED - County: Coke — City or town: Bronte

If accident was outside city limits indicate distance from nearest town: ___ miles *north-south* / ___ miles *east-west* of ☐ limits of / ☐ center of ___ *City or town*

ROAD ON WHICH ACCIDENT OCCURRED - U.S. 277
Give name of street or highway number (U S or State) if no highway number, identify by name

Check and complete one only: ☒ AT ITS INTERSECTION WITH S.H. 158 *Name of intersecting street or highway number*
OR
☐ NOT AT INTERSECTION — ___ feet *north-south* / ___ feet *east-west* of ___ *Show nearest intersecting street or highway, house number, bridge, railroad crossing, culvert, milepost, underpass, or other identifying landmark. Show exact distance*

DO NOT WRITE IN THIS SPACE: No — Loc — S R — Fat rec — Dr rec — Code — Type — FAT — P I — P D

TIME: Date of Accident April 20, 19 54 — Day of Week Tuesday — Hour 5:30 ☐ A M ☒ P M — *If exactly noon or midnight, so state*

ROAD

CHARACTER *(Check two)*	SURFACE CONDITION *(Check one)*	TRAFFIC CONTROL *(Check one or more)*	KIND OF LOCALITY *Check one to show that area within 300 feet was primarily*	LIGHT *(Check one)*
☒ Straight road ☐ Curve ☒ Level ☐ On grade ☐ Hillcrest	☒ Dry ☐ Wet ☐ Muddy ☐ Snowy ☐ Icy	☐ Officer or watchman ☒ Stop-and-go or flashing light ☐ Stop sign ☐ Warning sign (curve, school, etc) ☐ Railroad crossing gates ☐ Railroad automatic signal ☐ One way street ☐ Traffic lanes painted or marked ☒ Center stripe ☐ ___ *Specify Other* ☐ No traffic control present	☐ Manufacturing or industrial ☒ Shopping or business ☐ Residential district ☐ School or playground ☐ Open country ☐ ___ *Specify Other*	☒ Daylight ☐ Dusk ☐ Dawn ☐ Darkness - street lights ☐ Darkness - no street lights
SURFACE *(Check one)* ☐ Concrete ☒ Blacktop ☐ Brick ☐ Gravel ☐ Dirt ☐ ___ *Specify Other*	**DEFECTS** *(Check one or more)* ☐ Defective shoulders ☐ Holes, deep ruts, bumps, etc ☐ Loose material on surface ☐ Under construction ☐ ___ *Specify Other* ☒ No defects			**WEATHER** *(Check one)* ☒ Clear ☐ Raining ☐ Snowing ☐ Fog ☐ ___ *Specify Other*

VEHICLES

VEHICLE No 1 -
Year Model '52 Chev — Type of Vehicle Panel Truck *Sedan tractor-semi-trailer, taxi, etc* — Vehicle Registration '54 *Year* Texas *State* Z/Z 4102 *Number* — Commodity Carried ___ *Butane, mixed freight etc* — ☐ Loaded ☐ Empty
DRIVER Mary Ellen Doe, *Name* 619 Lake Austin Boulevard, *Address* Austin, Texas *City and State* — Age 19 — Sex F
Race of Driver W *White, negro, etc* — Driver's Occupation Student *Carpenter, doctor, sales clerk, etc* — Driving Experience 4 *Years* — Driver's License Texas *State* 93752001 *Number* — ☐ Chauffeur's ☒ Operator's ☐ Com Op
Speed Before Accident 30 m p h — Legal Speed Limit 30 m p h — Maximum Safe Speed 30 m p h — Approximate cost to repair vehicle $ 250.00
Owner Wm. Doe *Name* -Same- *Address* — Vehicle Removed To home by owner *Name of garage, home by owner, driven away, etc*

VEHICLE No 2 -
Year Model '53 Merc — Type of Vehicle Coach *Sedan, tractor-semi-trailer, taxi, etc* — Vehicle Registration '54 *Year* Texas *State* Z/Z 4905 *Number* — Commodity Carried ___ *Butane, mixed freight, etc* — ☐ Loaded ☐ Empty
DRIVER John H. Rhoe, *Name* 2102 Lavaca Street, *Address* Austin, Texas *City and State* — Age 40 — Sex M
Race of Driver W *White, negro, etc* — Driver's Occupation Salesman *Carpenter, doctor, sales clerk, etc* — Driving Experience 22 *Years* — Driver's License Texas *State* 99600007 *Number* — ☐ Chauffeur's ☐ Operator's ☒ Com Op
Speed Before Accident 10 m p h — Legal Speed Limit 30 m p h — Maximum Safe Speed 0 m p h — Approximate cost to repair vehicle $ 100.00
Owner ___ *Name* -Same- *Address* — Vehicle Removed To driven away *Name of garage, home by owner, driven away, etc*

For Other vehicles use another form — *Total vehicles involved*

DAMAGE TO PROPERTY OTHER THAN VEHICLES: None *Name object, show ownership, and state nature of damage* — Approximate cost to repair $

CASUALTIES — NONE

No 1 - Name ___ Address ___ Age ___ Sex ___ Race ___ Was person killed? ___ Date of Death ___ Taken to ___ By ___ — ☐ Driver ☐ Passenger } In vehicle No ☐ Pedestrian ☐ ___ *Specify other*

No 2 - Name ___ Address ___ Age ___ Sex ___ Race ___ Was person killed? ___ Date of Death ___ Taken to ___ By ___ — ☐ Driver ☐ Passenger } In vehicle No ☐ Pedestrian ☐ ___ *Specify other*

Total

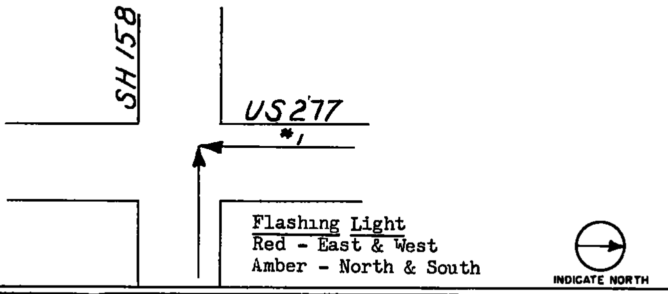
WITNESSES - NONE

Name ___ Address ___ — Where Was Witness *In veh 2, ped 60 ft east, etc*
Name ___ Address ___

REV CF 11 52

Figure 1. Typical traffic accident report.

INDICATE ON THIS DIAGRAM WHAT HAPPENED



INSTRUCTIONS
1 Follow dotted lines to draw outline of roadway at place of accident
2 Number each vehicle and show direction of travel by arrow
3 Use solid line to show path before accident, dotted line after accident
4 Show pedestrian by
5 Show railroad by
6 Show distance and direction to landmarks, identify landmarks by name or number

WHAT DRIVERS WERE DOING *(Check one for each driver)*

Driver 1 2
- ☒ ☒ Going straight ahead
- ☐ ☐ Making right turn
- ☐ ☐ Making left turn
- ☐ ☐ Making U turn
- ☐ ☐ Slowing or stopping
- ☐ ☐ Starting in traffic lane
- ☐ ☐ Starting from parked position
- ☐ ☐ Stopped in traffic lane
- ☐ ☐ Properly parked
- ☐ ☐ Backing

(Check applicable items)
- ☐ ☐ Passing
- ☐ ☐ Avoiding vehicle, object or pedestrian
- ☐ ☐ Skidded - before applying brakes
- ☐ ☐ Skidded - after applying brakes
- ☐ ☐ Driverless moving vehicle

DRIVERS VIOLATIONS INDICATED *(Check one or more for each driver)*

Driver 1 2
- ☐ ☐ Had been drinking
- ☐ ☐ Exceeded safe speed
- ☐ ☐ Exceeded legal speed
- ☐ ☒ Failed to grant right of way to vehicle
- ☐ ☐ Following too closely
- ☐ ☐ Passing without sufficient clearance
- ☐ ☐ Passing in no passing zone
- ☐ ☐ Passing on wrong side
- ☐ ☐ Other improper passing
- ☐ ☐ On wrong side of road - not passing
- ☐ ☐ Failure to signal or improper signal
- ☐ ☐ Improper turn - wide right turn
- ☐ ☐ Improper turn - cut corner on left
- ☐ ☐ Improper turn - from wrong lane
- ☐ ☐ Railroad crossing violation
- ☐ ☐ Disregard stop sign
- ☐ ☐ Disregard stop-and-go light
- ☐ ☐ Disregard warning sign

Driver 1 2
- ☐ ☐ Improper parking location
- ☐ ☐ Improper starting from parked position
- ☐ ☐ Impeding traffic-too slow
- ☐ ☐ Careless or reckless driving
- ☐ ☐ Hit and Run (F S R A)
- ☐ ☐ Overweight or oversize
- ☐ ☐ Other improper action
- ☒ ☐ No improper driving

WHAT PEDESTRIAN WAS DOING *(Check one)*
- ☐ Crossing at intersection - with signal
- ☐ Crossing at intersection - against signal
- ☐ Crossing at intersection - no signal
- ☐ Crossing at intersection - diagonally
- ☐ Crossing not at intersection
- ☐ Coming from behind parked cars
- ☐ Walking in roadway - *(Check two below)*
  - ☐ With traffic
  - ☐ Against traffic
  - ☐ Sidewalks available
  - ☐ Sidewalks not available
- ☐ Pushing or working on vehicle
- ☐ Other working on roadway
- ☐ Playing on roadway
- ☐ Hitching on vehicle
- ☐ Not on roadway - *(Explain)*
- ☐ *Specify other action*

CONDITION OF DRIVERS AND PEDESTRIAN

PHYSICAL

Driver 1 2 Ped
- ☐ ☐ ☐ Ill
- ☐ ☐ ☐ Fatigued
- ☐ ☐ ☐ Apparently asleep
- ☐ ☐ ☐ Body defect (arms, legs, hearing, eyesight, paralysis, etc)
- ☒ ☒ ☐ Apparently normal
- ☐ ☐ ☐ Condition not known

Explain condition

DRINKING

Driver 1 2 Ped
- ☒ ☒ ☐ Had not been drinking
- ☐ ☐ ☐ Not known whether drinking

Had been drinking If so
- ☐ ☐ ☐ Obviously drunk
- ☐ ☐ ☐ Ability impaired
- ☐ ☐ ☐ Ability not impaired
- ☐ ☐ ☐ Not known if impaired

VEHICLE CONDITION *(Check one or more)*

Driver 1 2
- ☐ ☐ Defective brakes
- ☐ ☐ Improper lights
- ☐ ☐ Defective steering mechanism
- ☐ ☐ Defective tires
- ☐ ☐ Other defects
- ☒ ☒ No defects
- ☐ ☐ Defects not known
- ☐ ☐ Chains in use

DRIVER VISION OBSCURED *(Check one or more in each section)*

Driver 1 2
- ☐ ☐ Rain, snow, etc on windshield
- ☐ ☐ Windshield otherwise obscured
- ☐ ☐ Vision obscured by load on vehicle
- ☐ ☐ *Specify other*
- ☒ ☒ Vision not obscured

Driver 1 2
- ☐ ☐ Trees, crops, etc
- ☐ ☐ Building
- ☐ ☐ Embankment
- ☐ ☐ Signboard
- ☐ ☐ Hillcrest
- ☐ ☐ Parked vehicles
- ☐ ☐ Moving vehicles
- ☐ ☐ *Specify other*
- ☒ ☒ Not obscured

DESCRIBE WHAT HAPPENED

No. 2 stopped at red flashing light then pulled into intersection hitting No. 1 broadside with right front of vehicle No. 2.

ARRESTS Name John H. Rhoe Charge Fail to grant R.O.W. (vehicle)

Name Charge

INVESTIGATION Time notified of accident 4-20-54 *Date* 6:30 *Hour* ☐ AM ☒ PM Time arrived at the scene 4-20-54 *Date* 7:15 *Hour* ☐ AM ☒ PM Were photographs taken? ☐ Yes ☒ No

Where else was investigation made? scene only Is investigation complete? ☒ Yes ☐ No Driver report forms furnished to ☒ Driver 1 ☐ Driver 2

★**SIGNATURE** *Investigator's rank and name* T.H.P. *Department* 4-20-54 *Date of report*

IMPORTANT! *The driver of every motor vehicle involved in an accident is required to submit a separate accident report even though the accident was investigated by an officer. Drivers' accident report forms are available at all city, county, and state police offices.* REV C F 5 16 50

Figure 1. (Continued).

Serial 78121

TEXAS HIGHWAY DEPARTMENT
DIVISION OF MAINTENANCE OPERATIONS
TRAFFIC ENGINEERING SECTION
ACCIDENT ANALYSIS CODE SHEET

Coded by ________
Punched by ________
Checked by ________

Serial Number					County			Highway Number 1: Control				Section		F.A.	Milepost			Type	Width		Curves	Sight Restriction	
7	8	1	2	1	0	4	1	0	2	6	4	0	4	4	1	4	4	1	2	0	0	0	0
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Highway Number 2: Section		F.A.	Type	Width		Intersection Type		Direction of Travel No.1	No.2	Type of Accident	Manner of Collision	Contributing Factor		Car Number 1: Maneuver			From		To		Car Number 2: Maneuver			From		To	
0	1	4	1	2	0	4	1	1	7	2	2	0	8	0	0	1	0	1	0	1	0	0	1	4	5	0	1
25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52

Violation	Driver Condition No.1	No.2	Vehicle Condition No.1	No.2	Date: Mo.	Day		Yr.	Day of Week	Time		Alignment	Surface Type	Surface Condition	Road Defects	Traffic Control	Locality Type	Weather	Vehicle Type No.1	No.2	Speed Before Accident No.1	No.2	Number of Vehicles	Number Killed	Number Injured		
2	1	1	1	1	4	2	0	4	3	1	7	1	2	1	9	3	2	1	2	1	4	2	2	0	0		
53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

STATISTICAL DIVISION
TEXAS DEPARTMENT OF PUBLIC SAFETY

Figure 2. Typical code sheet.

CODE HEADINGS

1 SERIAL NUMBER - COLUMNS 1-5
2 COUNTY - COLUMNS 6-8
3 CONTROL, HIGHWAY NO. 1 - COLUMNS 9-12
4 SECTION, HIGHWAY NO. 1 - COLUMNS 13-14
5 FEDERAL AID STATUS, HIGHWAY NO 1 - COLUMN 15
6 MILEPOST, HIGHWAY NO 1 - COLUMNS 16-18
7 ROADWAY TYPE, HIGHWAY NO 1 - COLUMN 19
8 ROADWAY WIDTH, HIGHWAY NO 1 - COLUMNS 20-21
9. EXCESSIVE CURVES, HIGHWAY NO 1 - COLUMN 22
10 SIGHT DISTANCE RESTRICTION, HIGHWAY NO. 1 - COLUMNS 23-24
11 SECTION, HIGHWAY NO 2 - COLUMNS 25-26
12 FEDERAL AID STATUS, HIGHWAY NO. 2 - COLUMN 27
13. ROADWAY TYPE, HIGHWAY NO 2 - COLUMN 28
14 ROADWAY WIDTH, HIGHWAY NO. 2 - COLUMNS 29-30
15. INTERSECTION TYPE - COLUMNS 31-32
16. DIRECTION OF TRAVEL BEFORE ACCIDENT - COLUMNS 33-34
17. TYPE OF ACCIDENT - COLUMN 35
18 MANNER OF COLLISION - COLUMN 36
19. CONTRIBUTING FACTORS - COLUMNS 37-38
20 MANEUVER - COLUMNS 39-41 and 46-48
21. FROM - COLUMNS 42-43 and 49-50
22 TO - COLUMNS 44-45 and 51-52
23 VIOLATION - COLUMN 53
24. CONDITION OF DRIVER - COLUMNS 54-55
25 CONDITION OF VEHICLE - COLUMNS 56-57
26. MONTH - COLUMN 58
27 DAY OF MONTH - COLUMNS 59-60
28. YEAR - COLUMN 61
29 DAY OF WEEK - COLUMN 62
30 TIME - COLUMNS 63-64
31 ROADWAY ALIGNMENT - COLUMN 65
32. SURFACE TYPE - COLUMN 66
33 SURFACE CONDITION - COLUMN 67
34 ROAD DEFECTS - COLUMN 68
35 TRAFFIC CONTROL - COLUMN 69
36 TYPE OF LOCALITY - COLUMN 70
37 WEATHER CONDITION - COLUMN 71
38. TYPE OF VEHICLE - COLUMNS 72-73
39 VEHICLE SPEED BEFORE ACCIDENT - COLUMNS 74-75
40 NUMBER OF VEHICLES - COLUMN 76
41 FATALITY AND NUMBER - COLUMN 77
42. PERSONAL INJURY AND NUMBER - COLUMN 78

Figure 3. Code headings showing the categories of data which are transferred from the accident report to the IBM punch card.

processed by the Department of Public Safety, they are turned over to the Highway Department for coding. This is normally about 15 to 20 days after the date of occurrence of the accident. The reports are coded and returned to the Department of Public Safety for filing or transfer to another section. During the coding process, all of the information of engineering value is taken from the report as shown in Figure 1 and converted into numerical form as shown on the code sheet in Figure 2. This coding is, of course, the most fundamental part of the system. Much of the information on the report can be coded into numerical form merely by assigning numbers to each of the items in the particular category. The location and the collision diagram, however, presented a more complicated problem. A list of the code headings is shown in Figure 3.

The location of the accident as described in the original report (Figure 1) is either at or in terms of measured distance from some easily describable spot. In order to code the location, it was necessary to translate the information into a basic, consistent form. The most practical means for doing this was found to be the use of the Road Inventory Log Line Diagrams. A sample of a page from this log is shown in Figure 4. These are prepared by the Highway Planning Survey for all of the designated roads in the state and provide considerable data about each road including a milepost designation which indicates the mileage from the county line. These milepost data were used to show the location of the accident in the code. The coder first locates the accident on the log using the description of the location given in the original report. From the log, the coder then transcribes the control number, which is a breakdown of the highway system; the section number, which is a breakdown of the control number; and the milepost, which indicates the location of the accident to the nearest tenth mile. The location of the accident has now been established. The collision diagram remains as the next major difficulty.

The mileposts which were used in establishing the location of the accidents follow a definite pattern over the state. They normally increase from north to south on north-south highways and from west to east on west-east highways. This being the case, it was decided to use the direction of increasing milepost numbers on the major highway involved as the basis for showing the direction of travel of a vehicle. The other possible directions are indicated as shown in Figure 5. Thus, if a car is traveling in the direction opposite to the milepost numbers, it is coded as 5.

The next step in the preparation of the collision diagram is the manner of collision. The possibilities here are shown in Figure 6. The From, Maneuver and To codes complete the collision diagram. The From codes, some of which are shown in Figure 7, show where the vehicle was before it started the maneuver which led to the accident. The Maneuver code (Figure 8) shows what maneuver the vehicle made, and the To code, which uses the same items as the From code, shows where the vehicle went or intended to go. Thus, with Direction of Travel, From, Maneuver and To, the path of the vehicle has been established. This process can be repeated for a second vehicle if one is involved. The accident then occurred at the point where the two paths cross. Knowing the manner in which the two vehicles collided adds the final touch to the collision diagram.

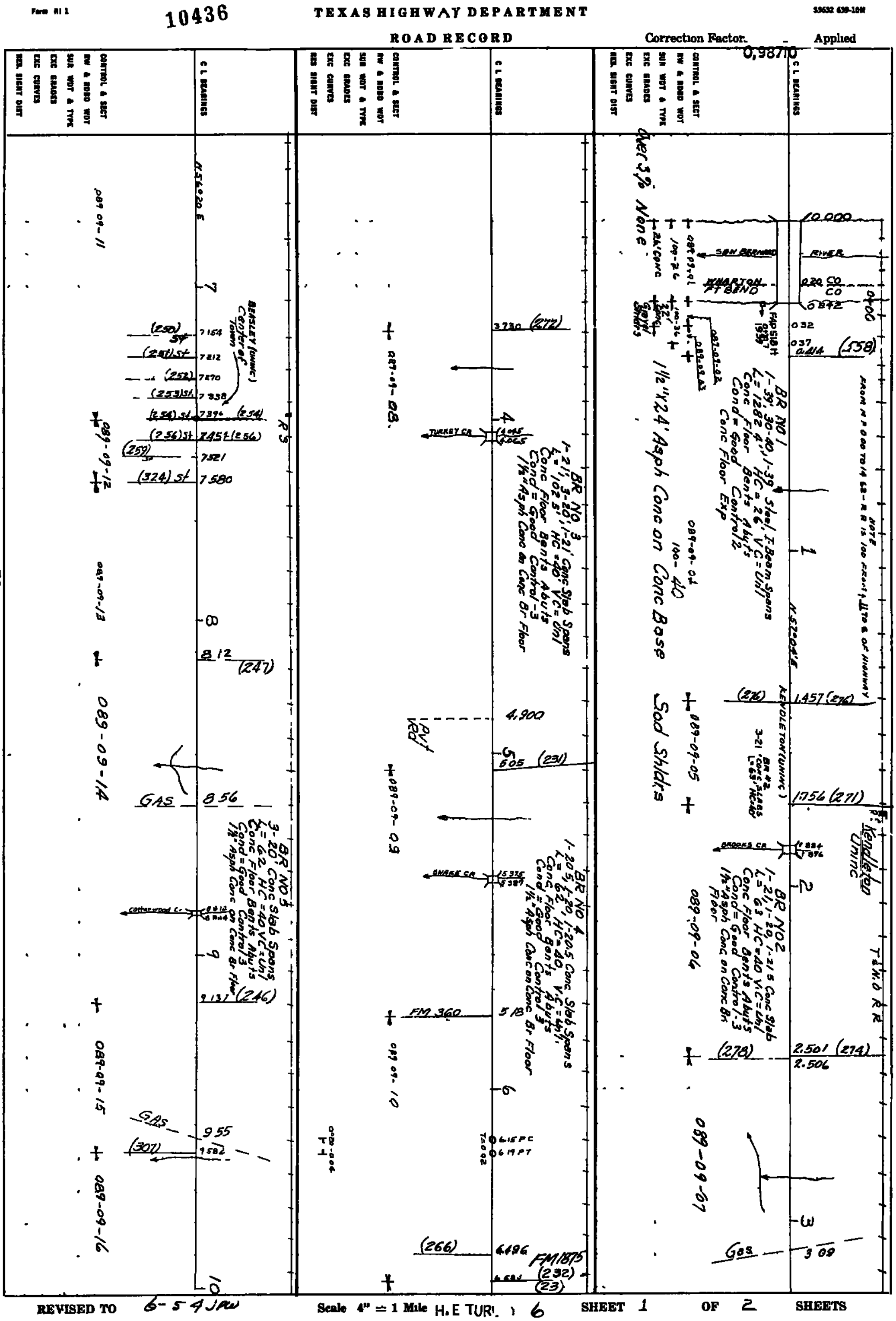
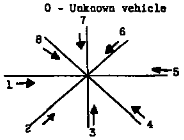


Figure 4. Typical sheet from road inventory log line diagram showing a section of US 277 in Coke County.

DIRECTION OF TRAVEL BEFORE ACCIDENT - COLUMNS 33-34

In this column the direction of travel of the vehicle is recorded It is measured with reference to the milepost numbering on the major highway That is to say, if mileposts on Highway No 1 are numbered from west to east, a car traveling from west to east on Highway No 1 would be going ahead and therefore be punched in number 1 A car approaching from the south on a lesser highway would be coming from the right and therefore punched in number 3 Right rear and opposite right, etc , should be used for traffic approaching at an angle Column 33 refers to Vehicle No 1 and Column 34 refers to Vehicle No 2

1 - Ahead
2 - Right rear
3 - Right
4 - Opposite right
5 - Opposite
6 - Opposite left
7 - Left
8 - Left rear
9 - No second vehicle*
0 - Unknown vehicle



Direction of → Milepost Numbers Either North to South or West to East

*This would apply for Column 34 where only one vehicle was involved

Figure 5. Page from Code Manual showing the code for Direction of Travel.

MANNER OF COLLISION - COLUMN 36

In this column code the manner of collision as follows This information will come from the sketch on the back of the report and from the discussion

1 - Non-collision
2 - Right angle
3 - Head-on
4 - Sideswipe, same direction
5 - Sideswipe, opposite direction
6 - Left turn
7 - Right turn
8 - Rear end
9 - Parking maneuver
+ - Fixed object
0 - Other (includes animal or pedestrian)

Figure 6. Page from Code Manual showing the code for Manner of Collision.

If only one car was involved, the From, Maneuver and To codes plus the Manner of Collision code show at what point the vehicle became involved in an accident.

It might be well to point out some of the basic considerations which guided the thinking in setting up the code. The reason for setting up a system was to provide information which could be used in preventing future accidents. This being the case, the events leading up to and including the first collision were thought to be of prime importance. Subsequent events are not particularly important as far as accident prevention work is concerned. Complete data on only two vehicles and drivers were included, and although more than two vehicles are often involved, it was thought that the cause of the accident lies with the collision of the first two. Other vehicles subsequently involved become so as the direct result of the first collision and probably would not have been in an accident at all had not the first collision occurred. By limiting the amount of coded data in this manner, it was felt that the percentage of pertinent information, that is data which can actually be put to use in determining means of preventing future accidents, was kept at a very high level.

The coding and the code sheet shown in Figure 2 are the first step in the process. From the code sheet, the data are transferred to an IBM card as shown in Figure 9. This involves merely punching the numbers from the code sheet into the card. Complete data on each accident have now been transferred to a single IBM card. In this form, it is highly versatile since it can be manipulated quickly and inexpensively into any order required and can be listed mechanically.

Since the system was put into operation on July 1, 1954, the records for the last six months of the year 1954 are the only ones now complete and the listings published. The 1955 records are in the process of being completed and will be published in the very near future. Three standard forms of presenting the data are in use at the present time along with county spot maps which are not a product of the punch card process but which add considerably to the general usefulness of the information. These are (1) the master tabulation, Figure 10, which is a complete tabulation of all the data on each card listed by county and highway section and in increasing milepost order within the section - a section being a breakdown of the highway system with a numerical designation not duplicated in the state and

FROM - COLUMNS 42-43 and 49-50

In these columns code where the vehicle was before the accident or before beginning the maneuver which led to the accident Columns 42 and 43 refer to Vehicle No 1 and Columns 49 and 50 refer to Vehicle No 2

Highway and Right-of-Way Features

Highway No 1

01 - Lane to right of center line or median
02 - Second lane to right of center line or median
03 - Third or more lane to right of center line or median
04 - Right shoulder
05 - Parallel parking stall on right
06 - Angle parking stall on right
07 - Sidewalk parallel to highway on right
08 - Sidewalk at right angles to highway from right
09 - Island or divider on right
10 - Bridge end or rail on right
11 - Parking area off shoulder on right
12 -
13 -
14 -
15 - Lane to left of center line or median
16 - Second lane to left of center line or median
17 - Third or more lane to left of center line or median
18 - Left shoulder
19 - Parallel parking stall on left
20 - Angle parking stall on left
21 - Sidewalk parallel to highway on left
22 - Sidewalk at right angles to highway from left
23 - Island or divider on left
24 - Bridge end or rail on left
25 - Parking area off shoulder on left
26 -

Figure 7. Page from Code Manual showing the code for From and To. The same items are used for both From and To.

ranging in length from about 5 to 25 miles; (2) Tabulation No. 2, which is a summary of accidents by section, broken down by severity and manner of collision; and (3) an accident rate tabulation by highway section, Figure 11, wherein the accident data have been correlated with vehicle miles, which are also on IBM punch cards, making it pos-

MANEUVER - COLUMNS 39-41 and 46-48 MAJOR HEADING BREAKDOWN

In these columns code the maneuver which the vehicle was making, preparing to make or attempting to make at the time of the accident. Columns 39-41 refer to Vehicle No 1 and Columns 46-48 refer to Vehicle No. 2

The following tabulation is a breakdown of the major categories of maneuvers. It will be necessary to get the actual code from the following pages.

Codes

001-050 - Moving Ahead
051-100 - Turning
101-150 - Passing
151-200 - Driving Across Centerline, Not Passing
201-290 - Driving Off Of and Onto the Roadway
291-300 - Lost Control on Roadway
301-400 - Parked, Stopped or Moving Slowly
401-450 - Pedestrian Maneuver
451-475 - Animal Maneuver, Other than Animal Drawn Vehicle
476-500 - Train Maneuver

Animal Drawn Vehicle Maneuvers will be the same as other vehicles

U turning vehicles shall be considered as left turning vehicles unless a specific U turn code is provided.

MANEUVER
CODES

Turning - Codes 051-100

051 - Making right turn
052 - Making prohibited right turn
053 - Making right turn from wrong lane
054 - Making right turn into wrong lane
055 - Making wide right turn
056 - Cut right turn too short

075 - Making left turn
076 - Making prohibited left turn
077 - Making left turn from wrong lane
078 - Making left turn into wrong lane
079 - Making wide left turn
080 - Cut left turn too short

091 - Making U turn
092 - Making prohibited U turn
093 - Making U turn from wrong lane
094 - Making U turn into wrong lane
095 - Making wide U turn
096 - Cut U turn too short

MANEUVER
CODES

Moving Ahead - Codes 001-050

001 - Going ahead in lane to right of centerline or median
002 - Going ahead in 2nd lane to right of centerline or median
003 - Going ahead in 3rd lane to right of centerline or median
004 - Going ahead on right shoulder
005 - Going ahead in middle lane of three lane road
006 - Going around curve to right to right of centerline or median
007 - Going around curve to left to right of centerline or median

Figure 8. Part of Code Manual showing the major breakdown of the maneuver code and part of the maneuver codes items.

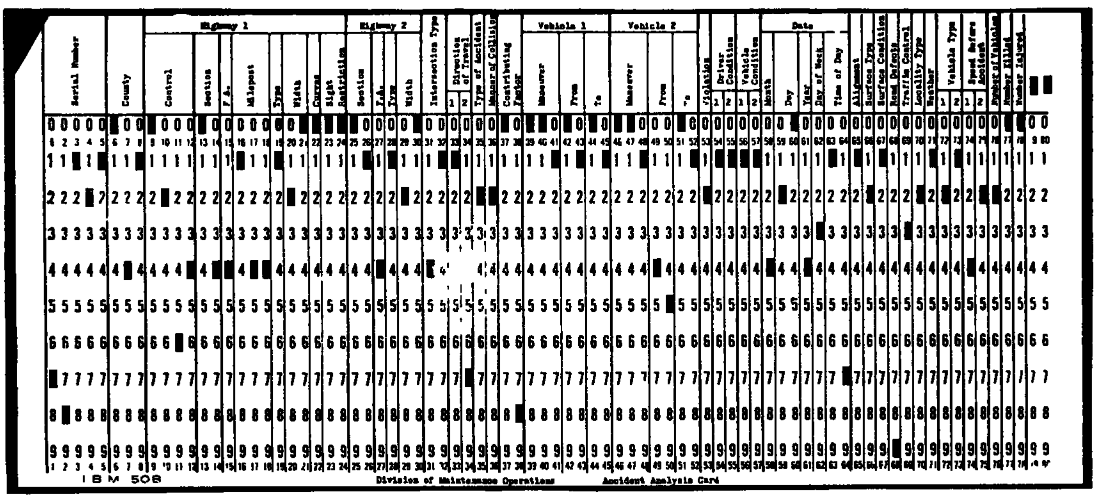


Figure 9. Typical IBM punch card.

TABULATION NO. 1, MASTER LISTING

Control No Highway No 1	Section Highway No 1	Section Highway No 2	Highway No 1: Milepost	F A Status	Type	Width	Curves	Sight Restriction	Hwy No 2: F A Status	Type	Width	Intersection Type	No 1 No 2 Direction of Travel	Type of Accident	Manner of Collision	Contributing Factor	Car No 1: Maneuver	From	To	Car No 2: Maneuver	From	To	Violation	No 1 No 2 Driver Condition	No 1 No 2 Vehicle Condition	Date: Month	Day of Month	Year	Day of Week	Time	Alignment	Surface Type	Surface Cond	Road Defect	Traffic Control	Locality Type	Weather	No 1 No 2 Vehicle Type	No 1 No 2 Speed Before Accident	Number of Vehicles	Number Killed	Number Injured	Serial Number
52	2		D05		11	48		MI		BAILEY							9	US		84																							
52	02	00	042	2	1	20	0	00	0	0	00	00	11	2	8	00	001	01	01	001	01	01	1	11	12	8	21	4	7	10	1	2	2	9	9	5	2	21	50	2	0	0	28508
52	02	00	058	2	1	20	0	00	0	0	00	00	51	2	6	08	091	15	01	001	01	01	7	11	11	9	26	4	1	19	1	2	2	0	9	5	2	13	00	3	0	0	32442
52	02	00	058	2	1	20	0	00	0	0	00	00	19	7	0	00	001	01	01	452	04	01	0	19	1-	9	12	4	1	20	1	2	0	0	0	5	0	19	6-	1	0	0	34453
52	02	00	089	2	1	20	0	00	0	0	05	00	55	2	7	07	051	15	15	001	15	15	6	11	11	-	15	4	2	08	1	2	0	0	0	5	0	12	40	2	0	0	38426
52	02	00	106	2	3	38	0	00	0	0	02	34	57	2	2	08	001	15	15	080	45	15	8	11	10	8	03	4	3	13	1	2	1	9	2	2	1	12	40	2	0	1	26685
52	3		D05		8	30		MI		BAILEY							9	US		84																							
52	03	00	106	2	3	38	0	00	0	0	04	00	55	2	6	08	093	16	15	001	15	15	7	11	00	8	03	4	6	18	1	2	1	9	8	2	1	11	25	2	0	0	40303
52	03	00	114	2	1	20	0	00	0	0	00	00	55	2	6	38	001	15	15	091	18	15	7	11	11	8	12	4	5	15	1	2	1	9	8	2	1	13	22	2	0	0	27565
52	03	00	118	2	1	22	0	00	0	0	00	00	15	2	5	17	001	01	01	104	15	01	1	11	11	7	07	4	4	08	1	2	0	0	0	5	0	11	07	2	2	0	4029
52	03	00	145	2	1	20	0	00	0	0	00	00	19	7	0	36	001	15	15	451	15	15	0	09	0-	7	19	4	2	01	1	2	0	0	0	5	0	1-	7-	1	0	0	25232
52	03	00	155	2	1	20	0	00	0	0	00	00	19	9	0	00	001	01	01	001	15	01	0	19	1-	8	12	4	5	20	1	2	1	9	9	5	1	1-	6-	1	0	0	27564
145	1		D05		6	50		MI		BAILEY							9	US		70																							
145	01	01	000	2	1	20	0	00	4	1	20	41	15	2	6	08	075	45	15	001	15	15	2	11	11	9	09	4	5	10	1	2	0	0	2	0	0	11	33	2	0	0	30705
145	01	00	009	2	1	20	1	00	0	0	10	00	19	0	1	00	239	01	04	000	00	00	5	19	0-	-	25	4	5	22	4	2	0	0	0	0	0	1-	6-	1	0	0	39480

TEXAS HIGHWAY DEPARTMENT

DIVISION OF MAINTENANCE OPERATIONS — TRAFFIC ENGINEERING SECTION

Figure 10. Typical sheet from the master tabulation showing complete data on some of the accidents in Anderson County.

County Knox District 25

Highway	Control	Section	Length in Miles	Vehicle Miles in 1000's	Fatalities	Number of Accidents: Fatal	Fatal + Injury	Total	Accident Rates Per 100 Million Vehicle Miles: Total	Fatality	Fatal Accident	Fatal + Injury
S 283	98	4	15 9	5			1	3	328 7			109.5
S 283	98	5	12.5	8			1	4	273 9			68.4
US 82	133	2	11 0	13			1	4	168 5			42.1
US 82	133	3	18 6	24			2	4	91 3			45.6
US 277	157	2	11.1	18			4	13	395.7			121.7
SH 222	496	1	10 2	9			1	6	365 2			60.8
SH 222	496	2	.4		1	1	2	8				
FM 143	496	4	7.8	2								-
FM 1043	496	5	2 4									—
FM 267	538	1	10 9	3								
FM 267	538	2	17 5	2				1	273 9	-		—
FM 1756	538	5	3.9	—				1	—	—	—	—
FM 266	758	1	7.6	1				2	95.8	—	—	—
FM 1587	1512	1	5.1	1				2	95 8	-	—	—

Figure 11. Typical sheet from the accident rate tabulations for the sections of road in Knox County.

sible to compute accidents rates for each of the 5,000 sections of the Texas highway system. Four rates for each section are shown. They are Fatality Rate, Fatal Accident Rate, Fatal + Injury Accident Rate and Total Accident Rate. The Fatal + Injury Rate is used because for such short units of road, the number of accidents is often very small and the rates erratic. By figuring a rate which included both fatal and injury accidents, the sample was as large as possible and at the same time included only those categories of accidents for which the percentage of accidents reported was very high.

These rate calculations are an excellent example of the extreme adaptability of IBM punch cards in accident analyses. Four rates were computed for each of about 5,000 sections, making a total of about 20,000 computations which were accomplished mechanically in about two days. This would have been nearly impossible by any other method.

The master tabulation provides the districts with information which can be applied to specific locations, making it possible to construct collision diagrams — the most fundamental use of accident records. Tabulation No. 2 and the rate figures are valuable in making comparisons and in evaluating sections of road in terms of improvements and needed improvements. In addition to these, there are endless possibilities for analyses with the records in punch card form. Special studies covering any phase of the information in the card can be made quickly and easily, making the accident records applicable to use in many phases of highway research.

The mechanics of the system, which has been in operation since July 1, 1954, operate very smoothly. Although the amount of data accumulated up to this time is too small for a final evaluation, all indications are that the districts are making considerable use of the information furnished them and that the system will prove to be of great benefit.

Virginia's Cooperative Accident Analysis System

ALFRED VICK, III, Associate Traffic and Planning Engineer
Virginia Department of Highways

● THIS report will describe Virginia's cooperative accident analysis system. The need for more constructive use of the information contained in the accident records available in Virginia became apparent to the Highway Commissioner, General James A. Anderson, and other administrative personnel of the Highway Department. In 1952, this resulted in the establishment of the present accident analysis system which combines the use of mechanical punch cards and a special adaptation of the graphic log system. As the title of this report indicates, the outstanding feature of this accident analysis system is the fact that it is a joint safety program participated in by both the State Police and the Highway Department. To coordinate and supervise this program, the Accident Study Section was created within the Traffic and Planning Division of the Virginia Department of Highways. The personnel in this section consists of the section head, three investigators, one statistician, two traffic technicians, and one clerk stenographer.

Accident facts are one of the most convincing means of presenting to the public and state legislature the complex and varied problems facing present day road builders. These facts help justify the amount of funds needed to carry out an adequate highway program.

DEVELOPMENT OF TRAFFIC ACCIDENT PREVENTION PROGRAM IN VIRGINIA

One of the earliest and most important steps in the development of the traffic accident prevention program in Virginia was the enactment by the state legislature of the Motor Vehicle Safety Responsibility Act, which became effective on January 1, 1945. This act made it mandatory for the driver of any vehicle involved in an accident resulting in injuries or death to any person or property damage of $50 or more, to file a report of the accident with the Division of Motor Vehicles. One section of this act required the Division of Motor Vehicles to furnish the Department of State Police with a photostatic copy of each original accident report filed at the Division. This act was responsible for the State Police revising the existing mechanical punch card system for handling traffic accident data, so that more detailed information could be secured from the photostatic copies of the original accident reports. The State Police use accident information gained through this procedure to aid them in the enforcement of the Motor Vehicle Code. Further, it is of immeasurable benefit in determining the assignment of manpower and equipment, as well as where the State Police should concentrate their efforts in driver education.

The first extensive use of accident records by the Highway Department was in 1945, when one man from the Traffic and Planning Division worked in the Accident Records Section of the State Police collecting manually accident data from the photostats of reported accidents to be used in connection with certain traffic studies and investigations. This was the earliest planned cooperative effort of the State Police and the Highway Department in the mutual use of accident records. It was necessary for the Highway Department to collect information manually because the State Police punch card system did not include detailed information concerning the influence of highway characteristics and conditions on the causation of traffic accidents. In order to obtain the desired highway data, it was agreed by the State Police and Highway Department that an additional system of mechanical punch cards was required to augment the existing State Police punch card system.

The author of this report, under the guidance and supervision of K. G. McWane, former Traffic and Planning Engineer and M. M. Todd, former Associate Traffic and Planning Engineer of the Virginia Department of Highways, planned this joint safety program in 1951. During the planning phase, the code manual for the highway accident analysis system was prepared using the Connecticut State Highway Department Accident Analysis Code Manual as a guide. The mechanical punch card system for accident analysis was placed in operation in the fall of 1952.

The following were the objectives to be obtained through the new system: (1) the determination of the accident frequency rates of road sections for the Rural Primary System, (2) the listing of the essential details of the individual accidents for use in formulating corrective measures and for the programming of new improvements for those sections having an abnormally high accident frequency, and (3) the pinpointing of specific locations where accident occurrence is abnormal.

At the end of the first year of operation, these three objectives had been accomplished.

In order to maintain adequately the additional punch card system for the Highway Department, it was necessary to add five persons to the existing State Police Accident Section. Two of these employees are used to locate each accident case file on the straight line graphic log sheet and record data for highway coding on the top of each case file. Two other employees are used to code the information from the photostatic copies of the accident case file onto highway code sheets. The other employee is used to punch and verify the highway mechanical punch cards from the code sheets, as well as to sort the punch cards for filing. The additional cost of personnel to supplement the State Police Headquarters Staff amounted to approximately $12,500 per year, which is included within the budget of the Department of State Police.

Accident statistics for the year 1950, were used as a basis for the planning phase of the new program. During that year, 46,371 accidents were reported on Virginia's highways and in these accidents, 915 persons were killed and 21,840 injured. For each of these accidents, reports were made by the drivers involved and the police officers making the investigation. Thus, the Department of State Police examined and analyzed some 100,000 individual reports, in order to provide summaries of the circumstances surrounding each of the 46,371 accidents, as required by the Virginia law. In Virginia approximately 80 percent of all rural accidents occur on the Primary System of 8,600 miles, which comprises only 18 percent of the State Highway System.

With the foregoing information and the desire to minimize the volume of the new analysis, it was decided to confine the continuing study to the rural portion of the Primary System, lying outside of municipalities having a population of more than 3,500. Therefore, studies of accidents occurring in the larger towns and cities, or on the Secondary System are not included in the highway accident analysis system.

OPERATION OF MECHANICAL PUNCH CARD SYSTEM FOR ACCIDENT ANALYSIS

To understand fully the operation of the new accident analysis system, it is best to start with the original accident report filled out by the individual driver or the police officer investigating the accident. These forms are sent to the Division of Motor Vehicles where they are processed solely from the point of view of enforcing the Motor Vehicle Safety Responsibility Act and disciplinary or preventive action against the licenses of accident prone drivers.

Photostatic copies of the original reports are made by the Division of Motor Vehicles and sent to the Accident Records Section of the State Police. The joint program goes into operation as soon as the photostats are received by the Accident Section. The first step in processing the photostats is to assemble all reports for one month by county and route order. After this operation, the investigating officers' and individual drivers' reports are matched and a case file is made of each accident. The State Police Highway Locator takes each case file and from the information available, determines the highway location information for each individual case. He then secures the essential highway characteristic information for each accident location from straight line graphic logs of the Rural Primary System.

One of the most important elements of the accident analysis system is the graphic log; therefore, it is important that these logs be accurate and up to date at all times. The Accident Study Section is notified by the Construction Division of all pertinent construction information, as well as the starting and completion dates of all construction projects. Upon notification of the construction project completion date, two men from the Accident Study Section relog the route so that any changes due to reconstruction will be included on the new graphic log. This particular phase of the operation is not entirely satisfactory, as sufficient personnel is not available in the Accident Study Section to handle this portion of the program.

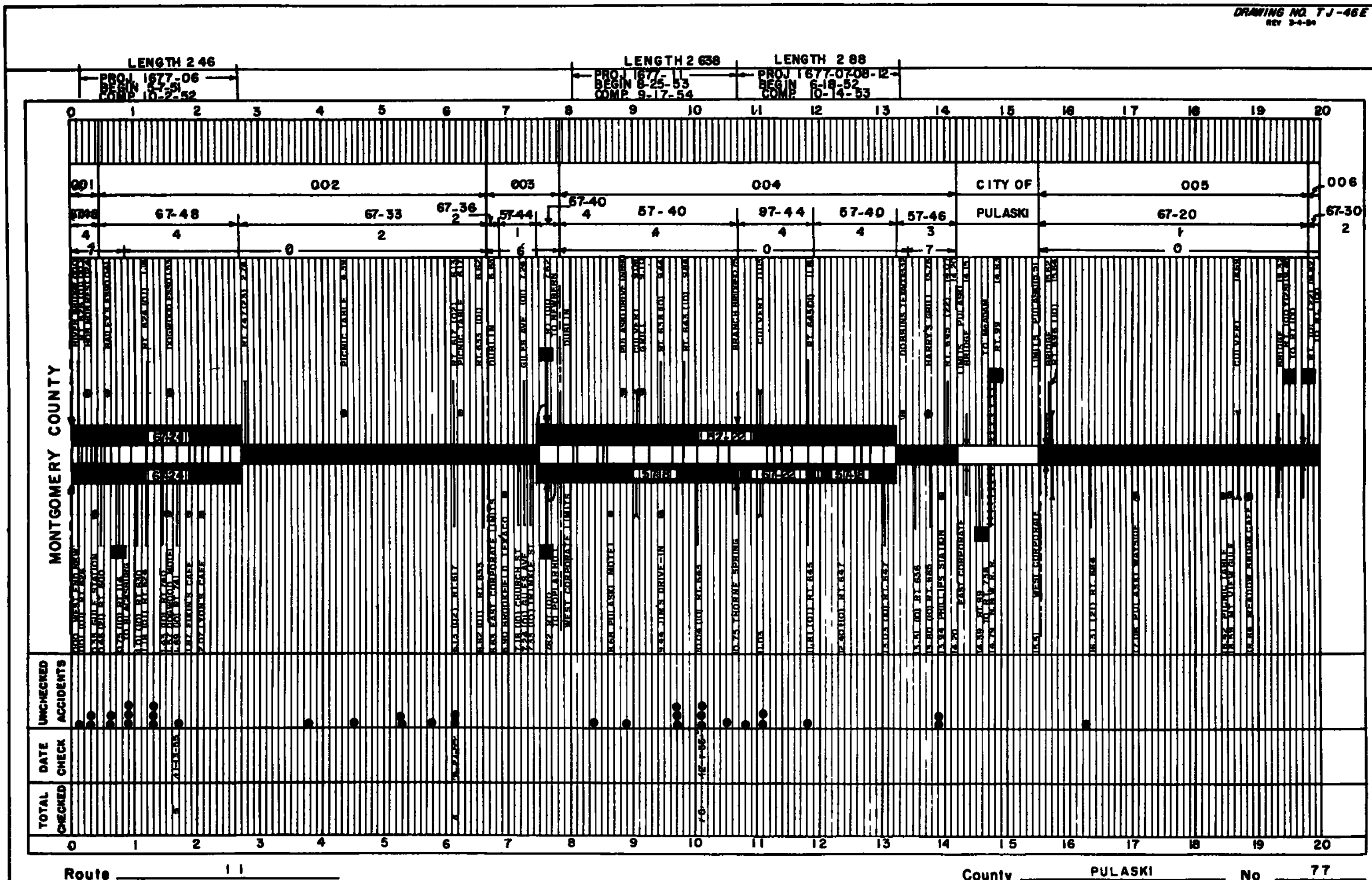


Figure 1. Straight line accident graphic log.

A straight line graphic log is prepared for each route of the Rural Primary System. Figure 1 is an example of the accident graphic log sheet used in the accident analysis system. This figure shows a 20 mile section of Route 11 in Pulaski County, which can be considered as a typical straight line graphic log used in the location of each individual accident, as well as indicating accident prone locations. Along the top edge of the graphic log is shown the construction project number, the starting and completion dates of construction, and the total length of the road project. At the bottom of the graphic log sheet is indicated the route number, county, and county code number. The scale of the graphic log representing the milepost line is found at two places on this figure: one just beneath the line indicating the project information, and the other above the line giving the route number and county name. This scale is determined by the density of roadside development along a particular route; thus, the usual scale of one inch equals one mile does not always apply. The maintenance section number is shown on the first line below the upper milepost line. In sequence on separate lines beneath the maintenance section number line is given the information: surface type in code and actual surface width, type of highway facility (kind of highway) in code, and roadside development in code. The wide black band shown in the center of the graphic log sheet is the straight line representation of the route with descriptive material on either side indicating county lines, corporate limits of cities and towns, primary and secondary roads, bridges, culverts, and roadside establishments, such as service stations, restaurants, and motels. The two black parallel bands represent divided highways. The spotting of commercial establishments has been very beneficial in the plotting of individual drivers' accident reports.

Location-Five or More Accidents

County ____Fairfax____

Route No ____7____

Section No ____005____ M P ____03 3____

From Date ____1-1-55____ To Date ____7-14-55____

Date Posted ____8-16-55____

Figure 2. Request for check investigation form.

The three wide spaces at the bottom of the graphic log are used in the prompt identification of accident prone locations. The first of these spaces marked "Unchecked Accidents" is used by the highway locator for the placing of a pencil dot at the exact milepost where the accident occurred. When five accidents have been recorded at any milepost, the highway locator then erases the pencil dots and records the date of this action in the second space marked "Date Checked." In the third space marked "Total Accidents," an accumulative total is kept of each five accidents occurring at the particular milepost. Each time five accidents are recorded in the third space, the locator fills out a Request for Check Investigation Form which is sent to the Accident Study Section for field investigation purposes. This form is a 3- x 5-in. card showing the county, route number, the maintenance section, and the exact milepost where five accidents have occurred. On this form is also indicated the period within which the five accidents occurred, as well as the date of the posting. Figure 2 is an example of the Request for Check Investigation Form. In Virginia a policy has been established in which five accidents at a particular milepost justify a complete investigation of the accident records and field conditions at this location.

When the Accident Study Section receives the Request for Check Investigation Form from the State Police, it is assigned to one of the field accident investigators. Prior to making a field investigation, certain information pertaining to previous and existing road conditions is obtained from the appropriate divisions within the Highway Department, which is helpful in determining the causes of accidents at the location under investigation. The investigator also checks the accident records and tabulates all accidents at the given location to discover, if possible, whether a consistent pattern of circumstances exists. He also secures the traffic volume, road capacity, and accident rate on the particular section of road, as well as whether a previous study has been made of that road section. All office information is taken into the field when the investigator checks the existing road conditions at the location. The resident engineer and

017— 69 — 30 — 2 — 0 — 15.7 (01)

MAIL TO DIVISION OF MOTOR VEHICLES, BOX 1298, RICHMOND (10), VIRGINIA

TIME — Date of Accident: January 2, 1956 — Day of Week: Monday — Hour: A.M. 8:30 P.M.

DO NOT WRITE IN THIS SPACE: NO / CA / LET / LET - / TYPE - / NO [redacted] / CODED BY / TYPE / FAT / PI / PD 25 / PDU / TT / RVS / NSP / OFF

LOCATION

PLACE WHERE ACCIDENT HAPPENED — County: Fairfax — City or town:

If accident occurred in rural area indicate distance from nearest town. Use two distances and two directions if necessary

miles north / miles south / miles east / 2 miles west — of — ☒ limits of / ☐ center of — Falls Church (City or town)

ACCIDENT HAPPENED ON: US Routes 29/211 Lee Highway (*Give name of street or highway number (U S or State). If no highway number, identify by name*)

Check and complete one
- ☒ AT ITS INTERSECTION WITH — Route 650 (*Name of intersecting street or highway number*)
- OR IF
- ☐ NOT AT INTERSECTION — feet north of / feet south / feet east / feet west (*Show nearest intersecting street or highway, house number, curve, bridge, railroad crossing, alley, driveway, culvert, milepost, underpass, numbered telephone pole, or other identifying landmark. Show exact distance, using two directions and two distances if necessary*)

ROAD

CHARACTER (*Check two*): ☒ Straight road; ☐ Curve; ☐ Level; ☐ On grade; ☐ Hillcrest

SURFACE (*Check one*): ☐ Concrete; ☒ Blacktop; ☐ Brick; ☐ Gravel; ☐ Dirt; ☐ *Specify other*

SURFACE CONDITION (*Check one*): ☐ Dry; ☒ Wet; ☐ Muddy; ☐ Snowy; ☐ Icy

DEFECTS (*Check one or more*): ☐ Defective shoulders; ☐ Holes, deep ruts, bumps; ☐ Loose material on surface; ☐ Road under construction; ☐ *Specify other*; ☒ No defects

TRAFFIC CONTROL (*Check one or more*): ☐ Officer or watchman; ☐ Stop-and-go or flashing light; ☐ Stop sign; ☒ Warning sign; ☐ Railroad crossing gates; ☐ Railroad automatic signal; ☐ One way street; ☒ Traffic lanes painted or marked; ☐ Opposing traffic lanes separated; *by what*; ☐ *Specify other*; ☐ No traffic control present

KIND OF LOCALITY (*Check one to show that the area adjacent to the street or highway within 300 feet was primarily*): ☐ Manufacturing or industrial; ☐ Shopping or business; ☐ Residential district; ☐ School or playground; ☒ Open country; ☐ *Specify other*

LIGHT (*Check one*): ☐ Daylight; ☐ Dusk; ☐ Dawn; ☐ Darkness — street lighted; ☒ Darkness — street not lighted

WEATHER (*Check one*): ☐ Clear; ☒ Cloudy; ☐ Raining; ☐ Snowing; ☐ Fog; ☐ *Specify other*

VEHICLES

YOUR VEHICLE — No 1
- Year: 55 — Make: Ford — Type: Sedan — Vehicle License Plate: Year 55, State Va., Number 000-000 — I.C.C. Plate No — Was Vehicle Insured?: Yes
- DRIVER: John J. Doe — 00 E. Main St. — Richmond, Va. — Age 35 — Sex M — Race White
- Driver's Occupation: Salesman — Driving Experience: 14 Years — Driver's License: Va. 000-000 — ☐ Chauffeur ☒ Operator ☐ Beginner — Speed before accident: 30 — Speed limit: 55 — Maximum safe speed: 55 (Miles per hour)
- OWNER: John J. Doe — 00 E. Main St. — Richmond, Va.
- PARTS OF VEHICLE DAMAGED: Front right fender, headlight and grill
- Approximate cost to repair vehicle: $ 225.00

OTHER VEHICLE — No 2
- Year: 51 — Make: Chev. — Type: Truck — Vehicle License Plate: Year 55, State Va., Number T-000 — I.C.C. Plate No — Was Vehicle Insured?: Yes
- DRIVER: Richard R. Smith — 10 Glebe Rd. — Arlington, Va. — Age 22 — Sex M — Race White
- Driver's Occupation: Contractor — Driving Experience: 5 Years — Driver's License: Va. 0003 — ☐ Chauffeur ☒ Operator ☐ Beginner — Speed before accident: 5 — Speed limit: 55 — Maximum safe speed: 55 (Miles per hour)
- OWNER: Smith Contruction Corporation, Glebe Rd., — Arlington, Va.
- PARTS OF VEHICLE DAMAGED: Grill
- Approximate cost to repair vehicle: $ 30.

For other vehicles use another form — Total vehicles involved: 2

DAMAGE TO PROPERTY OTHER THAN VEHICLES: None (*Name object, show ownership, and state nature of damage*) — Approximate cost to repair $

INJURED

- Name: John J. Doe — Address: 00 E. Main St. Richmond, Va. — Age 35 — Sex M — Race White — Nature and extent of injuries: Broken left arm — Was person killed? No — ☒ Driver ☐ Passenger — In vehicle No 1 — ☐ Pedestrian — ☐ *Specify other*
- Name — Address — Age — Sex — Race — Nature and extent of injuries — Was person killed? — ☐ Driver ☐ Passenger — In vehicle No — ☐ Pedestrian — ☐ *Specify other*

Total injured: 1

S R 300—Revised 5-1-50

IMPORTANT! If you had an automobile liability policy at the time of the accident, secure from your agent or insurance company a notice of insurance (Form SR-21) and send it with this report to the Division of Motor Vehicles or have your agent send it at once

Figure 3. Typical accident case file showing placement of highway coded information from accident graphic log.

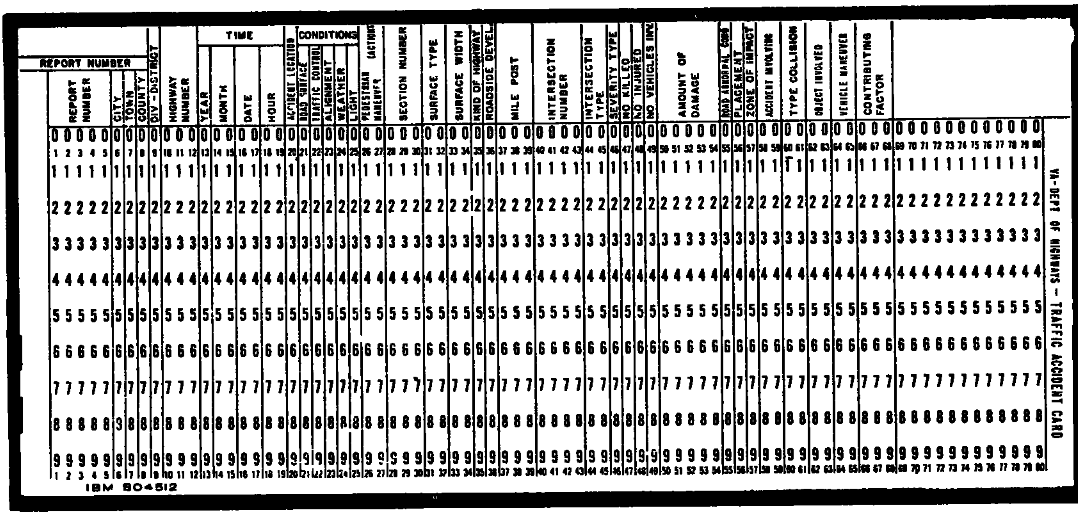


Figure 4. Highway individual accident IBM punch card.

state trooper familiar with the location under study, are contacted to get first hand information about existing road conditions at all hours of the day and night. In accident investigation work, it is essential to have an understanding of driver behavior and traffic patterns during the peak and off peak periods. After carefully analyzing all of the data collected in the office and field, the investigator submits his recommendations for corrective treatment.

After locating each accident on the straight line graphic log, the locator places specific highway information in code form across the top of each case file (see Figure 3). Upon completion of the above operation, the accident reports are then ready to be coded by the State Police Staff, once for the State Police system and again for the highway analysis system, after which IBM cards are punched for each system (see Figure 4). This figure shows the 80 column individual IBM card that is used in the highway mechanical punch card system. Some of the data listed on the card are report number, time of accident, road conditions, section number, surface type, surface width, exact milepost, severity of the accident, type of collision, vehicle maneuver, and contributing factors.

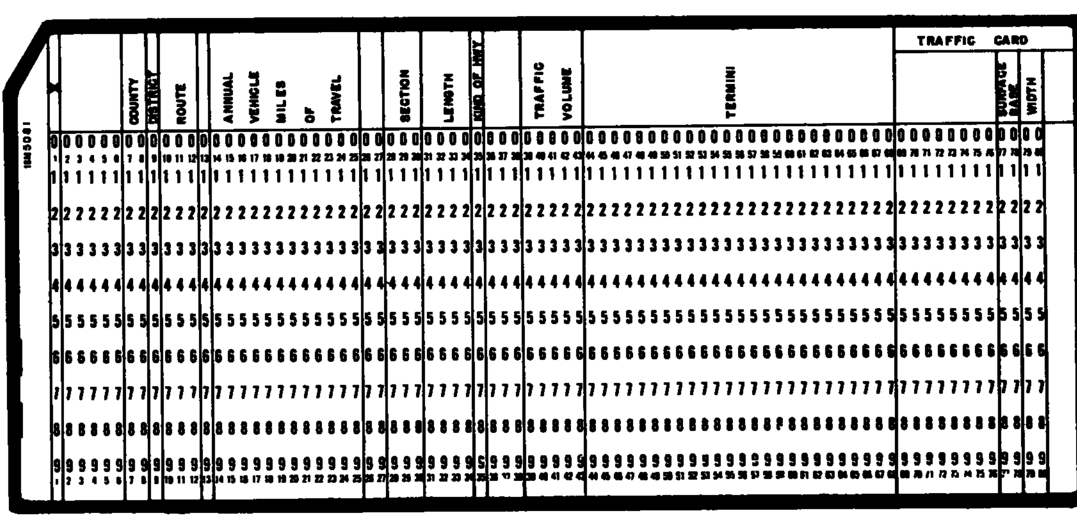


Figure 5. Highway IBM traffic card.

After the highway analysis cards are completed and arranged for filing, they are transferred to the Accident Study Section of the Highway Department for subsequent use. From these, various summaries are prepared and other pertinent information is immediately available. The Highway IBM Section processes these cards upon specific instructions from the Accident Study Section.

In 1954, nearly 21,000 individual record punch cards were so prepared representing all reported accidents on the Rural Primary System; and from these cards 3,000 summary cards were made. The first step taken by the Highway IBM Section in the preparation of the summary cards is to list and reproduce the maintenance control section cards. Every maintenance section of the Rural Primary System is identified on a separate punch card by county and route number codes and by a four digit section code number. The sectionalization of the Rural Primary System in Virginia was revised in 1949, for cost accounting procedure. The completed maintenance section tabulation produced by the IBM section is sent to the Rural Statistical Section for the insertion of annual average 24 hour traffic on each maintenance section. The Accident Study Section also places on this tabulation the types of highway facilities (kind of highway) in code for each appropriate section. Upon completion of the above work, the tabulation is returned to the Highway IBM Section where the annual average 24 hour traffic and kind of highway codes are key punched into reproduced traffic cards. By means of a 604 IBM calculator, the annual vehicle miles are obtained by computing the 24 hour traffic times the length in miles times 365 days. This operation completes the traffic card. An example of this traffic card is shown in Figure 5.

The next procedural step is to match-merge the accident card against the traffic card on a collator which verifies county, route, and section. Any cards having errors are pulled and corrected, then merged back into the completed card file. After the above operation, the next phase involves the combination of data on the traffic and individual accident cards by the use of a tabulator and summary punch (controlling on county, route, and section), thereby producing the summary card. An example of this summary card is shown in Figure 6.

Another phase of our card procedure was to run the summary cards through the 604 IBM calculator, thereby computing accident rates, injury rates, and death rates with the results automatically punched into summary cards. By use of the tabulator, a listing of the summary cards showing route, county, section, accident rate, injury rate, a and death rate is produced. From this listing it is possible to identify the most hazardous sections on the Rural Primary System. After the section has been identified, it is a simple task to determine exactly where in the section the accidents are occurring, when they are occurring, under what conditions, and the type of accidents (Figure 7).

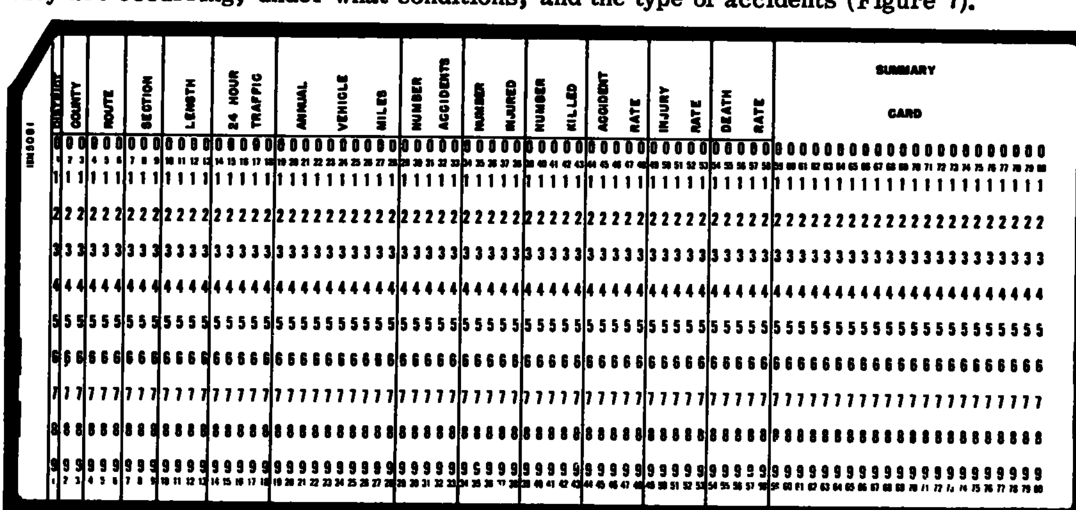


Figure 6. Highway IBM summary punch card.

ROUTE NUMBER	COUNTY CODE NO	SECTION NUMBER	ACCIDENT RATE	INJURY RATE	DEATH RATE
1	89	001	517	337	26
1	89	002	518	328	15
2	16	003	204	87	102
2	88	004	408	136	
3	23	001	128	256	
3	23	002	236	101	
3	48	001	93	93	
3	48	002	480	87	
3	48	003	242	132	
3	51	002	534	178	
3	51	005	353	126	
3	51	006	317	264	
3	68	001	184	553	
3	79	001	303	34	
3	79	002	146	73	
3	79	004	410	246	
3	88	005	416	222	
3	88	006	603	464	
3	89	003	345	158	43
3	96	001	143	95	
3	96	002	767	639	
3	96	004	270	337	
3	96	005	217	299	
5	18	001	175	88	
5	18	002	164	164	
5	43	003	654	1308	
5	43	004	338	271	

Figure 7. Frequency rates by route, county and section.

ROUTE	COUNTY	SECTION	MILEPOST	REPORT NUMBER	DISTRICT	DIVISION	YEAR	MONTH	DAY	HOUR	ACCIDENT LOCATION	ROAD SURFACE	TRAFFIC CONTROL	ALIGNMENT	WEATHER	LIGHT	PEDESTRIAN MANEUVER	SURFACE TYPE	SURFACE WIDTH	KIND OF HIGHWAY	ROADSIDE DEVEL	INTERSECTION NUMBER	INTERSECTION TYPE	SEVERITY TYPE	NO KILLED	NO INJURED	NO VEHICLES INVOLVED	AMOUNT OF PROPERTY DAMAGE	ROAD ABNORMAL CONDITIONS	PLACEMENT	ZONE OF IMPACT	ACCIDENT INVOLVING	TYPE OF COLLISION	OBJECT INVOLVED	VEHICLE MANEUVER	CONTRIBUTING FACTOR
1	00	001	002	34703	7	3	2	8	11	15	2	1	1	1	1	1		68	44	3	7		10	4			2	100		4	5	01	03	01	69	020
1	00	001	002	34704	7	3	2	8	13	18	2	1	1	1	1	1		68	44	3	7		10	4			2	185		3	1	01	05	01	74	022
1	00	001	002	46141	7	3	2	10	2	6	0	1	8	1	1	1		68	44	3	7			4			2	300		3	0	01	03	01	09	312
1	00	001	002	46147	7	3	2	10	24	17	2	1	1	1	1	4		68	44	3	7		10	4			1	700	1	3	6	20	07	01	00	001
1	00	001	003	53066	7	3	2	11	25	18	0	1	8	1	2	4		68	44	3	7			3		1	1	150		3	0	02	04	01	04	015
1	00	001	003	58930	7	3	2	12	24	9	2	1	2	1	2	1		68	44	3	7		10	4			2	300		4	1	25	05	01	54	016
1	00	001	003	29858	7	3	2	7	22	13	2	1	8	1	1	1		68	44	3	7		10	3		1	1	250		3	5	14	08	03	00	003
1	00	001	003	20459	7	3	2	5	3	15	0	1	8	1	9	1		68	44	3	7			3		7	2	1450		3	0	01	04	01	02	017
1	00	001	004	15279	7	3	2	4	20	10	0	1	8	1	1	1		68	44	3	7			4			2	123		4	0	01	04	01	02	017
1	00	001	004	40640	7	3	2	9	20	21	5	1	8	1	1	4		68	44	3	7			4			2	400		3	0	01	05	01	29	015
1	00	001	005	3072	7	3	2	1	22	6	2	2	8	1	5	4		68	44	3	7		10	4			2	143		3	2	01	05	01	53	022
1	00	001	005	25414	7	3	2	6	19	9	2	1	8	1	1	1		68	44	3	7		10	4			2	152		3	2	01	03	01	69	020
1	00	001	005	15281	7	3	2	4	28	13	5	2	8	1	5	1		68	44	3	7			4			1	4		4	0	03	05	01	34	022
1	00	001	005	20473	7	3	2	5	31	20	2	1	1	3	2	2		68	44	3	7		10	4			2	313		4	1	01	03	01	69	016
1	00	001	005	46143	7	3	2	10	4	21	2	1	1	1	1	4		68	44	3	7		10	3		3	2	2000		3	6	01	03	01	69	019
1	00	001	005	46144	7	3	2	10	11	13	2	2	1	1	5	1		68	44	3	7		10	4			2	575		4	2	03	05	01	74	015
1	00	001	006	53056	7	3	2	11	3	7	0	2	1	4	5	1		68	44	3	7			4			2	56		3	0	01	03	01	09	020
1	00	001	006	53062	7	3	2	11	15	16	2	2	1	1	2	1		68	44	3	7		10	4			2	105		4	2	01	05	01	74	022
1	00	001	006	3066	7	3	2	1	1	2	2	2	1	1	5	4		68	44	3	7		10	3		3	2	1200		4	6	02	04	01	72	060
1	00	001	006	58931	7	3	2	12	24	16	0	1	8	1	1	1		68	44	3	7			3		1	2	350		3	0	02	03	01	03	020
1	00	001	006	29852	7	3	2	7	7	20	2	2	1	1	5	4		68	44	3	7		10	4			2	275		3	6	01	03	01	69	020
1	00	001	006	29854	7	3	2	7	8	22	0	2	8	1	5	5		68	44	3	7			3		2	2	425		9	0	01	03	01	09	020
1	00	001	006	29857	7	3	2	7	18	13	2	1	1	1	1	1		68	44	3	7		10	4			2	300		4	1	01	05	01	54	022
1	00	001	006	11238	7	3	2	3	12	17	5	1	8	1	1	1		68	44	3	7			4			2	275		4	0	01	05	01	31	022
1	00	001	006	40642	7	3	2	9	27	19	0	1	8	1	1	4		68	44	3	7			4			2	160		4	0	23	04	01	05	101
1	00	001	006	46145	7	3	2	10	11	8	0	2	8	1	5	1	05	68	44	3	7		10	2		1	1	25		3	0	06	09	01	01	046
1	00	001	006	46148	7	3	2	10	24	15	2	1	1	1	1	1		68	44	3	7		10	4			2	275		4	6	01	03	01	69	300

Figure 8. Listing of highway accident IBM cards by route, section and milepost.

TABLE 1

SUMMARY OF ACCIDENTS BY HIGHWAY DISTRICTS RURAL PRIMARY SYSTEM YEAR – 1954

DISTRICT	LENGTH (MILES)	1954 VEHICLE MILES OF TRAVEL	FATAL ACCIDENTS	PERSONS KILLED	INJURY ACCIDENTS	PERSONS INJURED	PROPERTY DAMAGE ACCIDENTS	TOTAL ACCIDENTS	AMOUNT OF PROPERTY DAMAGE	ACCIDENT RATE	INJURY RATE	DEATH RATE
BRISTOL	1,162.57	665,665,465	47	56	624	1,123	1,479	2,150	$ 1,061,201	222	169	8 4
SALEM	997.65	721,095,460	45	55	809	1,450	1,617	2,471	1,322,621	342	201	7.6
LYNCHBURG	969 05	576,149,215	39	47	548	1,015	1,180	1,767	920,026	307	176	8.2
RICHMOND	1,075 85	1,071,523,930	59	71	805	1,434	1,866	2,730	1,333,135	255	134	6 6
SUFFOLK	827.41	1,006,000,955	76	95	1,133	2,013	2,857	4,066	1,822,104	404	200	9 4
FREDERICKSBURG	762 00	553,610,100	53	60	584	1,139	1,095	1,732	1,031,771	313	206	10 8
CULPEPER	1,110 35	1,263,548,605	77	85	1,368	2,361	3,048	4,493	1,945,983	356	187	6 7
STAUNTON	1,037 53	719,096,720	44	56	649	1,100	1,436	2,129	1,056,188	296	153	7 8
TOTAL	7,942 41	6,576,690,450	440	525	6,520	11,635	14,578	21,538	$10,493,029	327	178	9.0

TABLE 2
SUMMARY OF ACCIDENTS BY LOCATION
RURAL PRIMARY SYSTEM
YEAR 1954

Accident Location		Fatal Accidents	Persons Killed	Injury Accidents	Persons Injured	Property Damage Accidents	Total Accidents	Amount Of Property Damage
Between Intersections		379	456	4,247	7,471	8,224	12,850	$ 7,057,557
At Opening in Median Divider		2	2	46	69	173	221	82,952
Intersection Rural Primary Route And:	Rural Primary Routes	16	20	360	678	1,049	1,425	561,474
	Other Public Road or Street	33	37	976	1,833	2,589	3,598	1,393,109
	Alley	0	0	3	5	18	21	4,573
	Private Drive	5	5	412	670	1,248	1,665	621,781
	Commercial Entrance	5	5	452	875	1,181	1,638	705,527
	Interchange Ramp	0	0	6	10	32	38	8,244
	Interchange Ramp And Other Road	0	0	1	1	8	9	3,277
	Railroad Track	0	0	17	23	56	73	54,520
TOTAL		440	525	6,520	11,635	14,578	21,538	$10,493,029

TABLE 3

SUMMARY OF ACCIDENTS BY TYPE OF ROADWAY
RURAL PRIMARY SYSTEM
YEAR – 1954

ROADWAY TYPE	LENGTH (MILES)	1954 VEHICLE MILES OF TRAVEL	FATAL ACCIDENTS	PERSONS KILLED	INJURY ACCIDENTS	PERSONS INJURED	PROPERTY DAMAGE ACCIDENTS	TOTAL ACCIDENTS	AMOUNT OF PROPERTY DAMAGE	ACCIDENT RATE	INJURY RATE	DEATH RATE
2 - LANE	7,000.88	4,277,546,325	270	309	4,279	7,693	9,075	13,624	$ 6,828,960	318	180	7.2
3 - LANE	449.83	881,943,660	53	75	734	1,284	1,697	2,484	1,099,488	282	146	8.5
4 - LANE UNDIVIDED	235.87	641,057,530	72	90	701	1,292	1,654	2,427	1,356,776	379	202	14.0
4 - LANE DIVIDED	227.31	649,559,110	35	41	591	1,027	1,487	2,113	881,790	325	158	6.3
LIMITED ACCESS PARTIAL CONTROL	16.75	74,394,300	7	7	91	146	225	313	142,091	420	196	9.4
LIMITED ACCESS FULL CONTROL	11.77	52,189,525	3	3	23	43	41	77	34,925	148	82	5.7
MISCELLANEOUS	--	--	0	0	101	150	399	500	149,999	-	-	-
TOTAL	7,942.41	6,576,690,450	440	525	6,520	11,635	14,578	21,538	$10,493,029	327	178	8.0

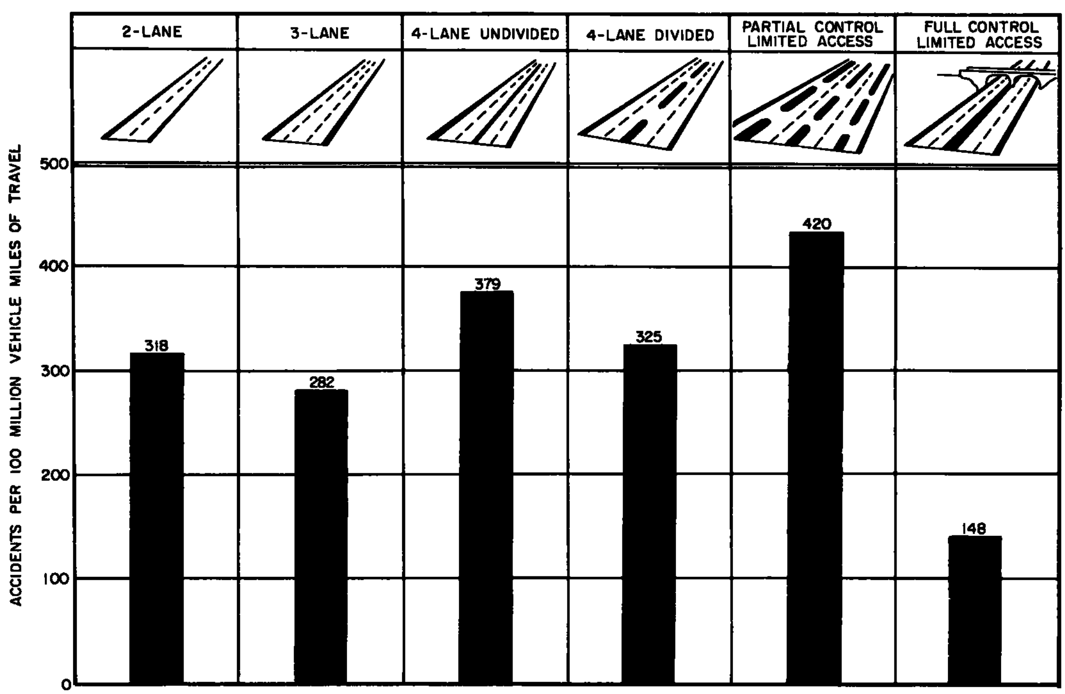


Figure 9. Comparison of accident rates by roadway type rural primary system, 1954.

Monthly individual accident cards are sorted and listed by milepost, section, county, and route. Current monthly cards are merged with previous month cards and at the end of the year, cards are listed for the yearly report. This tabulation is most useful since detailed information is available on all accidents occurring at a particular point (Figure 8).

Tables 1, 2, and 3 are illustrations of the various types of yearly summaries that can be produced by the use of the mechanical punch card system. These summaries cover such topics as (1) accidents by highway districts, (2) accidents by location, and (3) accidents by type of roadway.

From certain types of summaries based on information from the IBM punch cards, bar graphs can be compiled such as in Figure 9. This graph gives a comparison of accident rates on various types of highway facilities.

CONCLUSIONS

To date, the accident analysis system has been used only to a limited degree, in comparison to its numerous potential uses. However, the studies which have been completed as a result of this system have clearly shown its value in developing corrective treatment for existing highways and of even greater importance in establishing future highway needs. It is believed that the studies resulting from this system can also have a beneficial influence on future highway design in Virginia.

More effective use could be made of this system if it were not necessary to divert the limited personnel within the Accident Study Section from its primary function of accident analysis to the maintenance of the accident graphic logs of the Rural Primary System. Should any other state highway department consider setting up a similar accident analysis system, it is recommended that the responsibility for maintaining the graphic log be place elsewhere.

The accomplishments of the joint accident analysis program were possible only through the cooperative and unselfish participation of the Department of State Police and the Division of Motor Vehicles.

ACKNOWLEDGMENTS

Appreciation for assistance rendered in the development of Virginia's Cooperative Accident Analysis System and the material used in the compilation of this paper is expressed to the following individuals and agencies: General James A. Anderson, Commissioner, Virginia Department of Highways, and his immediate staff; the Connecticut State Highway Department, particularly Roy E. Jorgenson, former Deputy Commissioner and Chief Engineer and staff; K. G. McWane, former Traffic and Planning Engineer, Virginia Department of Highways; M. M. Todd, former Associate Traffic and Planning Engineer, Virginia Department of Highways; Captain W. L. Groth, former Safety Engineer, Virginia Department of State Police; State Police Accident Records Section; Virginia Division of Motor Vehicles; and Betty Snellings, of the IBM Section, Virginia Department of Highways.

REFERENCES

1. Connecticut State Highway Department Motor Vehicle Accident Analysis Code Manual, dated January, 1949.

HRB:OR-32

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