HIGHWAY RESEARCH BOARD

Bulletin 73

Driver Characteristics and Accidents

National Academy of Sciences—
National Research Council

publication 264

2101 Constitution Avenue, Washington 25, D. C.

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Bulletin 73

Driver Characteristics and Accidents

PRESENTED AT THE

Thirty-Second Annual Meeting

January 13-16, 1953

1953
Washington, D. C.

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FOREWORD

The included papers were presented at the Thirty-second Annual Meeting of the Highway Research Board on a program sponsored by the Committee on Road-User Characteristics of the Department of Traffic and Operations.

Contributions from different points of view of different investigators are of paramount importance in stimulating new approaches and further research in a field where these are badly needed. As is the custom, discussions were invited to aid in bringing out points of importance and of interest in the fields under consideration.

As indicated elsewhere, all opinions and interpretations are those of the authors and not necessarily of the Highway Research Board or its departments or committees.

It is a pleasure to express for the Committee on Road-User Characteristics its appreciation to those who participated both by preparation and presentation of research reports and by preparation of discussions.

T. W. Forbes, Chairman
Committee on Road-User Characteristics

May 25, 1953

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Driver Characteristics and Accidents

The ATA CASE-INTERVIEW PLAN as a METHOD for DRIVER IMPROVEMENT

Merwyn A. Kraft, Director
Department of Personnel and Accident Prevention
American Transit Association

THOSE of you who were able to attend the Highway Safety Research Correlation Conference held under the auspices of the Committee on Highway Safety Research* in June of last year, and those of you who may have read the report of that conference, may recall a discussion of management procedures as reported for the group chairmaned by J. E. Uhlaner.** This discussion followed a report by Harold Edgerton on some of his work with the armed services. Uhlaner's group recommended "further studies of management procedures relative to safety performance of motor fleets" and raised the question: "To what extent do management procedures, that empirically differentiate high and lower safety motor fleets produce changes in safe and efficient performance?"

At that meeting, I commented to the effect that certain management procedures had proved successful in accident prevention in commercial fleets and suggested the possibility of research on the applicability of some of these for use by motor vehicle administrators in controlling the private motorist. Today, I shall discuss one specific management procedure to which I was referring at that time. This is the Case-Interview Plan for Administration of Discipline, as developed by the American Transit Association.

This plan is a procedure for use by management with employees whose performance on the job has become so poor that either immediate and substantial improvement is considered necessary, or dismissal will be warranted. The primary objective of the plan is to obtain improved performance. However, when improved performance is not forthcoming, provision is made so that the management action of dismissal will be substantiated.

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*The Committee on Highway Safety Research of the National Academy of Sciences—National Research Council is organized separately from the Highway Research Board. The latter is under the Division of Engineering and Industrial Research while the former operates in parallel fashion to stimulate research in all of the scientific fields and divisions of NAS-NRC. Its emphasis is on human factors related to highway safety although these are considered in relation to engineering and physical factors.

**Report of Group B, J. E. Uhlaner, Chairman. Report of Highway Safety Research Correlation Conference, June, 1952, NAS-NRC Committee on Highway Safety Research, Washington, D. C. pp. 67. See Item 4, p. 31.

Before discussing details of the plan, and as a background for considering its applicability, let us review together the record of a problem employee, the type of person with whom we are presently concerned. This is the record of a bus operator in the employ of a large city transit company.

Since being employed in March 1946, this man has on his record: 34 accidents, 18 of which were judged preventable; failed to report 6 times; turned in short 19 times; 13 passenger complaints and 3 traffic violation reports. Certainly we cannot consider that as a good record, or even an acceptable one, in our industry. However, of perhaps greater significance than the record in this discussion is the manner in which management has handled this case as it developed over a 6½-yr. period.

Now, let me cite all items on this record which illustrate the pattern of disciplinary action taken by management.

- 3/19/46 - Employed as bus operator
- 12/4/46 - Advised of record - must improve
- 1/8/47 - Preventable accident, suspended 3 days - warned of poor record
- 7/30/47 - Warned on nonattendance
- 9/16/47 - Suspended pending hearing for dismissal - Reinstated 10/28/47
- 7/30/48 - Preventable accident - Lectured on poor accident record - Suspended 5 days
- 11/11/48 - Preventable accident - Suspended 2 days
- 12/16/48 - Interviewed and given last warning
- 6/3/49 - Warned - running by passengers
- 7/1/49 - Warned on turning in short
- 8/15/49 - Warned - abusive to passengers
- 12/13/49 - Preventable accident - Interviewed and discharged - Reinstated 12/20/49
- 4/12/50 - Warned on turning in short
- 5/25/50 - Warned - abusive to passengers
- 9/3/50 - Preventable accident - suspended 1 day
- 11/24/50 - Preventable accident - suspended 2 days
- 11/29/50 - Warned - running by passengers
- 12/12/50 - Preventable accident - Given last warning on attitude, accident record, complaints, turning in short. Given last chance and retrained.
- 6/11/51 - Warned - turned short
- 11/11/51 - Warned - abusive to passengers
- 11/19/51 - Warned - running by red lights
- 11/30/51 - Warned - failed to pull into bus stops
- 12/9/51 - Interviewed on general record. Advised it was poor
- 2/16/52 - Preventable accident - Suspended 3 days. Advised unless a complete new attitude and change of operation, he will be dismissed.

Certainly we can agree that this man is not a desirable employee. We probably also can agree that there are numerous other persons with equally poor and perhaps even poorer records, still in the employ of many companies. Why is it, then, that these people continue to stay on our pay rolls as employees?

Very direct and yet very common answers seem to be: "The union won't let us fire them. If we fire this man and the case is carried to arbitration, the man will be reinstated with back pay. We can't make a discharge case stick if it involves only accidents; the man must be guilty of some more serious offense."

Why, only a few months ago in New York there was a 3-day wildcat strike where one of the reasons given was that the men were angered over the dismissal of an operator for "a bad accident record." He apparently had had only 10 accidents in a year's time.

This unhealthy and unfortunate situation appears to exist more widely than we like to admit, yet does it necessarily have to be so? I say No, and I say No on the grounds that an increasing number of companies have been able to inaugurate procedures for handling these problem employees which seem to be almost foolproof. They either get the desired improvement in performance or they get a discharge that sticks. To illustrate, I quote:

"As regards those who do not show the required improvement, we have had no difficulty in dismissing them. Several cases have been appealed by the union authorities to our president, thence to the conciliation board, and in each case we were successful, I believe because we were able to show a clear and sincere attempt to correct the employee.

"One in particular was of a man who had been employed in 1947 and had always had a bad accident record, but because of the fact he was a union official we 'soft pedalled' the issue till late in 1950 when he became involved in a collision with another company vehicle. This was followed by an interview which was later followed up by a second interview advising him that his performance was still not acceptable. Finally, late in the spring of 1951, we dismissed him after an accident.

"The union appealed to every authority without success. The union people now seem to have accepted the procedure and only make a sort of policy appeal realizing it is useless to go beyond this step."

While there is still more encouraging evidence on the effectiveness of the procedure in handling of discharge cases, we must not neglect the other objective — and actually the most important objective — the improvement of performance.

Here, too, the results have been most gratifying. For example, a recent report on the effectiveness of the plan, sent to me by an over-the-road bus company, reads as follows:

"During the period from February, 1951, and up to March, 1952, 27 individual interviews were held for the purpose of improving the standards of work performance of these employees. Of the 27 original interviews, there have been 14 follow-up interviews with these employees, and outstanding improvement in their attitude and work performance has resulted.

"The records of all 27 drivers were checked for the number of accidents they had had in one year prior to their initial interview, an aggregate of 336 months of driving. The 27 drivers had 57 collision accidents during that period. Those same 27 men have driven a total of 219 months since their interview and have had eleven collision accidents. These figures are very convincing evidence of the value of the plan to our organization."

Referring to these figures, for the period prior to the interview they show 6 man-months of operation for every accident, while for the period after the interview this had increased to 20 man-months of operation for every accident, an improvement of 70 percent in the accident rate per month of operation for this group.

Still another company--in fact, the first transit company with which we tried out the procedure--made a special study covering the first 14 men interviewed, the records for one year before and one year after the initial interview. This revealed a 90 percent reduction in complaints and a 76 percent reduction in accidents.

To us who are interested in the prevention of accidents, in better public relations, in improved employee relations, and in higher efficiency generally, these results cannot be laughed off. They are of real, practical importance. Moreover, these are not isolated examples. There are many more just like them.

Up to now I have talked merely about results being obtained from the use of a procedure, plan, or interview. Many of you are undoubtedly wondering just what this procedure actually is and how it differs from the procedures or interviews now being used quite generally among transportation companies. What is there about this particular interview technique which enables one to get such results?

For full details, I would refer you to a printed manual entitled "The Case Interview Plan for Administration of Discipline" available from the American Transit Association. Details of the interview pattern are given in Appendix A and two typical cases with records are cited in Appendix B.

Actually, the procedure calls for an interview conducted along well-defined lines. There are a series of specific steps which are taken, for best results, according to a definite sequence. Moreover, it probably is the sequence of steps taken during the interview which distinguishes this case interview from the interviews conducted by most companies today. Experience also indicates that it is the sequence which makes the case interview so effective.

Still another element in the interview plan is the written record. As you know, many corrective interviews are held with employees, but the records that are made of them consist, for the most part, of mere notations, such as "reprimanded," "warned," "suspended two days."

The record called for under the case interview plan is quite different and certainly much more complete. First, there is a statement as to the reason for interview; next, a very complete statement on past record. Following this is a brief, summary version of the employee's statements; then a summary of the supervisor's statements and finally—the most important part of the record--a statement as to the mutual understanding and plan for future performance.

The purpose of this record is to have, in written form, the essential elements of the record and the essential facts brought out during the interview so that there can be no misunderstanding as to just what took place. Both the position of the company with respect to performance on the job, and the expression of understanding in acceptance of these conditions by the employee, are made perfectly clear.

If the interview is conducted properly and an accurate record made of it, then there can be no question as to the quality and character of performance expected by management and as to the understanding by the employee of what is expected of him, and expected of him as a condition of employment.

It is this form of record which prevents union representatives or the employee from later claiming that they did not realize just what was expected or that the employee might lose his job if he failed to do certain specific things.

Still another somewhat unique feature of this interview plan is the follow-up interview. In our minds, the initial corrective interview does not settle anything. It merely opens up a case which remains open until there has been a check on future performance and a follow-up interview.

This follow-up interview is scheduled to take place just as soon after the initial interview as there is reasonable grounds to believe that a definite pattern of future performance has been established. In any event, the follow-up interview should be held not longer than three months from the date of the initial interview, and sooner if possible.

At the time of the follow-up interview, the situation may fall into one of three categories: (1) the employee has failed to meet the mutually understood job requirements as outlined in the initial interview; (2) the employee has shown definite improvements in performance on the items covered in the initial interview; or (3) the employee might have gone well beyond acceptable performance and done an exceptionally good job on the items covered in the initial interview. Naturally, the follow-up interview pattern fits the specific situation.

As a result of the follow-up interview, there also is a written record made which first specified the situation, cites the specific reason for interview and summarizes the supervisor's statements, the employee's statements and the disposition of the case.

This follow-up interview, and its record, are of critical importance to the success of the plan. In discharge cases, the full justification for the action on the part of the company is set forth in clear, completely understandable terms. In the cases where there has been improvement in performance, then recognition is given to this by management, both to the employee in person and definitely on his record. It may sound odd, but one of the most common statements by employees as a result of follow-up interviews is: "I'm very grateful to know that my efforts to do a better job have been recognized and that the company is willing to make such a notation on my record."

To me, this is fundamental to the attainment of improved employee relations. Management must be equally willing to recognize satisfactory performance, and to do so on the record, as it is to cite employees for their failures to perform properly.

Up to now, I have discussed the so-called case interview plan only as a means by which management may take major corrective action. However, that is not the entire scope of the plan since it also calls for similar action on the part of management when an employee performs far above normal job requirements and, therefore, is entitled to formal commendatory action. In such instances, a formal interview is held and a formal record is made. In this way, management again demonstrates as much willingness to place exceptional performance on the record as to place below standard performance on the record.

The case interview plan is built upon sound principles of human relations and lends itself to the practice of intelligent, modern leadership techniques. It is designed to attain the following five specific objectives: (1) improve performance of employees to the point of at least satisfying minimum standards, or provide justification for removal from the job; (2) establish or reestablish the dignity and the effectiveness of supervisors and build greater confidence between employees and management; (3) put objectivity into personnel records by creating a record which includes a clear and accurate statement of the employee's performance, whether good or poor, together with a statement of the understanding as to future performance reached during the interview; (4) stimulate the desire to meet high standards of performance by providing a formal means whereby exceptionally good performance is discussed with the employee and is made a permanent part of his record; and (5) provide a means by which all levels of management may keep intelligent control over the consistency, the fairness and the effectiveness of discipline being administered throughout the organization.

As to Item 1, the foregoing discussion has endeavored to demonstrate how that objective is attained.

As to Item 2, the results reported to us by managements who now use the plan definitely indicate that that objective is accomplished.

On Item 3, the matter of objectivity in personnel records, the fact that union representatives, arbitrators and conciliators invariably support the action of management is rather convincing evidence that this particular form of record does have objectivity.

As to Item 4, while the occasions for commendation are much less frequent than for correction, the willingness of management to recognize such acts through formal action cannot help but stimulate employees to maintain high standards of performance.

Finally, on Item 5, the existence of complete records covering all cases requiring major corrective action enables an interchange among all levels of management on the handling of these cases and provides the opportunity for adequate review both before and after the formal handling of all cases. This can assure control over the consistency and the fairness of all discipline administered throughout an entire organization. I am sure we can agree on the necessity and desirability of this.

The A.T.A. Case-Interview Plan has proved to be a very effective method for driver improvement. Interest in it is growing and it is believed that a similar approach could very well be used effectively by motor-vehicle administrators with private motorists.

Appendix A

The Case Interview as a Corrective Measure

The case-interview plan, when used for the correction of exceptionally poor performance, calls for the use of a standardized procedure which consists of the following steps, normally taken in the sequence set forth: (1) Prepare for the interview; (2) state specific reasons for the interview to the employee; (3) have the employee explain his actions; (4) arouse recognition by the employee of the seriousness of his errors; (5) create a desire on the part of the employee to improve; (6) state specifically how the employee is expected to perform in the future; (7) arrive at a mutual understanding as to just exactly what both the supervisor and the employee will do to bring about improvement; (8) write a report of the interview for the record; and (9) make certain that the employee is fully aware of what is put into his record.

The Case Interview as a Commendatory Measure

The use of the case interview in a commendatory situation follows a pattern similar to that of the corrective interview but the specific steps are slightly different, as is also the final form of the record.

The steps involved in a commendatory interview are as follows: (1) Prepare for the interview; (2) state specific reasons for the interview to the employee; (3) permit the employee to comment on his actions; (4) arouse recognition by the employee of the value, or importance, of his actions; (5) create the desire on the part of the employee to continue such performance or to do still better; (6) write a report of the interview for the record; and (7) make certain that the employee is fully aware of what is put into his record.

* * * *

Appendix B

Example of A Corrective Disciplinary Interview, Record, Follow-up and Action Resulting Finally in Dismissal

Personal History

Name -	R. J. Peters*
Age -	25
Employed -	October 13th, 1949 as an operator at North End Div.
Previous History -	Worked as taxi driver after leaving school Service 3 years armed forces Transport driver

Personal Record

November 1, 1949 -	Collision with auto which was overtaking bus and cut in ahead. Operator not at fault.
November 21,1949 -	Rear end collision with auto. Operator at fault. Inspector Lucas rode with this operator for an hour and instructed and encouraged him.
December 1, 1949-	Cautioned by Inspector Jackson for running ahead of schedule.
December 15,1949 -	Collision with an auto when passing same at night in the rain. Operator at fault in not allowing for greasy roadway. Interviewed by divisional superintendent and advised on safe operation and proper judgment of clearance.

*All names of persons used in the sample cases are completely fictitious.

February 12, 1950	- Cautioned by Inspector Jones for running ahead of schedule.
March 8, 1950	- Collision with auto when passing same. Operator not considered at fault.
April 13, 1950	- Summonsed for going through a red light.
June 3, 1950	- Reported by Inspector Jackson for running ahead of schedule.
August 11, 1950	- Complaint received from passengers stating that they were thrown to the floor by the sudden stopping of bus operated by Peters.
Sept. 28, 1950	- Collision with motorcycle when operating coach at night. Operator considered at fault. Interviewed by divisional superintendent and given 3 days training in safe operation at the school of instruction.
October 17, 1950	- Reprimanded by Inspector Jones for running ahead of schedule.
October 30, 1950	- Referred to superintendent of instruction for interview.

* * * *

XYZ TRANSPORTATION COMPANY

Corrective — Initial Interview

NAME:......R. J. Peters.......... NUMBER...1262.... DATE...October 30, 1950.........

POSITION:......Bus Operator...

DEPARTMENT: ...Transportation............ DIVISION .....North End.....................

LENGTH OF SERVICE: With Co. ....1 year.. Present Position ....1 year............

REASON FOR INTERVIEW:

Annual summary of operation revealed bad record of collisions and minor accidents as well as failure to respond to advice and instruction on safe driving practices. Appears careless and unable to judge vehicle in traffic or under bad rail conditions. Careless about maintaining schedule and observing regulations.

PAST RECORD:

Five collisions in 1st year as operator, fully responsible in 3 instances. Had one passenger complaint on rough operation and four cases of running ahead of schedule. One summons for traffic violation - going through red light.

EMPLOYEE'S STATEMENTS (Summary):

Peters stated that he wasn't able to guess the actions of other vehicle operators and couldn't help their stupid driving. Said he was a competent driver but didn't feel there was enough time allowed on the schedule for safe operation, therefore he kept a bit ahead of schedule whenever he got a chance in order to allow extra time in case he got caught in heavy traffic later.

SUPERVISOR'S STATEMENTS (Summary):

As to his remark re other drivers, I reminded Peters that he had been found to be entirely at fault in three collisions, and that it was part of his job as a professional driver to drive so as to allow for the action of motorists. I also stressed that bad weather and night operation require extra care. He was warned that there was no excuse for running ahead of schedule. I made it clear that the excuse he offered was not acceptable as other operators were able to maintain their schedules. I emphasized that unless his record improved he could not continue as an operator.

MUTUAL UNDERSTANDING AND PLAN FOR FUTURE PERFORMANCE:

I have arranged for further training to be given to Peters at the school of instruction to help him correct any driving errors that may be contributing to his trouble. He understands that he has no excuse for running ahead of schedule and must cease this practice at once. It was also made quite clear to him that he would be open to possible dismissal unless there was an immediate improvement in his accident record. He realizes that his record will be reviewed in 3 months.

Follow-up Date: ...January 25, 1951.

Superintendent of Instruction.......
Signature of Supervisor

* * * *

XYZ TRANSPORTATION COMPANY

Corrective — Follow-up Interview

NAME: ...R. J. Peters............ NUMBER: ..1262.... DATE: .January 25, 1951......

POSITION: .Bus Operator..

DEPARTMENT: ..Transportation.............. DIVISION: .....North End.................

LENGTH OF SERVICE: With Co. ...15 mos..... Present Position .....15 mos..............

THIS INTERVIEW WAS HELD AS THE RESULT OF THE FOLLOWING SITUATION:

(1) Failure to meet mutually understood job requirements as outlined in the case interview dated Oct. 30, 1950 ___X___

(2) Definite improvement in performance on items covered in the case interview dated .... ______

(3) Exceptionally good performance on all items covered in the case interview dated .... ______

(4) Other (Explain) .... ______

SPECIFIC REASON FOR INTERVIEW:
Has been involved in 2 collisions in last three months and was considered to be at fault in both cases. He was reported running ahead of schedule on 3 different occasions.

SUPERVISOR'S STATEMENTS (Summary):
I have explained to Peters that we cannot continue men on this job who do not obey the rules and are constantly involving the Co. in accidents. Pointed out that this was made clear to him in interview on October 30, 1950 and that he understood he would have to improve.

EMPLOYEE'S STATEMENTS (Summary):
Peters could give no explanation for his repeated disregard of the schedule. He maintained that the majority of the accidents he had been involved in were not his fault.

DISPOSITION OF CASE:

Referred to Department Head - dismissal recommended.

Superintendent of Instruction
....
Signature of Supervisor

1/26/52 - Interviewed by department head and dismissal confirmed
1/31/52 - Appealed, accompanied by union business agent. Department head stated that the record showed that Peters had been given every chance to improve and had not done so. The appeal was denied. Union declined to take any further action.

* * * *

ABC TRANSIT COMPANY

CORRECTIVE CASE INTERVIEW RECORD - INITIAL

Name George H. Johnson Date August 26, 1949
Position Bus Operator Division Lorain
Length of Service: With Company 10-28-46 In Present Position 10-28-46

REASON FOR INTERVIEW

Rear-end collision on August 15, 1949 and review of a generally poor accident record.

PAST RECORD

Since date of employment Johnson has been involved in 16 accidents - 11 traffic and 5 passenger. He is held entirely at fault for 8 of these accidents - 6 traffic and 2 passenger. Received one warning for going in a diner. Accident record reviewed on 5-20-47. Told to improve record. Commended on 12-29-47 for capable handling of passengers during snowstorm. Attended safety meeting on 5-7-48. One report, smoking on bus. Two-day suspension for rear-end collision of 6-21-49.

EMPLOYEE'S STATEMENT (Summary)

Johnson acknowledges responsibility for seven of these accidents but, it is his opinion that he should not be charged with the rear-end collision on August 15, 1949. His reason is - slack brakes on the bus #852. Johnson admits however that he was aware of the brakes being slack for more than one hour prior to the accident. He states that he was attempting to get through the PM rush before turning bus #852 in for slack brakes.

He gives the following reason as the causes for the remaining seven chargeable accidents - following vehicle ahead too closely, misjudgment of clearance, schedule consciousness, and finally Johnson states he has become overconfident regarding his ability as a bus operator.

Regarding going in diner and smoking on bus Johnson states he thought it OK to do this when no passengers were on.

SUPERVISOR'S STATEMENT (Summary)

I told Johnson that, although the brakes on Bus #852 were not as good as they could have been, they did nevertheless meet state requirements (Tests showed 27 ft. at 20 mph. on service brake. Fifty feet on emergency brake at 20 mph. State requirements are 30 ft. at 20 mph., and 60 ft. at 20 mph. for service brakes and emergency brakes, respectively). However, I told Johnson that, in view of his knowledge of the condition of the brakes and his failure to report this bus (#852) promptly for slack brakes, gives us no alternative but to charge him with this accident.

I explained why it is necessary for him to follow the vehicle ahead at a safe distance at all times. Regarding misjudgment of clearance, I told Johnson that, if there is the slightest doubt in his mind regarding clearance, that he must not attempt to go on, instead he is to wait until the way is clear.

As to the schedule consciousness, I told Johnson we appreciate his efforts to maintain schedule, but, not to the extent of chance taking, that from now on he is to operate his schedule consistent with safety.

Regarding his failing of overconfidence I told Johnson that, inasmuch as he personally recognized this fault we expect him to correct it immediately and permanently.

Finally, I told Johnson that his accident record is not good - that, it has been particularly bad since the first of this year. Furthermore, if he expects to continue as an employee of A.B.C. it is his responsibility to improve his record immediately and permanently. As for going in diner, he is not to do this except in case of necessity. About smoking, I told him he must not smoke at any time he is operating a bus.

MUTUAL UNDERSTANDING AND PLAN FOR FUTURE PERFORMANCE

Johnson understands that, he must improve his work performance to meet job requirements, immediately and permanently. He understands that his failure to do so could result in his dismissal.

He further states that in keeping with the above paragraph, he will maintain a safe following distance at all times, specifically, one vehicle length for each ten miles of speed, such distance to be increased two to three times on wet and slippery roadway. Will not attempt to move bus where clearance is insufficient, will report promptly any defect he may find in the bus he is driving, will not take chances to keep on time, will go into restaurant and diner only when necessary. He also understands he must not smoke while driving a bus.

It is understood that Johnson and myself will meet not later than November 26, 1949 to discuss his record.

This record has been shown to Geo. H. Johnson on August 27, 1949

Signed T. W. Motte
Signature of Supervisor

* * * *

ABC TRANSIT COMPANY

CORRECTIVE CASE INTERVIEW RECORD - FOLLOW-UP

Name George H. Johnson Date November 28, 1949

Position Bus Operator Division Lorain

Length of Service: With Company 10-28-46 In Present Position 10-28-46

This interview was held as the result of the following situation:

1. Failure to meet mutually understood job requirements as ourlined in the case interview dated ______________ ________

2. Definite improvement in performance on items covered in the case interview dated August 26, 1949 ____X____

3. Exceptionally good performance on all items covered in the case interview dated ________ ________

4. Other (Explain) ________

SPECIFIC REASON FOR INTERVIEW

To tell Johnson of the improvement in his accident record. No report of any kind since 8-26-49.

SUPERVISOR'S STATEMENTS (SUMMARY)

I told Johnson we recognize the fine job he has done during the past three months, and now that we know he can operate his bus safely, which is a job requirement, we expect him to continue to do so. Also, that although we consider this case closed as of today, it can be reopened at any future date that he fails to meet job requirements.

EMPLOYEE'S STATEMENTS (SUMMARY)

Johnson says he has tried to do a better job. That, for a while he felt he was under pressure. He states he finally eliminated this pressure by relaxing and doing as good a job as possible always keeping safety in mind. Johnson adds that he feels the interview three months ago did help him and he feels satisfied, now that the company recognizes his work. Also, that as far as he is concerned, his case will not be reopened.

DISPOSITION OF CASE

Definite improvement noted, and record placed in Operator's file.

This record has been shown to George H. Johnson on Nov. 29, 1949

Signed T. W. Motte
Signature of Supervisor

A SAMPLING STUDY of DRIVERS on the HIGHWAYS for the 24-HOUR PERIOD*

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SYNOPSIS

The paper is a presentation of the first 6 mo. of a round-the-clock sampling technique designed to throw light on the driving habits of the licensed population considering age, sex, speeds, age of car driven, and related factors.

It was found that speed and age are inversely related at times when the traffic flow is light. Heavy traffic seems to cramp the style of speed demons. This classification of drivers is most heavily constituted of man between the ages of 20 to 24. In all 51.3 percent of the traffic observed on rural highways between midnight and 0700 was in the 20-to-29-yr.-old group, mostly those 24 and below. This figure may be contrasted with 26.3 and 8.4 for the 30-to-39- and 40-to-49-yr.-old groups respectively. Further it may be compared with 22.6 percent for the same age groups in daylight driving and 24.0 percent from 1700 until midnight.

The average percent of women drivers on the highway around the clock was found to be 14.5 of the total. Their heaviest driving hours were between 1400 and 1600. Two other minor peak traffic periods for women were noted at 1800 and 2100. Women drive slightly more during midweek than on week ends.

Evidence was found of a block of wild drivers constituting about 10 percent of the 20-to-24-yr.-old group who flagrantly and dangerously violate the rules of driving safely from midnight to 0400. Only rarely were excessive speeds noted among other age groups or at other hours of the day. The mean speed for all men observed was 47.6 mph. at an average age of 36.2. The mean speed of drivers between midnight and 0500 was 50.6 mph. at an average age 29.3. If men under 27 were to reduce their accidents to the average for all men driving, the accident toll and consequent fatality lists of the state should be cut by 12 percent.

It would appear that night speed limits would reduce the hazards to the public from this group only by the strictest enforcement between midnight and 0500 daily. Provisional licenses for drivers up to 24 and governors on cars required for persons apprehended exceeding the speed limits might reduce accidents resulting from driving at speeds too fast for conditions or for the driver's experience and training.

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*This study was made possible through a 5-yr. grant from the Allstate Insurance Company to Iowa State College. The early part of the project was made with the assistance of Donald A. Hoppe, research assistant in the Driver Research Laboratory who made most of the observations and the preliminary analyses during the first 6 months.

LAST year the writer reported a study of age and sex (1) in relation to accident involvement before this body. It was shown that accidents are not equally distributed by age groups, nor are they equally distributed by age groups when mileage is held constant. A slight advantage was shown for women although no significant difference was found to exist when all ages were grouped together on a mileage basis.

In the study reported, no account could be taken of exposure; hence, the present research was designed in an attempt to throw light on the relative exposure due to hours of travel and speeds as they apply to the accident situation. Two pilot studies were carried out before the final design was established. The method developed is described more in detail in the appendix of this report.

The principal hypothesis to be tested may be stated as follows:

An overall description of the structure of the driving population may be obtained by a statified sampling technique.

Two corollary hypotheses were also investigated: (1) A sampling technique can be employed to give reliable parameters of the driving population for given conditions of driving. (2) It is possible to reduce the number of observation points by comparing the variance of randomly chosen points in a given geographical area.

Due to the wide variety of data available a number of subhypotheses will be stated, the data then presented with an indication as to whether or not the subhypothesis is confirmed.

METHOD AND PROCEDURE

After preliminary experimentation with two methods, photographic and observational, it was found that infra-red photography was not sufficiently developed for precision night work on the highway under the conditions of moving traffic. Variations in the illumination levels in daylight made photography rather impractical for dependable results under all the conditions of this study.

In order to increase observational precision in daylight a high-grade binocular was tried and found to be unsatisfactory. Consequently an 8-power elbow telescope was obtained and anchored between the front and rear seats of the experimental car. It was used as needed in identifying the make of the car and the license plate number at a distance. These were spoken into the microphone of a tape recorder and later transcribed at the office. As the vehicle came nearer, the identification was confirmed and the following data recorded on the tape: (1) year and make of car; (2) number of persons in the car; (3) sex of the driver; (4) estimated age of the driver; (5) verification of the license number on the car; (6) speed of the vehicle as recorded by a radar speed meter; and (7) distance from the centerline whenever possible to secure it. (This was found very difficult to get and was not used in the analysis of data.)

Unless traffic was heavier than average one trained observer could work alone in daylight. Every nth car was taken for recording of data on it in the more dense traffic. During much of the time one technician was assigned to the speed meter exclusively.

For nighttime observations the technique had to be varied somewhat at rural unlighted locations. Two stations were set up, one for checking speed and identifying the car. The second station was established at the first stoplight within the city. Only four types of data could be obtained at the second observation point as follows: (1) year and make of the car; (2) number of persons in the car; (3) age and sex of the driver; and (4) license number of the vehicle;

In case the numbers, the year and make of car did not check at the two stations that observation was not used in the data.

The license number recorded was then taken to Des Moines and the owner's name secured. He was sent a double postcard asking him to indicate the age of the driver, the sex of the driver and the number of persons in the car at the time observed. In this way reliability of the observation techniques could be determined. In addition he was asked to state the number of miles driven the hour of the observation. These returns were not complete.

The data were tabulated and punched on IBM cards. Although the last 6 mo. have not been completely processed, there will be something over 11,000 cases in all. Only a part of the analysis can be presented within the time limits of this paper.

RESULTS

The presentation of results here will deal only with certain correlations and comparisons by age and sex for the first 6 mo., or the winter season. Under this subdivision 4,622 cases randomly drawn are analyzed for the structure of the driving population in three ways, those pertaining to: (1) reliability of observations, (2) age and sex, and (3) factors relating to speed and time of the day.

Reliability of Observations

Since one of the primary purposes of the present study was to evaluate the accuracy of the method used in determining age and other data taken under the conditions imposed, the observations were correlated with those given in the license files. These results are shown in Tables 1, 2, and 3 and may be summarized as they relate to the subhypothesis given.

Subhypothesis 1: Observations as to age of the driver taken under conditions of this study are sufficiently accurate for purposes of traffic estimates in general.

TABLE 1

CORRELATION BETWEEN ESTIMATED AGE AND REPORTED AGE AND COMPARISON OF MEANS

	Correlations	Mean Reported Age	Mean Estimated Age
Male			
Urban-Day	0.882	40.60	39.17
Urban-Night	0.864	33.22	31.25
Rural-Day	0.826	41.33	40.21
Rural-Night Fast	0.743	37.43	36.65
Rural-Night Slow	0.729	32.69	32.02
Female			
Urban	0.810	36.35	34.97
Rural	0.615	36.04	34.72

TABLE 2

PERCENT TIMES THE SEX REPORTED WAS DIFFERENT THAN OBSERVED

Urban-Day	1.94
Urban-Night	3.62
Rural-Day	0.63
Rural-Night-Fast	0.53
Rural-Night-Slow	0.00

TABLE 3

PERCENT TIMES THE NUMBER OF PERSONS REPORTED DIFFERED FROM OBSERVED, AND COMPARISON OF MEANS

	Mean No. Observed	Mean No. Reported	Percent Reported Different
Urban-Day	1.67	1.74	8.26
Urban-Night	1.90	1.97	11.56
Rural-Day	2.04	2.11	7.93
Rural-Night-Fast	2.23	2.58	17.63
Rural-Night-Slow	1.82	2.12	11.82

Correlations between the observed ages and the reported ages are as high as ordinarily required for consistency of measurements of this type. Comparison of means for the observed and reported ages is within the experimental error of measurement. The mean age of men driving at night is about 7 years younger than those driving in daylight. There is no apparent difference between the ages of women drivers observed in urban and rural areas.

When split into rural-night fast and rural-night slow groups the latter were of slightly lower age, due probably to slower speeds of the drivers below 20 years of age at earlier hours of the period of darkness. The urban groups of men were younger than those observed in the country for the total 24-hr. period.

There was a negligible error in observation of sex averaging less than 1.5 percent. Greater discrepancy was noted in observation of the number of persons in the car as compared with reports received. The average discrepancy here was about 10 percent, but there is as much likelihood that a part of the variance could be accounted for largely on the basis of inaccuracy of reporting by the respondent. The driver receiving a card two days later might well have forgotten just who or how many persons were with him at the time. There is also the possibility of children being hidden, persons laying down in the seat, and other reasons for error in observation.

Speed was measured objectively with a Radar Speed Meter which is accurate within limits of 1 mph.

Subject to conditions of the study it may be stated that subhypothesis 1 is sustained and that the method is sufficiently reliable for application to traffic studies designed to secure information on the driver for use in scientific analysis of drivers in traffic.

Factors Relating to Age and Sex of Drivers

It would be impossible to discuss all the ramifications of these two variables but a concise statement may be made as subhypothesis 2 and stated in the null form: There is no difference in driving habits of men and women of different ages with respect to speed, age and time of day. Tables 4, 5, 6, 7 and 8 show these data. Figure 1 also shows the percent of men observed on the highways during different parts of the day and night.

Women were observed on the highway much less than men and in a companion study (2) the figures obtained were 17 percent night mileage for women and 28 percent for men. Between midnight and 0700 percentages of 1.9 and 5 of total mileage respectively were given by women and men.

While the mean age for rural and urban driving was almost the same for women, it was slightly different for men. Figure 2 shows the variation in percentages of men drivers observed during daylight, evening darkmess, night darkness, first 4 hr. after midnight, and for the full 24-hr. period.

Summarizing all the data it would seem to warrant the assertion that subhypothesis 2 is not confirmed and that the driving habits of men and women are sufficiently divergent to necessitate separate analyses and comparisons.

TABLE 4

HOURS WOMEN DRIVERS

Time of Day	Percent Women Private Passenger Car Drivers	More or less than Expected by Chi Squared
00-01	8.1	Less
01-07	3.7	Less
07	9.2	Less
08	11.9	----
09	15.2	----
10	18.3	More
11	17.7	More
12	16.3	----
13	12.3	Less
14	25.8	More
15	19.4	More
16	20.5	More
17	9.1	Less
18	11.2	Less
19	9.2	Less
20	8.0	Less
21	11.6	Less
22	9.1	Less
23	7.5	Less
Over-all percent	14.5	

TABLE 5

DISTRIBUTION OF SEX BY LOCATION

	Percent Women
Urban	18.3
Rural	8.8

Significantly more in urban by chi squared.

TABLE 6

DISTRIBUTION OF SEX BY TIME OF WEEK

	Percent Women
Week End	13.9
Midweek	15.2

Chi squared significant at 2-percent level.

TABLE 7

URBAN HOURLY MEANS FOR SPEED, AGE AND YEAR OF CAR

Hour	Mean Speed	Mean Age	Mean Year of Car
00	19.48	26.76	46.12
*01-03	20.42	26.04	46.06
*04-06	17.92	36.52	44.84
07	16.32	37.44	45.58
08	15.54	42.96	47.10
09	15.76	39.08	47.02
10	10.68	38.96	46.96
11	13.60	36.98	46.06
12	15.20	34.68	45.82
13	17.82	35.42	46.02
14	14.56	40.00	46.84
15	13.68	38.48	45.70
16	13.62	38.42	45.96
17	13.18	34.52	47.00
18	18.28	33.94	47.34
19	15.28	30.96	45.64
20	15.64	31.60	47.10
21	16.78	29.98	47.86
22	17.14	25.66	47.26
23	19.34	23.74	46.50

*It will be noted that in this table the 3-hr. periods from 1 to 4 and 4 to 7 were combined due to the number of cases observed.

TABLE 8

RURAL HOURLY MEANS FOR SPEED, AGE AND YEAR OF CAR

Hour	Mean Year of Car	Mean Age	Mean Speed
00	47.34	29.68	46.64
01-03	46.96	26.90	52.88
04-06	47.72	34.56	51.08
07	46.16	34.82	48.36
08	48.50	39.40	36.80-Fog
09	47.76	41.36	49.46
10	48.20	37.66	47.82
11	47.56	39.84	48.20
12	48.08	40.46	50.68
13	47.80	32.06	49.38
14	46.38	36.18	45.48
15	47.06	38.06	46.86
16	48.82	39.94	50.86
17	46.40	32.56	27.90-Ice
18	47.54	34.20	46.30
19	48.76	35.70	47.58
20	48.58	32.06	48.76
21	47.66	33.64	48.38
22	47.22	30.78	46.42
23	47.82	31.52	46.64

The lower speeds at 0800 and 1700 are also reflected in Figure 2 which shows the age breakdown on a part of these data. One set of observations under unusual conditions would unduly affect the means given since each value is based on four sets of observation.

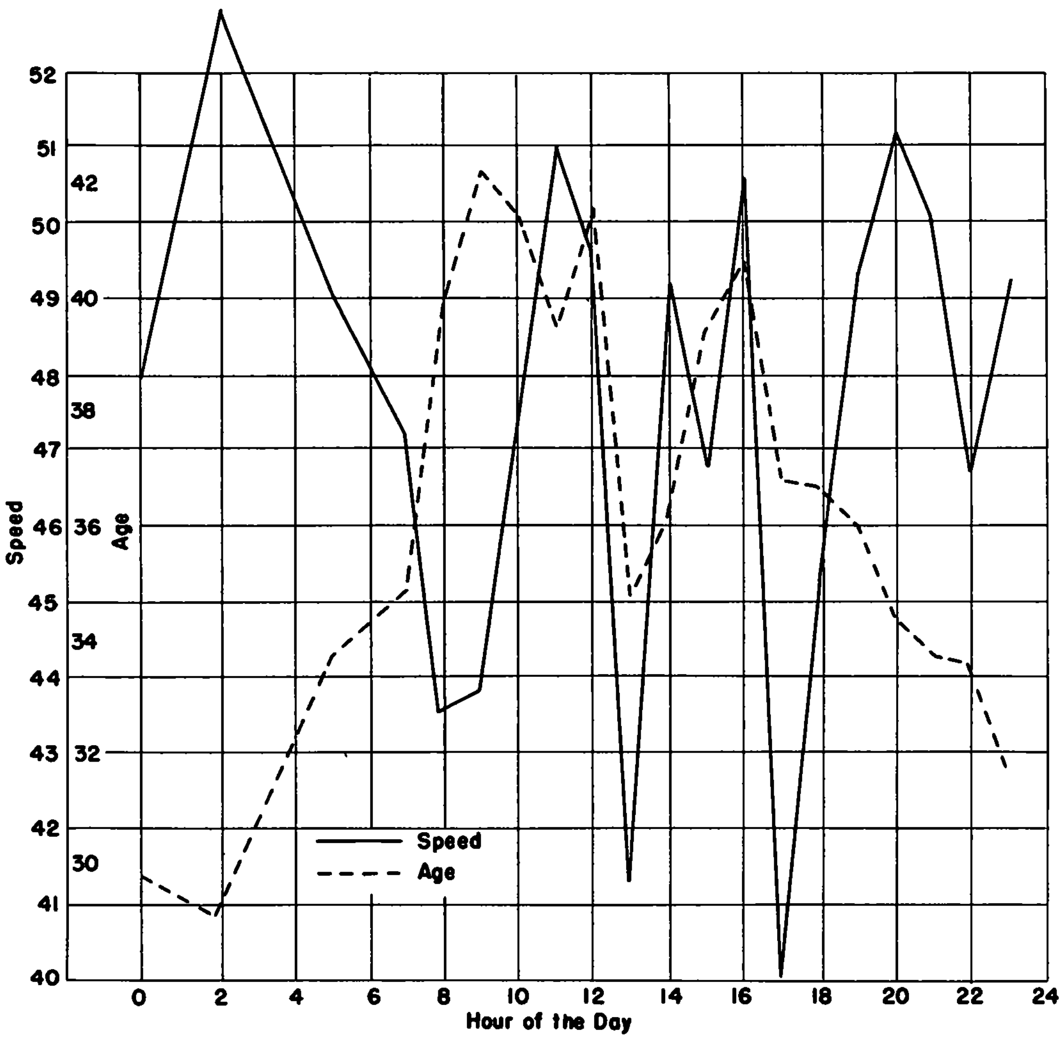


Figure 1. Speed and age by hour of the day.
(Winter Season)

Speed, Time of Day, Age of Driver and Age of Car

The factor of speed is interrelated with age and time of day. Heavy traffic and slower speeds are associated with higher age groups. Likewise speed seems to be associated with the age of the car.

Subhypothesis 3 may aid in orienting the problem for evaluation. It may be stated in the null form as follows: Speed variations in traffic are primarily a function of the age group of the driver.

To test this hypothesis a number of correlations were run and are shown in Table 10. Table 9 as well as Figure 2 also show relationships between age and speed at different hours of the day and for different age groups.

It would be expected that in urban driving the potential speed of the car would be of only slight importance while in rural areas the newer high-speed cars would tend to be driven faster.

Again considerable variance is found in the mean speeds of urban traffic throughout the day which are affected mostly by weather conditions. Shortly after midnight the mean urban speed for both sexes combined was slightly over 20 mph., while at 1000-1100, in the morning, the mean speed dropped to around 11 mph.

A speed peak occurs also at 0200 and at 1000 for urban traffic.

Traffic density seems to complicate relationships noted between speed and age in rural driving. While rather clear-cut as an inverse relationship between midnight and 0900-1000, around 1200 and until 1650 the relationship is equivocal. This cannot be deduced from correlation techniques since the relationship is not linear.

The correlation between speed and age for rural traffic during week ends when all hours are grouped together is lower than for midweek periods for male drivers. The reverse is true for midweek urban driving. While young men drive significantly faster than older men, it would appear that heavy traffic on rural highways over weekends tends to cramp their style except during late hours at night.

In both rural and urban areas older cars are driven by older persons, yet in the country older cars are driven at higher speeds. If age alone were considered the reverse might be expected. This is especially true for midweek traffic. In the city the correlations are reversed suggesting cat-and-mouse techniques so far as law enforcement and observance is concerned. It should be stated that careful consideration of the distributions seems to indicate a group of drivers between the ages of 20 and 24 who are likely to frequent the highways during late night hours. About 10 percent of this age group show characteristics of speeding from midnight to 0400. From the age of cars used and other cues it would appear that they may come from homes above the average in socio-economic status and represent types of individuals that cannot stand prosperity, with a tendency to show off. The other 90 percent of this age group showed normal conservative traits so far as speed is concerned and would probably give little trouble under ordinary circumstances.

TABLE 9

SUMMARY OF DATA ON PERCENTAGE OF DRIVERS OF DIFFERENT AGE GROUPS
(Men - Winter Season by hour of the Day)

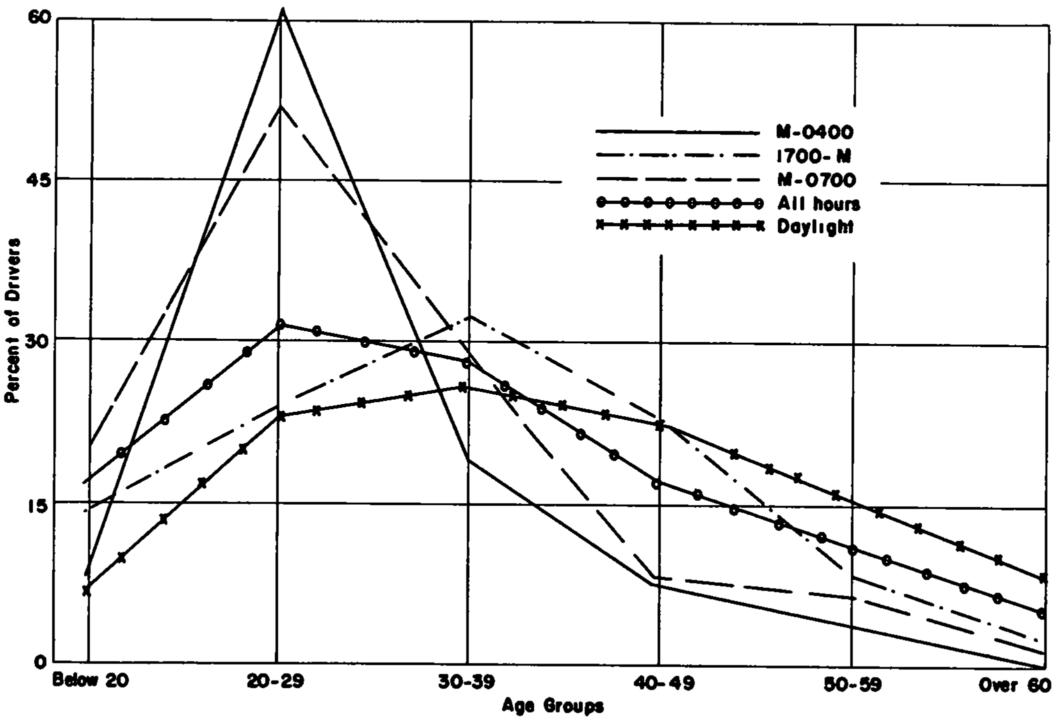
Hour	Teenage	20-29	30-39	40-49	50-59	60-69	70-79
01	9	59	15	12	4	2	0
1-2	8	50	21	9	9	0	0
2-3	5	58	26	9	0	0	0
3-4	7	79	11	3	0	0	0
4-5	0	41	41	5	14	0	0
5-6	7	50	31	7	3	8	0
6-7	7	22	39	14	13	3	0
7-8	12	29	28	14	13	4	0
8-9	7	22	23	18	18	10	2
9-10	4	20	22	27	15	12	0
10-11	4	17	27	20	24	7	1
11-12	7	13	35	20	18	5	0
12-13	2	16	29	31	12	10	3
13-14	10	31	28	14	13	4	0
14-15	9	30	24	19	11	4	0
15-16	5	22	21	29	12	9	5
16-17	1	26	26	21	16	10	0
17-18	15	17	24	28	12	2	2
18-19	6	20	40	21	8	5	0
19-20	8	26	28	22	15	1	0
20-21	10	28	29	22	8	3	0
21-22	8	25	40	19	6	2	0
22-23	17	17	38	21	5	1	0
23-24	10	35	30	18	5	2	0
Total Period	15.7	31.4	28.2	17.6	10.6	4.3	0.5
Daylight	6.1	22.6	26.3	21.3	15.2	7.5	1.1
*Night p.m.	14.8	24.0	32.7	21.5	8.4	2.3	0.3
**Night a.m.	20.4	51.3	26.3	8.4	6.2	1.8	0.0

*Dark to midnight
**Midnight to 0700 (Winter Season)

TABLE 10

CORRELATIONS BETWEEN AGE, SPEED AND YEAR OF CAR
FOR MALE DRIVERS

	Corr. Between Age & Speed	Corr. Between Age & Year of Car	Corr. Between Year of Car and Speed
Rural			
Week end	-0.078	0.174	0.247
Midweek	-0.140	0.167	1.196
Urban			
Week end	-0.318	0.126	-0.067
Midweek	-0.234	0.175	-0.106



Percent of male drivers on highway by hours.
(Winter Season by Age)

Applying all these observations to Subhypothesis 3 it may be concluded tentatively that the data tend to confirm it as stated only for a group of perhaps 10 percent of this age classifaction. It is rejected for the remaining 90 percent of younger drivers.

SUMMARY AND CONCLUSIONS

Results from a 6-mo., round-the-clock sampling study of drivers on the highway are given for the winter season. The following conclusions would seem to be warranted, subject to the nature of the study and other limitations noted:

1. The driving habits and exposure risks of men and women drivers are so vastly different that no fair direct comparison can be made between them. In any case women are a slightly better actuarial risk than men.

2. Youthful male drivers are travelling too fast at late hours of the night for their experience and conditions of illumination. With all the basic physical qualifications for superior driving performance their record of accidents and violations is entirely unwarranted. Their record does not noticeably improve until a period of 5 to 7 years has elapsed after being licensed.

3. Older cars are driven faster round the clock during the 24-hr. period in the country than new cars. This suggests a group of less responsible drivers are found on the highways at night. The reverse is true for urban traffic.

4. A sampling procedure and technique is set up evaluated which may prove of value in many types of traffic studies involving the driver.

5. The sampling procedure used, if streamlined, would seem to be adaptable to many studies of similar nature.

6. The primary hypothesis was confirmed and the two corollary hypotheses sustained with a reasonable degree of confidence.

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APPENDIX

RESULTS OF PILOT STUDIES ON DRIVER SAMPLING TECHNIQUE

(Prepared by Donald A. Hoppe)

Introduction

Pilot studies were necessary in order to find solutions for the two major problems involved in the sampling survey to determine age, sex and other characteristics of drivers at different times of the day. These problems were: (1) Development of a sampling procedure for location of the observation periods in time, and observation points in space. (2) Development of an observation technique for obtaining reliable information.

The pilot study for the first problem was conducted with the idea of determining an estimate of the variance between observation points, time of the day, day of the week and dates. The second was conducted with the aim of evaluating the observation techniques which have been developed.

Procedure for the First Pilot Study

For this pilot study five points were selected for observation at three different hours of the day. Points were selected rationally with the objective of observing points with different traffic characteristics. The three hours of the day observed for each of these points were (1) 7:45-8:45 a.m., (2) 2:00-3:00 p.m., (3) 6:00-7:00 p.m. These hours were selected in an attempt to determine what might be different types of traffic, i.e., chiefly workbound traffic, shopping and business traffic, and recreation traffic respectively.

The information obtained was the number of persons in the car, sex of driver, and an estimate of the age of the driver. Traffic was observed in only one direction at a time, but the direction observed was alternated every five minutes, and thus each direction was observed for 1/2 hr. for each hour of observation.

The observation points selected and the dates they were observed were as follows: (1) North Duff at Lincolnway, Monday, May 21 and June 25, 1951; (2) East 9th at Grand, Tuesday, May 22 and Tuesday, June 26, 1951; (3) US 69, 3 mi. north of Ames, Wednesday, May 23 and June 27, 1951; (4) Fifth between Burnett and Kellogg, Thursday, May 24 and June 28, 1951; (5) Lincolnway between Beech and Riverside, Friday, May 25 and June 29, 1951.

From the data obtained on these observations it was possible to run an analysis of variance on the following variables: (1) time, (2) location, (3) date. The results are shown in Table A.

TABLE A

ANALYSIS OF VARIANCE I - AGE OF DRIVER

Source	DF	SS	MS
Dates	1	25.5	25.5
Location	4	2,248.7	562.2
Time	2	4,914.6	2,457.3
Date x time	2	5,013.6	2,506.8
Date x location	4	2,852.8	713.2
Time x location	8	8,129.6	1,016.2
Date x time x location	8	10,359.6	1,295.0
Error	1470	233,370.2	1,587.6
Total	1499	266,914.6	

As the day of the week and the observation point were confounded in the above analysis it was necessary to make another series of observations to estimate the seriousness of that confounding. To do this one point was observed on each day of the week. The analysis of variance for this study is shown in Table B.

TABLE B

ANALYSIS OF VARIANCE II - AGE OF DRIVER

Source	DF	SS	MS
Time	2	992.4	496.2
Day of the Week	6	873.3	145.6
Time x days	12	5,461.8	455.2
Error	1029	184,184.3	179.0
Total	1049	191,511.8	

Sampling Design

From Tables A and B it can be seen that time and the interactions of time with the other variables are the largest sources of variance. With this in mind the following sampling procedure was designed.

As the variance contributed by locations was not large two locations were chosen: one rural point on US 69 south of Ames and one urban point on Fifth Street between Burnett and Kellogg in downtown Ames.

Since the day of the week was not a major source of variance the week was divided into two parts: (1) week end, consisting of Friday, Saturday, and Sunday and (2) mid-week, consisting of Monday, Tuesday, Wednesday, and Thursday.

For seasonal effect the year was divided into two seasons, winter beginning September 21 to March 21 inclusive, and summer starting March 21 to September 21 inclusive.

For hours, the day was considered as 24 hr. and each hour to be observed at both locations, both times of the week and both seasons. This makes a total of 192 hr. of observation during the year. The procedure calls for making an hour's observation at one observation point, skipping an hour, and then make another hour of observation at the other point.

The schedule of observations was determined at random and established for the entire year as follows:

Winter Season

Ob. No.	Time	Date	Location
1.	7-8	Fri., Sept. 21	1
	9-10	" " 21	2
2.	2-3	Wed., Oct. 3	2
	4-5	" " 3	1
3.	10-11	Fri., Oct. 5	1
	12-13	" " 5	2
4.	21-22	Thur., Oct. 11	2
	23-24	" " 11	1
5.	1-2	Sun., Oct. 14	2
	3-4	" " 14	1
6.	16-17	Mon., Oct. 15	2
	18-19	" " 15	1
7.	15-16	Sat., Oct. 20	1
	17-18	" " 20	2
8.	12-13	Thur., Oct. 25	2
	14-15	" " 25	1
9.	3-4	Fri., Oct. 26	2
	5-6	" " 26	1
10.	14-15	Tues., Oct. 30	2
	16-17	" " 30	1
11.	6-7	Sun., Nov. 4	1
	8-9	" " 4	2
12.	15-16	Mon., Nov. 5	2
	17-18	" " 5	1
13.	14-15	Sun., Nov. 11	1
	16-17	" " 11	2
14.	12-1	Tues., Nov. 13	2
	2-3	" " 13	1
15.	4-5	Sun., Nov. 18	1
	6-7	" " 18	2
16.	6-7	Tues., Nov. 20	2
	8-9	" " 20	1
17.	17-18	Sun., Nov. 25	1
	19-20	" " 25	2
18.	8-9	Thur. Nov. 29	2
	10-11	" " 29	1

Winter Season - continued

Ob. No.	Time	Date		Location
19.	5-6	Sat.,Dec.	1	1
	7-8	" "	1	2
20.	17-18	Wed.,Dec.	5	2
	19-20	" "	5	1
21.	11-12	Sun.,Dec.	9	1
	13-14	" "	9	2
22.	20-21	Wed.,Dec.	12	2
	22-23	" "	12	1
23.	2-3	Sat.,Dec.	15	1
	3-4	" "	15	2
24.	13-14	Wed.,Dec.	26	2
	15-16	" "	26	1
25.	12-1	Sat.,Dec.	29	2
	22-23	" "	29	1
26.	9-10	Wed.,Jan.	2	1
	11-12	" "	2	2
27.	19-20	Sun.,Jan.	6	2
	21-22	" "	6	1
28.	12-1	Mon.,Jan.	7	1
	22-23	" "	7	2
29.	9-10	Sat.,Jan.	12	2
	11-12	" "	12	1
30.	4-5	Wed.,Jan.	16	2
	6-7	" "	16	1
31.	1-2	Fri.,Jan.	18	2
	23-24	" "	18	1
32.	11-12	Mon.,Jan.	21	2
	13-14	" "	21	1
33.	21-22	Sun.,Jan.	27	1
	23-24	" "	27	2
34.	18-19	Tu.,Jan.	29	1
	20-21	" "	29	2
35.	8-9	Sat.,Feb.	2	1
	10-11	" "	2	2
36.	3-4	Thur.Feb.	7	1
	5-6	" "	7	2
37.	13-14	Sat.,Feb.	9	1
	15-16	" "	9	2
38.	7-8	Thur.Feb.	14	2
	9-10	" "	14	1
39.	18-19	Sat.,Feb.	16	2
	20-21	" "	16	1
40.	5-6	Mon.,Feb.	18	2
	7-8	" "	18	1
41.	12-1	Fri.,Feb.	22	1
	2-3	" "	22	2
42.	19-20	Thur.Feb.	28	1
	21-22	" "	28	2
43.	16-17	Fri.,Feb.	29	1
	18-19	" "	29	2
44.	1-2	Mon.,Mar.	3	1
	3-4	" "	3	2
45.	12-13	Fri.,Mar.	7	1
	14-15	" "	7	2
46.	10-11	Tu.,Mar.	11	2
	12-13	" "	11	1
47.	20-21	Fri.,Mar.	14	1
	22-23	" "	14	2
48.	1-2	Tu.,Mar.	18	1
	23-24	" "	18	2
49.	1-2	Fri.,Mar.	21	1
	3-4	" "	21	2
50.	20-21	Tu.,Mar.	25	2
	22-23	" "	25	1
51.	15-16	Fri.,Mar.	28	1
	17-18	" "	28	2
52.	12-13	Tu.,Apr.	1	2
	14-15	" "	1	1
53.	10-11	Fri.,Apr.	4	2
	12-13	" "	4	1
54.	1-2	Wed.,Apr.	9	2
	3-4	" "	9	1
55.	17-18	Sat.,Apr.	12	1
	19-20	" "	12	2
56.	1-2	Mon.,Apr.	14	1
	23-24	" "	14	2
57.	20-21	Sat.,Apr.	19	1
	22-23	" "	19	2
58.	3-4	Mon.,Apr.	21	2
	5-6	" "	21	1
59.	12-1	Fri.,Apr.	25	2
	22-23	" "	25	1
60.	5-6	Mon.,Apr.	28	2
	7-8	" "	28	1
61.	11-12	Sun.,May	4	1
	13-14	" "	4	2
62.	11-12	Tu., May	6	2
	13-14	" "	6	1
63.	13-14	Sat.,May	10	2
	15-16	" "	10	1
64.	16-17	Mon.,May	12	1
	18-19	" "	12	2
65.	7-8	Thur.May	22	2
	9-10	" "	22	1
66.	8-9	Fri.,May	23	1
	10-11	" "	23	2
67.	18-19	Wed.,May	28	2
	20-21	" "	28	1
68.	16-17	Sun.,June	1	2
	18-19	" "	1	1
69.	6-7	Tu.,June	3	1
	8-9	" "	3	2
70.	4-5	Fri.,June	6	1
	6-7	" "	6	2
71.	19-20	Tu.,June	10	2
	21-22	" "	10	1
72.	19-20	Sun.,June	15	1
	21-22	" "	15	2
73.	2-3	Sat.,June	21	1
	4-5	" "	21	2
74.	15-16	Wed.,June	25	2
	17-18	" "	25	1
75.	1-2	Sat.,June	28	2
	23-24	" "	28	1
76.	14-15	Thur.July	3	2
	16-17	" "	3	1
77.	12-1	Sun.,July	6	1
	2-3	" "	6	2
78.	10-11	Mon.,July	7	1
	12-13	" "	7	2

Winter Season - continued

Ob. No.	Time	Date	Location
79.	21-22	Sun.,July 13	2
	23-24	" " 13	1
80.	12-1	Wed.,July 16	1
	22-23	" " 16	2
81.	9-10	Sat.,July 19	2
	11-12	" " 19	1
82.	17-18	Thur.July 24	2
	19-20	" " 24	1
83.	5-6	Sat.,July 26	1
	7-8	" " 26	2
84.	8-9	Wed.,July 30	2
	10-11	" " 30	1
85.	7-8	Sun.,Aug., 5, '51	
	or	" " 3, '52	1
	9-10	Sun.,Aug. 5, '51	
	or	" " 3, '52	2
86.	2-3	Thur.Aug. 9, '51	
	or	" " 7, '52	2
	4-5	Thur.Aug. 9, '51	
	or	" " 7, '52	1
87.	12-13	Sun.,Aug. 12, '51	
	or	" " 10, '52	1
	14-15	Sun.,Aug. 12, '51	
	or	" " 10, '52	2
88.	12-1	Tu.,Aug. 14, '51	
	or	" " 12, '52	2
	2-3	Tu.,Aug. 14, '51	
	or	" " 12, '52	1
89.	3-4	Sun.Aug. 19, '51	
	or	" " 17, '52	1
	5-6	Sun.Aug. 19, '51	
	or	" " 17, '52	2

Ob. No.	Time	Date	Location
90.	13-14	Mon.,Aug. 20, '51	
	or	" " 18, '52	1
	15-16	Mon.,Aug. 20, '51	
	or	" " 18, '52	2
91.	18-19	Fri.,Aug. 24, '51	
	or	" " 22, '52	1
	20-21	Fri.,Aug. 24, '51	
	or	" " 22, '52	2
92.	21-22	Thu.,Sept. 6, '51	
	or	" " 4, '52	1
	23-24	Thu.,Sept. 6, '51	
	or	" " 4, '52	2
93.	6-7	Sat.,Sept. 8, '51	
	or	" " 6, '52	2
	8-9	Sat.,Sept. 8, '51	
	or	" " 6, '52	1
94.	4-5	Wed.,Sept. 12, '51	
	or	" " 10, '52	2
	6-7	Wed.,Sept. 12, '51	
	or	" " 10, '52	1
95.	14-15	Fri.,Sept. 14, '51	
	or	" " 12, '52	1
	16-17	Fri.,Sept. 14, '51	
	or	" " 12, '52	2
96.	9-10	Thur.Sept. 20, '51	
	or	" " 18, '52	1
	11-12	Thur.Sept. 20, '51	
	or	" " 18, '52	2

Procedure for the Second Pilot Study

The purpose of this study was to evaluate observation techniques. For the daytime procedure, eight observation points were picked at random from a list of 16. The days and hours of observation were also picked at random. The points and directions observed, and when they were observed are listed below:

1. Westbound traffic on Lincolnway between Welch and Hayward. Every third car was observed on May 2, 1951, between 4 and 5 p.m.

2. Southbound traffic on Highway 69 3 mi. north of Ames. Every other car was observed on Sunday, May 6, 1951, between 10 and 11 a.m.

3. All traffic in both directions on gravel road 3 mi. east and 2 mi. north of Ames. Observed on Wednesday, May 9, 1951, between 12 and 1 p.m.

4. Westbound traffic on East Ninth at Grand. Every car observed on Thursday, May 10, 1951, between 11 and 12 a.m.

5. Southbound traffic on North Duff at Lincolnway. Observed every other car on Wednesday, May 16, 1951, between 1 and 2 p.m.

6. Every car in both directions on 13th Street east of Ames city limits. Observed on Saturday, May 19, 1951, between 6 and 7 p.m.

7. Northbound traffic on Burnett between Sixth and Seventh. Every car was observed on Tuesday, May 29, 1951, between 5 and 6 p.m.

IMPORTANT

STOP ACCIDENTS

Return Postage Guaranteed
A. R. Lauer, Driving Laboratory
Iowa State College
Ames, Iowa

Driving Laboratory
Iowa State College
Ames, Iowa

Return to
Ames, Iowa

587 PERSONS WERE KILLED ON IOWA HIGHWAYS LAST YEAR. The Driving Laboratory at Iowa State College is making an effort to find ways of reducing this accident toll. One type of information needed is the characteristics of drivers at different times of the day. The only way we can get this is from drivers that are actually observed on the road. Please look on the inside to find when your vehicle was observed and then answer the questions below. Make a special effort to be accurate.

1. Age of person driving when your vehicle was observed____.
2. Sex of driver male____ 3 Number of persons in the female____ vehicle (including driver)_____.
4. Approximate number of miles driven by this driver between and on the day your vehicle was observed_____.

Please do not let your failure to return this card make it impossible for us to obtain a 100 percent return.

In making the survey to determine the characteristics of drivers we have been observing traffic going on

Your car, license number , was observed going by here at on

Your cooperation in answering the questions on the other side and returning the card will be greatly appreciated. The success of our study depends entirely on your willingness to do this.

We want to stress that we are interested in the characteristics of the driver of your vehicle only because it happened to be included in our sample of vehicles. It is not the objective of this study to observe for violations and it is in no way connected with any law enforcement agency.

THANK YOU FOR YOUR COOPERATION

Figure A

8. Westbound traffic on Fifth between Kellogg and Douglas. Every car was observed on Wednesday, May 30, 1951, between 8 and 9 a.m.

The information obtained was: (1) number of persons in the car, (2) sex of driver, (3) estimate of the age of the driver, etc., (4) year and make of car, and (5) license number of car.

For the first observation the names and addresses of the owners of the cars registered were obtained from the Department of Public Safety. A postcard was prepared for sending to the owners with the request that they report the age of the person driving when their car was observed. For the first point 20 cards were typed and sent out. As the return was fairly satisfactory and acceptance of the plan seemed satisfactory, 300 cards were printed. Because of the delay in printing no cards were sent out to the persons observed at Points 2 and 3. For the remainder of the observations cards were sent to all private car owners observed. The names and addresses were obtained from the same source. The card which had been prepared was not satisfactory for sending to the owners of commercial vehicles, since the exact vehicle observed was not designated on the card.

In this study a total of 595 vehicles were observed. Cards were sent to 318 owners. The over-all percentage returned was 46.8.

In general the information as to sex of the driver and the number of persons in the car reported on the card corresponded with the observed information. In five instances the sex was reported different than that which was observed. The question on the card about the number of persons in the car was ambiguous in that it did not state whether the driver should be included or not. The number reported on the card was different from the observed on 26 cases, with the number reported usually one less than the number observed. The correlation between the estimated ages and the ages reported on the cards was 0.831. The card was redesigned as shown in Figure A.

A similar procedure, but on a smaller scale, has been done for the night observation procedure. Cards were sent 60 owners. Of these 30 were returned and the correlation obtained between estimated age and reported age was 0.54. This is a significant correlation, but not high enough for the present purposes. It seemed reasonable to raise this correlation with practice.

RELATIONSHIP of PREVENTABLE to NONPREVENTABLE ACCIDENTS in the TRUCKING INDUSTRY

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and
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McLean Trucking Company

IT is not too uncommon to hear a safety director state that all accidents are chargeable to the drivers or workers involved in the accident. If a distinction between chargeable and nonchargeable accidents exists, it is extremely fine. In many organizations penalty is based on such an analysis. Generally in the trucking industry, accidents are classified as preventable or nonpreventable. The preventable accident is one in which the driver of the vehicle is clearly responsible for the accident. Such accidents as grade collisions with trains, backing accidents, collision with a vehicle ahead, accidents while passing, may be classified as preventable, except where even in these instances the driver incurred the accident through no fault of his own. A nonpreventable accident is one in which the driver of the vehicle is not responsible for the accident. Such accidents as a collision while properly parked, mechanical failures, and so forth may be classified as nonpreventable.

Ordinarily, in determining the preventable and nonpreventable classification of an accident in the trucking industry, the judges (investigating officer, safety director, field supervisor, safety supervisor, etc.) ask the question: "Could the driver have done anything to have prevented the accident?" If the answer is yes and they can determine what he should have done and could have done to have avoided the accident, the accident is charged to him. However, if there is nothing he could have done to have avoided the accident, the accident is not charged to him.

PROBLEM

The question of the relationship between preventable and nonpreventable accidents is the major objective of this paper. The hypothesis may be stated somewhat as follows: Preventable and nonpreventable accidents are closely related to one another in both their causes and general characteristics.

In this paper an attempt is made to answer the question more from a statistical point of view than from a descriptive analysis of the accidents. Moreover, no attention is placed on the reliability of the accident classification whether it be a preventable or nonpreventable one. Problems of low reliability in this area are well known to research workers in this field. The assumption is that whatever classification is available it is still the best that can be used in these analyses.

SUBJECTS

In this study 100 over-the-road tractor-trailed drivers employed by the McLean Trucking Company in Winston-Salem, North Carolina were used.

All of these drivers were studied during their first 12 mo. of employment. The basis of analysis used was the number of preventable or nonpreventable accidents incurred by the drivers for any month of the employment period. Records indicate that each driver drives approximately 5,000 mi. per mo. No attempt was made to control route traveled or time of year employed. In fact, this sample of 100 drivers was taken from a total driving population of 215 drivers.

METHOD

The methods used in the analysis of the data involved the following:

1. Analysis of the distributions of preventable and nonpreventable accidents for the 1 to 3, 4 to 6, 1 to 6, 7 to 12 and 1 to 12 month periods of employment were made. These distributions were studied by comparison to Poisson distributions based on the same means as the actual distribution. The statistical tool of chi squared was used in these analyses. Also, the amount of variance greater than that anticipated by chance was studied.

2. Correlations were computed between two successive periods of employment for both preventable and non-preventable accidents. The comparisons made were between the 1 to 3 and 4 to 6 mo., and 1 to 6 and 7 to 12 mo. of employment. Chi-squared tests of independence were used to determine the significance level of the correlations for the preventable accidents only.

3. Relationships of certain personal and psychological traits of these drivers with the number of preventable and nonpreventable accidents were computed. The t tests between the number of accidents (preventable or nonpreventable) for the upper and lower 50 percent and upper and lower 25 percent of drivers for each variable were determined.

4. A graphic presentation of preventable and nonpreventable accidents for 91 drivers employed for at least 18 mo. was made.

5. The coefficient of correlation between preventable and nonpreventable accidents for the full 12 mo. of employment was computed.

ANALYSIS OF DATA

In Table 1 are given the frequencies, means, variances and chi squares for the preventable accidents for 1 to 3, 4 to 6, and 6 mo. of employment. Comparisons are made of the actual accident distributions with Poisson or chance expectancy. Through the use of chi squared, it can be seen that the probabilities are not high enough to indicate that anything but chance is in operation. The probability level is 0.44 for the 1 to 3 mo. period. For the 4 to 6 mo. period the probability level was 0.68. For the full 6 mo. of employment the probability level is 0.50.

In Table 2 are given the frequencies, means, variances and chi squares for the preventable accidents for 1 to 6, 7 to 12 mo., and 12 mo. of employment. Probability levels here also indicate chance expectancy: 0.50 for 1 to 6 mo., 0.44 for 7 to 12 mo., and 0.64 for the 12-mo. period of employment.

TABLE 1

TABLE OF FREQUENCIES, MEANS, VARIANCES AND CHI SQUARES OF PREVENTABLE ACCIDENTS FOR 100 COMPANY-TRAINED TRUCK DRIVERS FOR 1 TO 3 MO., 4 TO 6 MO. AND 6 MO. OF EMPLOYMENT

No. of Preventable Accidents		1-3 Months	4-6 Months	6 Months
0		77	73	55
1		19	24	34
2		4	3	9
3		0	0	2
4		0	0	0
N		100	100	100
Means		.2700	.3000	.5800
Variances		.2771	.2700	.5436
Poisson "Fit"	X^2	.644	.189	1.410
	d.f.	1	1	2
	P	.44	.68	.50
$\frac{\text{Variance-Mean}}{\text{Variance}}$ x 100		2.6	—	—

TABLE 2

TABLE OF FREQUENCIES, MEANS, VARIANCES AND CHI SQUARES OF PREVENTABLE ACCIDENTS FOR 100 COMPANY-TRAINED TRUCK DRIVERS FOR 1 TO 6, 7 TO 12, AND 12 MO. OF EMPLOYMENT

No. of Preventable Accidents		1-6 Months	7-12 Months	12 Months
0		55	79	45
1		34	16	31
2		9	4	19
3		2	0	3
4		0	1	2
N		100	100	100
Means		.5800	.2800	.8600
Variances		.5436	.4016	.9204
Poisson "Fit"	X^2	1.410	2.761	1.718
	d.f.	2	3	3
	P	.50	.44	.64
$\frac{\text{Variance-Mean}}{\text{Variance}}$ x 100		—	30.3	6.6

In Table 3 are given the frequencies, means, variances and chi squares for the nonpreventable accidents for 1 to 3 mo., 4 to 6 mo., and 6 mo. of employment. Probabilities here are even higher than for similar periods in the preventable accidents: 0.88, 0.90, and 0.94, respectively.

TABLE 3

TABLE OF FREQUENCIES, MEANS, VARIANCES, AND CHI SQUARES
OF NONPREVENTABLE ACCIDENTS FOR 100 COMPANY TRAINED TRUCK DRIVERS
FOR 1 TO 3, 4 TO 6, AND 6 MO. OF EMPLOYMENT

No. of Nonpreventable Accidents		1-3 Months	4-6 Months	6 Months
0		76	80	62
1		21	18	28
2		3	2	8
3		0	0	1
4		0	0	1
N		100	100	100
Means		.2700	.2200	.5100
Variances		.2971	.2116	.5899
Poisson "Fit"	X^2	.0233	.0109	.3885
	d.f.	1	1	3
	P	.88	.90	.94
$\frac{\text{Variance-Mean}}{\text{Variance}} \times 100$		9.0	---	13.5

In Table 4 are given the similar data for nonpreventable accidents for 1 to 6, 7 to 12, and 12 mo. of employment. Probabilities, here, are 0.94, 0.96, and 0.45, respectively.

TABLE 4

TABLE OF FREQUENCIES, MEANS, VARIANCES AND CHI SQUARES
OF NONPREVENTABLE ACCIDENTS FOR 100 COMPANY-TRAINED TRUCK DRIVERS
FOR 1 TO 6, 7 TO 12, AND 12 MO. OF EMPLOYMENT

No. of Nonpreventable Accidents		1-6 Months	7-12 Months	12 Months
0		62	75	44
1		28	21	38
2		8	3	12
3		1	0	4
4		1	1	2
N		100	100	100
Means		.5100	.3100	.8200
Variances		.5899	.3939	.8676
Poisson "Fit"	X^2	.3885	.2336	2.5450
	d.f.	3	3	3
	P	.94	.96	.45
$\frac{\text{Variance-Mean}}{\text{Variance}} \times 100$		13.5	21.3	5.49

This phase of the analysis indicates that both types of accidents tend to behave like chance distributions of the Poisson variety and that closer chance expectancy is observed in the nonpreventable accident classifications. One should state that some question has been raised as to the applicability of chi squared as a fine-enough tool for making these distinctions.

In Tables 5, 6, 7, and 8 are shown the bivariate distributions for both the preventable and nonpreventable accidents.

TABLE 5

BIVARIATE DISTRIBUTION OF PREVENTABLE ACCIDENTS FOR 100 COMPANY-TRAINED TRUCK DRIVERS FOR 1 TO 3 AND 4 TO 6 MO. OF EMPLOYMENT

Period I (1-3 Months)	Period 2 (4-6 Months) 0	1	2	3	4	Total
0	56	18	3	---	---	77
1	15	4	---	---	---	19
2	2	2	---	---	---	4
3	---	---	---	---	---	0
4	---	---	---	---	---	0
Total	73	24	3	0	0	100

r = .004 X^2 test of independence = .270 d.f. = 4 p = 99

TABLE 6

BIVARIATE DISTRIBUTION OF PREVENTABLE ACCIDENTS FOR 100 COMPANY-TRAINED TRUCK DRIVERS FOR 1 TO 6 AND 7 TO 12 MO. OF EMPLOYMENT

Period I (1-6 Months)	Period 2 (7-12 Months) 0	1	2	3	4	Total
0	45	6	3	---	1	55
1	25	8	1	---	---	34
2	8	1	---	---	---	9
3	1	1	---	---	---	2
4	---	---	---	---	---	0
Total	79	16	4	---	1	100

r = .027 X^2 test of indpendence =4.370 p = .37 d.f.= 4

In the preventable classification for the period 1 to 3 with 4 to 6 mo., r was 0.004 and lacks statistical significance. This was also true in the relationship noted for the 1-to-6-mo. with the 7-to-12 mo. period with a coefficient of correlation of 0.027. The chi-squared tests of independence indicated that neither correlation was significant or showed relationship.

In the nonpreventable classification, an r of 0.19 was obtained for the 1-to-3 mo. with the 4-to-6 mo. period and an r of -0.42 for the 1-to-6-mo. with the 7-to-12-mo. period.

TABLE 7

BIVARIATE DISTRIBUTION OF NONPREVENTABLE ACCIDENTS FOR 100 COMPANY-TRAINED TRUCK DRIVERS FOR 1 TO 3 AND 4 TO 6 MO. OF EMPLOYMENT

Period 1 (1-3 Months)	Period 2 (4-6 Months) 0	1	2	3	4	Total
0	62	13	1	—	—	76
1	15	5	1	—	—	21
2	2	—	1	—	—	3
3	—	—	—	—	—	
4	—	—	—	—	—	
TOtal	79	18	3			100

r = .19

TABLE 8

BIVARIATE DISTRIBUTION OF NONPREVENTABLE ACCIDENTS FOR 100 COMPANY-TRAINED TRUCK DRIVERS FOR 1 TO 6 AND 7 TO 12 MO. OF EMPLOYMENT

Period 1 (1-6 Months)	Period 2 (7-12 Months) 0	1	2	3	4	Total
0	44	15	2	—	1	62
1	22	5	1	—	—	28
2	6	2	—	—	—	8
3	1	—	—	—	—	1
4	1	—	—	—	—	1
Total	74	22	3	0	1	100

r = -.42

With the exception of the last coefficient of correlation one must conclude that there is lack of consistency in the number of either preventable or nonpreventable accidents incurred by the drivers for any two successive periods of time. At this point, no suitable explanation has been disclosed for the high negative correlation for the nonpreventable accidents when the 1-to-6-mo. period was related to the 7-to-12-mo. period other than the fact that this high correlation probably occurred by chance.

In Tables 9 and 10 are given the t values between the number of accidents (preventable and nonpreventable) for the upper and lower 50 percent and upper and lower 25 percent of drivers for each variable, the personal or psychological data. For the preventable accidents two factors appear to distinguish low accident drivers at a reasonable statistically significant level, these being dependency and emotional stability. Age and mechanical comprehension appear to be also important. For the nonpreventable accidents, no one variable showed differences to be statistically significant. Self-sufficiency, a trait of personality measured by the Bernreuter Personality Inventory showed a t value of 1.32 significant at less than the 10-

TABLE 9

TABLE OF MEANS AND STANDARD DEVIATIONS FOR NUMBER OF PREVENTABLE ACCIDENTS FOR THE LOWER AND UPPER 50 PERCENT AND LOWER AND UPPER 25 PERCENT OF THE COMPANY-TRAINED DRIVERS ON EACH PERSONAL FACTOR AND PSYCHOLOGICAL TEST AND RELATIONSHIPS EXPRESSED BY t RATIOS

Variable	Lower 50% Mean	Lower 50% σ	Upper 50% Mean	Upper 50% σ	t	Lower 25% Mean	Lower 25% σ	Upper 25% Mean	Upper 25% σ	t
Age	.0580	.079	.0760	.076	1.16	.0500	.075	.0592	.060	.48
Education	.0630	.070	.0726	.084	.62	.0728	.072	.0992	.091	1.14
Dependents	.0830	.090	.0526	.059	2.00**	.0764	.091	.0460	.058	1.41
Experience	.0660	.076	.0680	.079	.13	.0624	.079	.0896	.088	1.15
Wonderlic (Intelligence	.0646	.079	.0694	.077	.31	.0628	.072	.0660	.062	.17
Bennett Mech. Comprehension	.0730	.088	.0576	.061	1.02	.0596	.065	.0656	.057	.85
Emotional Stability	.0528	.072	.0812	.081	1.84*	.0528	.062	.0656	.057	.77
Self-Sufficiency	.0662	.075	.0678	.081	.10	.0620	.075	.0564	.066	.28
Dominance	.0578	.077	.0728	.077	.97	.0660	.071	.0860	.084	.91

***Significant at the 1% level of confidence
** Significant at the 5% level of confidence
* Significant at the 10% level of confidence

TABLE 10

TABLE OF MEANS AND STANDARD DEVIATIONS FOR NUMBER OF NONPREVENTABLE ACCIDENTS FOR THE LOWER AND UPPER 50 PERCENT AND LOWER AND UPPER 25 PERCENT OF THE COMPANY-TRAINED DRIVERS ON EACH PERSONAL FACTOR AND PSYCHOLOGICAL TEST AND RELATIONSHIPS EXPRESSED BY t RATIOS

Variable	Lower 50% Mean	Lower 50% σ	Upper 50% Mean	Upper 50% σ	t	Lower 25% Mean	Lower 25% σ	Upper 25% Mean	Upper 25% σ	t
Age	.0726	.078	.0588	.076	.91	.0560	.070	.0784	.089	.98
Education	.0656	.076	.0692	.079	.23	.0684	.080	.0592	.069	.44
Dependents	.0560	.070	.0772	.084	1.38	.0728	.073	.0888	.097	.67
Experience	.0658	.078	.0690	.077	.21	.0692	.070	.0520	.052	1.00
Wonderlic Intelligence	.0608	.074	.0724	.081	.75	.0684	.073	.0792	.077	.51
Bennett Mech. Comprehension	.0674	.086	.0658	.069	.10	.0488	.074	.0456	.053	.18
Emotional Stability	.0640	.060	.0490	.077	1.09	.0960	.066	.0524	.091	1.96*
Self-Sufficiency	.0774	.084	.0574	.069	1.32	.0756	.091	.0556	.077	.84
Dominance	.0626	.076	.0722	.079	.62	.0656	.078	.0588	.065	.34

***Significant at the 1% level of confidence
** Significant at the 5% level of confidence
* Significant at the 10% level of confidence

percent level and dependency with a t value of 1.38 which is also significant at less than the 10-percent level.

This analysis appears to indicate that more of the personal or human element is involved in the preventable type of accident than in the nonpreventable type.

In Figure 1 are shown side by side the preventable and nonpreventable accidents for 91 drivers employed for at least 18 mo. These curves show that preventable accidents appear to follow a curvilinear relationship—rapid acceleration with gradual deceleration, particularly after the twelfth month of employment whereas the nonpreventable accidents appear to behave in a more linear fashion. In other words, the number of nonpreventable accidents a driver will have is more dependent on the length of the driving period whereas the number of preventable accidents tends to fall off after a certain period of employment.

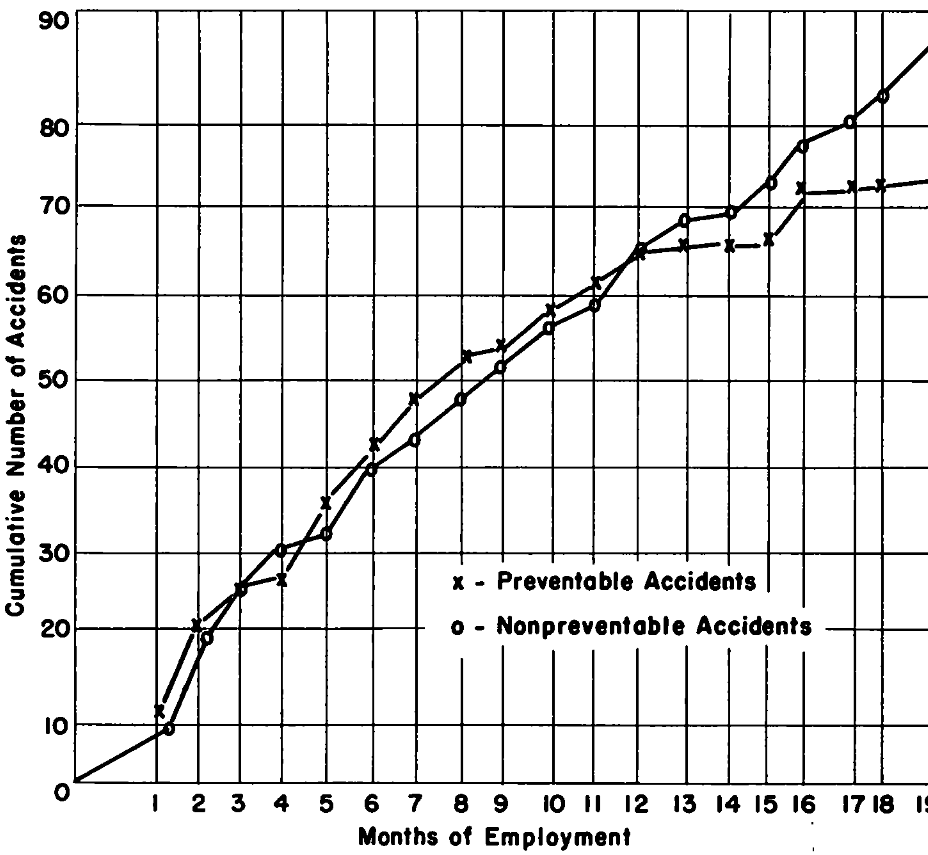

Figure 1. Preventable and nonpreventable accidents for 91 drivers employed for at least 18 mo.

Finally, a coefficient of correlation was computed between the number of preventable and nonpreventable accidents for the full 12 mo. of employment. This correlation was minus 0.12 and was not statistically significant. This fact means that the number of preventable accidents incurred by drivers is not related to the number of nonpreventable accidents incurred by these same drivers for a given period of time.

CONCLUSIONS

1. Nonpreventable accidents tend to occur over a given period of time more in line with chance expectancy than preventable accidents.

2. Personal and psychological factors appear to be more related to preventable accidents than to nonpreventable accidents.

3. Both the preventable and nonpreventable accidents tend to have notoriously low reliabilities or consistency of occurrence between two successive periods of time.

4. Zero relationships exist between the number of preventable and nonpreventable accidents for a group of drivers for a given period of time.

In summary, this paper shows that the distinction between preventable and nonpreventable accidents is not clear cut.

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RAPID-DECELERATION TESTS of CHEST-LEVEL SAFETY BELT

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SYNOPSIS

This paper presents the engineering and safety aspects in the development, method of mounting, and testing of an automobile safety belt and attachments. Thirteen individual tests were made under controlled conditions in the field. In the series of tests, the automobile and driver were decelerated at rates up to approximately 3.5 G.

Under ideal conditions a vehicle cannot be decelerated at a rate faster than about 0.9 G and passengers are exposed to the danger of at least minor injuries at even lesser rates. On the basis of measurements on nontelescoped sections, it is known that in a headon collision between two cars, each traveling at 35 to 40 mph., average decelerations of around 16 G's are produced. In such accidents the driver, and especially passengers, are subjected to considerably higher decelerations. In the simulated collision decelerations described in this report, the driver of the test car was uninjured in any of the 13 trials.

On the basis of these tests, it is indicated that if properly designed safety belts are installed and used in automobiles, a substantial reduction in both the frequency and severity of injuries to car occupants can be effected.

THE purpose of this research was to secure sufficient data to substantiate, or possibly render invalid, the hypothesis that rapid decelerations encountered in automobile collision need not, in many cases, result in death or even serious injury to the motorist, but rather, in no injury whatever, if the motorist is so protected that he is decelerated with, and at substantially the same rate as, the intact portion of the crashing vehicle in which he is riding.

Of the many conceivable protective devices, the type which acted as a restraining barrier, preventing the accident victim from striking the windshield, dash-panel, or other parts of the car, seemed to be most worthy of experimentation. An automobile safety belt possessing the desired quality was, therefore, built into a test car (Fig. 1).

The deceleration equipment consisted of a Navy aircraft tailhook secured to the rear of the test car and four suitably connected 1-ton reinforced-concrete sled-type blocks.

The tests were performed by successively driving the car into engagement with the low-slung connecting cable of the concrete block train. Commencing with an engaging speed of about 15 mph., the speed was gradually increased to 25 mph. The 25 mph. run produced automobile decelerations

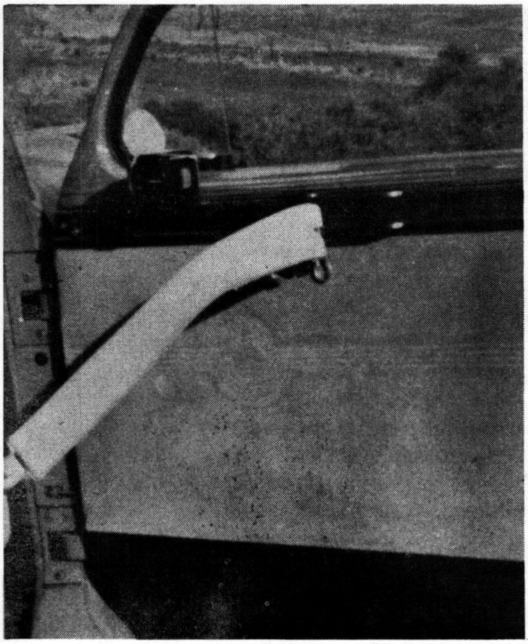
Figure 1.

which briefly reached 3.4 G, as determined from a frame-by-frame analysis of motion picture film. However, the smooth-curve plot of Figure 7 has averaged out these short-interval high decelerations so that the value shown more closely represents the deceleration to which the driver was subjected. The decelerations, as shown by a decelerometer mounted on the car, and the effectiveness of the safety belt for various rates of deceleration, were recorded by a motion-picture camera mounted on, but outside, the car, to the left of the driver. The overall deceleration pattern of the test car was recorded by a second motion-picture camera located at a favorable ground position. The film record of the ground camera provided, by means of a frame-by-frame analysis, an independent method of calculating the deceleration rates.

Deceleration Equipment

Perhaps the most desirable type of equipment for automotive-deceleration tests would be an installation of the Naval Aircraft Field Carrier Arresting and Launching Gear. If this gear were at all obtainable, the delay in its procurement and installation would have made it unlikely that it could have been made operational in time to meet the schedule of this research project.

A means was devised which served the purpose equally as well as the desired gear, and with considerably less investment in time and money. A naval aircraft tailhook and supporting mechanism was obtained from a wrecked airplane and was mounted on the rear of the test car. The hook was positioned so that it trailed behind the car with its tip about 1 in. above the ground. This tailhook rig is illustrated in Figure 2.

The arresting gear consisted of four flat concrete blocks joined by 25 ft. of 3/4-in. standard hoisting steel cable. Two concrete blocks were placed on each side of the dirt test road with the connecting cable stretched across the road between them. The cable was propped up by wood blocks to about 2 or 3 in. above the road. The test car was driven over this cable at various speeds to get a variation of maximum deceleration caused by the tailhook engaging the arresting cable and pulling the blocks together as well as in the direction of the car's motion (Fig. 3).

Instrumentation for these tests included the use of two motion-picture cameras, one mounted on the test car and the other on the ground near the point of maximum deceleration. A decelerometer was mounted in the test car

Figure 2.

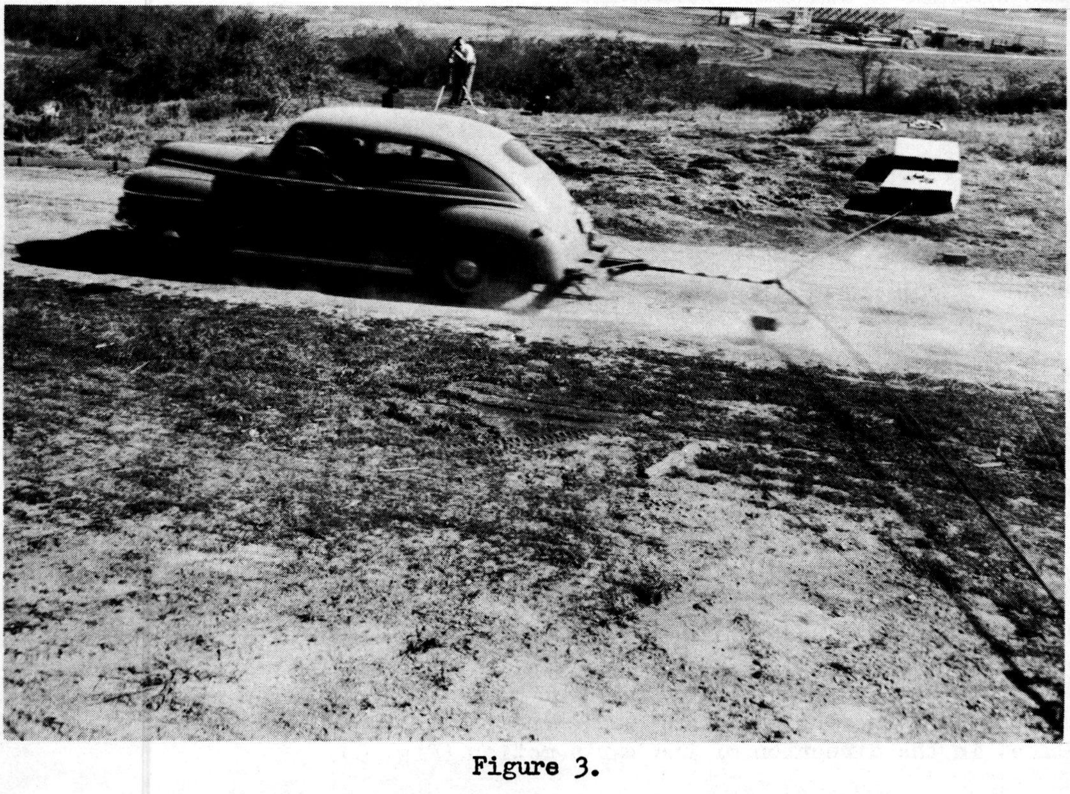

Figure 3.

within view of the recording camera. An electromatic speed meter was used to check the speed of the car at the instant of simulated impact. A special timing device and various curb position markers were used, Figure 4, so that deceleration could be calculated from a frame-by-frame analysis of the motion-picture film. This instrumentation made it possible to record the protective qualities of the crash belt so that these data could be studied carefully at a later time under more favorable conditions. The car camera was attached to the vehicle by a bracket and in a position which viewed the driver and the effects of impact on him together with the decelerometer included to give the rate of deceleration.

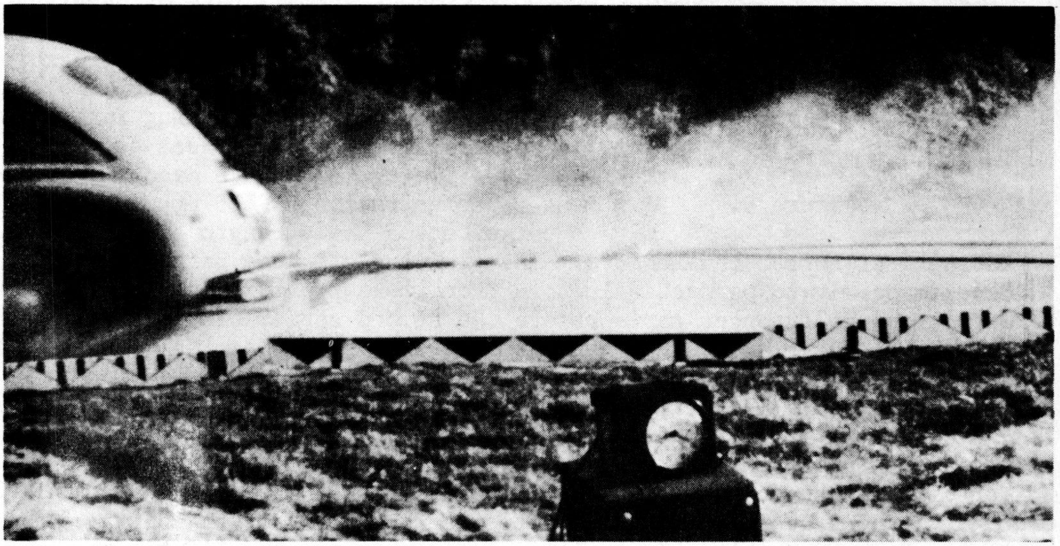

Figure 4.

Deceleration Tests

In addition to the mechanical arresting gear shown in some of the photographs of this report, the following modifications were made in order to prepare the test car for a nondestructive rapid-deceleration test. Not more than 4 gal. of gasoline were left in the fuel tank. The air cleaner was removed from the carburetor, and the spare tire, jack, and tools were removed from the trunk. Two electrical clip leads were connected across the terminals of the ignition lock so that the engine could be turned off from the gear shift by the act of dropping the two electrical leads held together by the same hand that was used for shifting gears.

The first series of tests were conducted primarily to check the operation of the deceleration equipment while the second series of tests were directed toward the study of the effectiveness of the automobile safety belt. For the second series, two additional pieces of equipment were used: an electromatic speed meter which functions on the Doppler principle was used to provide an additional means for speed determination of the test car, and an aircraft gun-sight camera, modified with a wide-angle, short-distance lens was mounted by a bracket 3 ft. outside the left-front window, as shown in Figure 5.

A fork lift was used to adjust each pair of 1-ton concrete blocks in such a position that the connecting cable was stretched perpendicularly

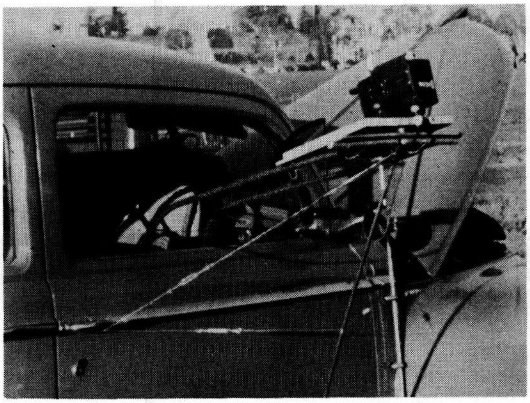

Figure 5.

across the dirt road. The test car was first driven at 10 mph. over the cable having only one concrete block on each end. The car tailhook engaged the cable which dragged the blocks and decelerated the car satisfactorily, but at 20 mph., the blocks were dragged to a trailing position at a small rate of deceleration, indicating that higher rates of decelerating could be attained more effectively from the use of two pairs of blocks. The remaining runs were made with the latter set up.

The sixth run was made at a speedometer reading of 35 mph.,1/ which exceeded the strength of some of the arresting gear supporting members. The yielding of these parts allowed the tailhook assembly to be partially torn from its supports. The weak members were replaced by stronger parts before the second series of tests were made.

The second series of runs were conducted in the following manner: The cable and blocks were placed in the proper position by the driver of the fork lift and the stationary cameras manned.2/ The test car was driven up the road about 1,000 ft. and then turned around. The driver held the ignition leads in his right hand, and with his left hand, switched on the car's motion-picture camera as the vehicle was accelerating. The car was accelerated in second gear to the desired test speed and was then shifted into neutral. Following this, the ignition leads were dropped to stop the engine as the test driver slid sideways in the seat to the front passenger position. Almost as soon as the driver assumed this position, the tailhook engaged the cable and decelerated the car. The car camera recorded the test driver's thrust against the safety belt.

For the final run, which was at a speed of about 25 mph., a deceleration of approximately 3.4 G was briefly obtained3/, but not without causing structural failure of arresting hook brackets (Fig. 6). Two 5/8-in. bolts snapped, a 4-in. 7.7-lb.-per-ft. steel I-beam, 40 in. long, bent at the center to a 6-in. deflection, and the tailhook assembly, for the second time, was partially torn from its housing. The test driver had on this and on previous runs experienced a severe snap of the head forward, though this event was not accompanied by any pain or after discomfort. The computed 3.4 G applied to the 160-lb. driver indicated that the safety belt had to withstand an induced body weight of approximately 500 lb. Less than a 10-in. length of the 3-in.-wide belt was used to resist this 500 lb. load,

1/ - Frame-by-frame analysis has shown this to be approximately 25 mph.

2/ - 16 mm. Cine Special II, and a 4- by 5-in. Speed Graphic. The camera mounted on the test car was a modified 16-mm. G.S.A.P.

3/ - The accelerometer mounted on the car showed, according to the photographic record, a peak deceleration reading of 7.6 G, as reported in the synopsis published in January 1953 in HRB's ABSTRACTS. However, subsequent analysis of the motion-picture records indicates such a high rate of deceleration could not have existed over a long-enough period of time to be of significance for this study. Therefore, the values computed from motion-picture records of car motion have been used throughout.

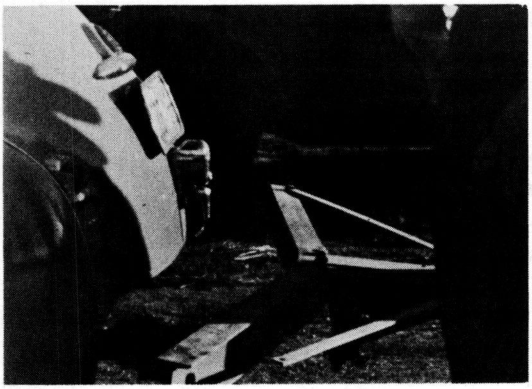

Figure 6.

which means that less than $\frac{1}{4}$ sq. ft. of the chest area had a 500-lb. load applied.4/ This is equivalent to 2,000 lb. per sq. ft. and is probably the reason why the test driver during this final run experienced a sharp pain, in the vicinity of the backbone at the height of the safety belt, which persisted for several hours after this last test run. Apparently the force applied to the chest wall was transmitted by the ribs to the backbone, causing discomfort in the muscle tissue paralleling the backbone at this point.

This condition suggests the need for a belt, or belt saddle, wider than 3 in. to give more adequate distribution of deceleration forces. A $4\frac{1}{2}$-in. belt would probably provide satisfactory protection for the majority of accidents, but such a belt may prove objectionable to the wearer, owing to the possible inconvenience or discomfort which the greater width may cause.

Deceleration Curves

Figure 7 shows a composite graphing of: (1) A family of curves portraying the theoretical deceleration pattern for a car decelerated from different initial speeds by means of the concrete-block drag-method just described. The data for plotting these curves were obtained by solving the equations of motion (shown in the appendix) on a differential analyzer. (2) Two experimentally obtained deceleration curves for a car having an initial velocity of approximately 23 and 24 mph. and which has been decelerated by the concrete-block drag method (developed from frame-by-frame analysis method). (3) An experimentally obtained deceleration curve for a Chevrolet-Ford head-on collision at the approximate speeds of 25 and 18 mph., respectively.

The differential analyzer curves show that greater initial rates of deceleration are obtained for correspondingly higher initial velocities but that this deceleration differential for various initial velocities becomes relatively insignificant after the first $\frac{1}{2}$ sec. of deceleration.

The experimentally obtained drag-block deceleration curves for initial velocities of 23 and 24 mph. compare favorably with their theoretically determined counterpart after the first 0.2 sec. of deceleration. The deviation of the experimental from the theoretical deceleration pattern for the first 0.2 sec. is in the direction which makes the experimental curve more closely resemble the deceleration pattern of the headon crash. The drag-block curves have been oriented with respect to the headon collision curve so that the principal peak deceleration appears at about the same time after impact. This superposition demonstrates that the drag-block method produces

4/ - The effect of the frictional restraint offered by the seat is considered negligible for these approximations.

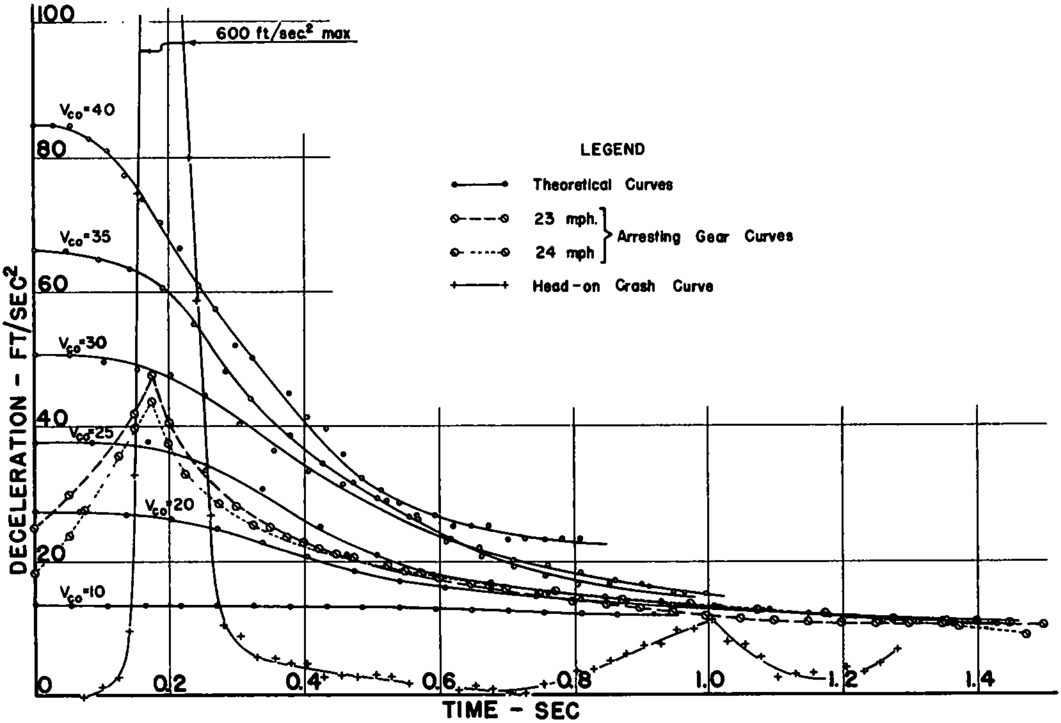

Figure 7.

a much-smaller peak deceleration during a much longer period of time than is shown for the headon collision. This condition illustrates one of the difficulties in developing a nondestructive means for decelerating an automobile in a manner which corresponds sufficiently close to the conditions that prevail in an average automobile collision so that a reasonable appraisal of safety devices may be made. It is for this reason that the institute has, for the past year, been developing equipment for testing various motorist restraints by means of experimentally staged automobile collisions with fixed objects.

<u>Discussion of Error for the Decelerations Determined From the Frame-by-Frame Analysis of Motion-Picture-Film Records</u>

A Bausch and Lomb Contour Measuring Projector was used to measure distances which a car moved in successive frames relative to a calibrated marker within the photographed field. The time for the incremental change of car position per frame was determined from an electric timing device, also in the field of vision, for the concrete-block deceleration runs, and by a 60-cycle light beam imposed on the edge of the camera film for the high-speed camera used in recording the headon collision.

Micrometers facilitate measurement of displacements of the table of the Contour Measuring Projector to an accuracy of 0.0002 in. However, the grain size of the film's emulsion and other inherent sources of error introduce additional errors of reading. To determine the total error due to film reading, 10 readings of one frame representing the most-defined and 10 of the least-defined frame of this film sequence were made and from this, two times the standard deviation of the measurements was determined to be of the order of ± 0.0005 inch.

In order to test the effect of this maximum error on the decelerations ultimately developed from the distance measurements, a series of frames covering a typical peak deceleration were analyzed. To each of the distances measured, a maximum deviation of +0.0005 in. and again -0.0005 in. were applied, thus forming three values of distances for each frame. In differentiating these distances with respect to time, the negative distance was matched with the succeeding positive and this, in turn, with the succeeding negative, so the resulting velocity expressed a maximum error as compared with the velocity determined from the normal reading. This same procedure was again applied to the differentiation of velocity. Although amplified to the extreme, the errors in deceleration did not vary from the observed values more than an average of ± 0.18 G, or about 13 percent. By this particular method, the errors in deceleration may vary from the observed values by a maximum of ± 0.18 G, or a possible error of about 13 percent. In view of the complexity of the mechanical system involved, an error of the above-mentioned magnitude is not considered unreasonable. Furthermore, within a 13-percent variation of G forces, the dynamic response of the human body will not be significantly changed. Nevertheless, it would appear to be desirable to accurately determine the error inherent in frame-by-frame analysis.5/

5/ - In the future, this problem will be evaluated by calibrating the Camera-Contour measuring Projector-Graphical Analysis systems simultaneously by a procedure suggested by Heinz Haber, which involves a trial run made on a test object dropped from a suitable height several yards in front of the camera. The necessary timing and calibration marking devices will be included in the photographed field. The deviation from one G acceleration thus calculated from a frame-by-frame analysis will, at once, be apparent.

REVIEW AND CONCLUSIONS

The tests reported in this paper were undertaken in an attempt to determine the effects of rapid deceleration on a motorist restrained by a safety belt having a fixed configuration. The entire range of decelerations were not, of course, initially known. Of necessity, the testing program ended with the failure of certain parts of the arresting gear at which point the maximum deceleration was reached.

On the basis of the tests reported herein and motor vehicle accident statistics6/ the following conclusions appear to be warranted:

1. Deaths and serious injuries have been incurred by motorists riding in crashing vehicles in which the deceleration rates were of a low order of magnitude. The tests reported suggest that injuries sustained as a direct result of forward impact can either be prevented entirely or greatly minimized through the use of a safety belt equal or superior to the one described above.

2. The chest-type safety belt provides an effective means of protecting a vehicle occupant against the results of forward impact forces without placing objectionable restraints on the body.7/

3. The chest-type belt overcomes the greatest single weakness of the lap-type belt by preventing pivoting at the waist. Thus, violent impact between the head and the steering wheel, dashboard, windshield, or other interior part of the vehicle is prevented.

4. While more statistical data are needed to accurately portray the facts, it is undeniable that a substantial number of fatal automobile accidents are directly attributable to vehicle occupants being catapulted through doors which have been forced open by forces resulting from impact. In a selective study of 209 collisions8/ involving 97 fatalities, one author attributes 32 of the fatalities to door failures. The chest-type belt, by virtue of the fastening arrangements, has the quality of preventing accidental opening of car front doors during or immediately following impact.

5. The results of the tests described were sufficiently favorable to indicate the desirability of further investigation of the potential benefits of safety belts in automobiles. Such an investigation is in the advanced planning stage by the Institute of Transportation and Traffic Engineering.

6/ - "Accident Facts," annual publication of National Safety Council.

7/ - A safety belt of the type described was consistently used by the junior author on an extended cross-country trip of 9,000 mi.

8/- Harper, William W., "Prevention and Reduction of Injuries in Traffic Collisions", Parachute Corp. of America, 6625 Sunset Blvd., Hollywood, California

ACKNOWLEDGEMENT

The authors wish to express their most sincere appreciation to Arnold Rosenbloom in the derivation of the equations of motion; to Don Lebell and George Bekey in the solution of the equations on the differential analyzer to Paul Barbour for film analysis, and to members of the institute staff who ably assisted in the field operations.

APPENDIX

THE DIFFERENTIAL EQUATIONS FOR THE CONCRETE BLOCK DRAG METHOD

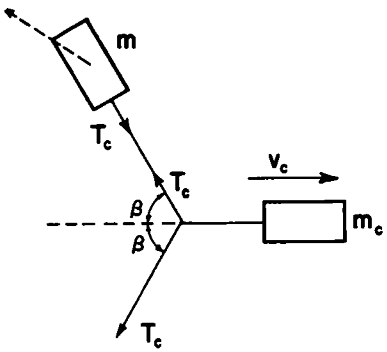

Figure A

A free-body diagram of the forces involved during the deceleration of an automobile by the concrete block drag method is illustrated. As the car decelerates the blocks are pulled into line with the car's motion.

The cable force T_c varies with the angle β . It was this nonlinearity which made the use of the analyzer desirable. For differential analyzer solution the equations of motion of the system were expressed as:

$$(1)\quad \frac{dV}{dt} = -\frac{2m}{2m + m_c}\frac{d}{dT}(\dot{\beta}\sin\beta) - \frac{2fr}{(2m + m_c)v_{co}^2}\frac{V + \dot{\beta}\sin\beta}{\sqrt{\dot{\beta}^2 + 2\dot{\beta}V\sin\beta + V^2}}$$

$$(2)\quad \frac{d}{dT}(\dot{\beta}\cos\beta) = \frac{m_c\tan\beta}{2m}\frac{dV}{dT} - \frac{fr}{mv_{co}^2}\frac{\beta\cos\beta}{\sqrt{\dot{\beta}^2 + 2\dot{\beta}V\sin\beta + V^2}}$$

Where:

- m = mass of one pair of blocks
- m_c = mass of the car
- f = Friction force (assumed constant)
- v_c = Instantaneous car velocity
- v_{co} = Velocity of car immediately after impact
- r = one-half the cable distance between the centers of mass of the pairs of concrete blocks
- β = angle of cable with respect to direction of car
- V = dimension less velocity of car, (v_c/v_{co}) where v_c is the instantaneous car velocity and v_{co} is v_c the instant of impact.
- T = dimensionless time, (tv_{co}/r) where t is time in seconds.

The velocity and time variables were nondimensionalized for generalization of the solution.

DISCUSSION

HUGH De HAVEN, Director, Crash Injury Research, Cornell University Medical College: Mathewson and Severy are to be complimented for having initiated tests of the effectiveness of chest-level safety belts in automobiles. Their findings are interesting and provocative. The test conditions implied considerable personal danger; volunteering for such tests required no uncertain amount of courage.

Although it is fair to accept the authors' classification of their tests as "first attempts", considerable importance is attached to such first attempts, because of their stimulation of thought in undertaking future studies of the effectiveness of safety belts, shoulder harness, and chest straps.

Looking toward reports of future tests, it is very important to convey, in the body of the text, the type of safety installation tested. The title of the paper clearly states that the report deals with "the effectiveness of a chest-level safety belt", whereas the installation is referred to in the text as "an automobile safety belt". Use of this phraseology could be very confusing in a quotation from this paper because the public concept of a safety belt is a restraining device which holds the user at the waist, rather than a chest-level restraining strap.

Of primary importance, however, is the question as to whether the conditions of force set up in the Mathewson-Severy test methods fulfilled the requirements of a "simulated collision deceleration" sufficiently to test the overall effectiveness of a chest-level restraining device. It is doubtful that the test conditions set up forces as high as those occurring even in moderately severe automobile accidents.

The cable-and-drag-block procedure, used by Mathewson and Severy to slow down the test car, seemingly produced decelerations no greater than those encountered in normal landings on the decks of aircraft carriers. Prior to the use of shoulder harness, Navy pilots customarily braced and protected themselves in 3 G carrier landings. Like the arresting gear used on aircraft carriers, the drag-block procedures produced a slow onset of force, a low rate of change of acceleration, and moderate deceleration. By comparison, the forces set up in moderate automobile accidents are abrupt and severe. The only type of accident likely to produce a pure drag-block fore-and-aft force effect would be if a car ran off the road and encountered progressively resistant brush.

Unquestionably, a chest-level strap would protect the occupants of cars under such (3 G) conditions and also in cases where the brakes are applied suddenly; the strap also would give protection in direct head-on collisions at very low speeds (perhaps up to 15 mph.). It is questionable, however, whether a chest-level strap, strung from one side of the car to the other, would afford effective restraint in head-on collisions above

10 mph., or in run-of-the-mill traffic accidents where the car rolls over, or strikes other than directly head-on, or bounces violently so the occupants are pitched above or below the belt, or to one side.

It appears, therefore, that the effectiveness of chest-level safety straps may have been tested under very limited and somewhat unreal "accident" conditions. Although this point is touched on in the paper, it might have been given more emphasis, in order to prevent overrating the protective effects of such installations by casual readers.

In order to further explore the protective effects of chest-level straps, a second group of tests now is being considered. In these, the straps may be installed in cars which may be subjected to head-on and angular collisions, representative of low-speed run-of-the-mill accidents. If such tests are undertaken, it would be wise, for the sake of safety, to use very-low initial speeds (no greater than 10 mph.) if human volunteers are involved. In these future tests, instrumentation also should be considered which will record the rate of onset of force as well as the magnitude of decelerations.

Since no data are provided on the frequency of response or other characteristics of the accelerometer used in the tests, one must speculate on the magnitude and duration of peak loads. Reference to a 7.6 G reading on the accelerometer suggests that rather high peak loads were present which may have had considerable significance to the study. Jolt loads or peak loads—rather than the accelerations obtained from time-displacement analysis—may have caused the ultimate failure of the tail-hook assembly and may also have contributed to a snap effect which brought the driver to the threshold of injury.

A consideration which should enter future calculations is that a 3.4 G deceleration, acting on a driver weighing 160 lb., will not necessarily produce a load on the chest strap of 3.4 times 160 lb., or approximately 540 lb. Presumably, the test driver instinctively braced his feet against the floor and this would, automatically, relieve the strap of a substantial percentage of the induced weight of the feet, legs, thighs, and lower torso. Possibly less than 50 percent of the total induced body weight acted on the strap.

On the other hand, if the test subject was not in contact with the strap when the deceleration occurred, and if the rate of change of acceleration was high, then instead of progressively adding the induced weight of his upper torso to the strap, during a period of increasing force, the test subject may have picked up a substantial difference of velocity with respect to the car and the safety device. If this occurred, the test subject could have been "thrown" against the strap and the jolt load may have greatly exceeded the authors' calculation of 500 lb. On future tests, it would be highly desirable to measure dynamic loads applied to the strap with regard to rate of application, peaks, and duration of force. In addition, strain gauges should be incorporated in safety-belt assemblies so that resultant strains on the webbing and its attachments can be determined.

As measurements of the true load imposed on the chest-level belt, and on the chest of the test driver, were not obtained in the Mathewson-Severy tests, the cause of the sharp pain reported in the dorsal region remains in doubt. Possibly the chest was loaded close to the danger point; possibly flexion of the dorsal spine when the driver's head snapped forward, rather than the induced load on the object, was the causative factor.

Although the nature of test conditions and instrumentation used in these first tests permits a limited evaluation of the effectiveness of chest-level straps, continuation of the authors' work promises to provide data of exceptional value to the public.

For the present it seems doubtful that the limited data available from arresting-hook and drag-block tests should be used for drawing conclusions on the effectiveness of chest-level straps in common types of automobile accidents. Even in low-speed (20 mph.) collisions, of the type where a car ahead slows down abruptly and the following car slides into it, the force of deceleration might be abrupt and might approximate the 600-ft.-per-sec.-per-sec. (20-G) deceleration experimentally obtained in an 18-to-24 mph. head-on collision, as represented by the curve in Figure 7.

The family of curves shown in Figure 7 (derived from the differential equations presented in the appendix) do not seem closely related to either of the curves representing simulated 23-to-24-mph. test decelerations. In turn, these simulated collision curves are quite unlike the curve representing a true 18-to-24-mph. crash deceleration.

The abrupt increase of force in this crash curve, with the high, brief peak and rapid sign off, point to important dissimilarities between true collision forces and those used for evaluating the effectiveness of chest level straps.

It appears that the theoretical curves in Figure 7 describe the last part of the deceleration set up by dragging the blocks after the several components of the system are in motion and after an equilibrium has been established. These curves, therefore, may not deal with an extremely important part of a true crash deceleration - particularly that interval during which high inertia effects are present in the system.

Some consideration also should be given to the tendency of a tail hook to hold down the rear end of a car during a snubbing deceleration; for when the brakes are applied suddenly or when a car collides with an object, there appears to be a tendency for the rear end of cars to pitch upward, so that the occupants, particularly in rear seats, might be thrown above a transversely mounted chest-level strap in ways which would apply severe forces to their lower ribs and soft portions of the abdomen, rather than to their chests. These effects, of course, would vary, depending on the heights of the persons using the strap.

It is to be hoped that before further investigations of the effectiveness of chest-level straps are undertaken, measurements can be made of the duration of forces in moderately severe automobile accidents, so that test conditions closely simulating these forces can be employed in further evaluations of the effectiveness of chest-level straps, safety belts, and other types of restraining gear.

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