A STUDIED APPROACH TO TRANSIT SAFETY

STAFF AND SUPERVISORY INSTRUCTION CLASSES
SUPPLEMENTED WITH DEMONSTRATIONS OF
BUS PERFORMANCES ON THE
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
TRAINING COURSE

Prepared and Conducted by
Certain Transportation Department
Staff Employees of the
Southern California Rapid Transit District
And its Consultant, Mr. David D. Canning

March, 1965

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FOREWORD

During the mid-thirties, Mr. Fred C. Patton, General Manager of the Los Angeles Motor Coach Company, arranged for an accredited course in "Highway Transportation" to be part of the curriculum of the Frank Wiggins Trade School located in Los Angeles. There were no textbooks on the subject and Mr. Les Appel, Director of Research of the Pacific Electric Company, and Mr. David D. Canning, Assistant Manager of the Los Angeles Motor Coach Company, prepared the class material. During the approximate three years that the classes were held, a wealth of material was developed, some of which was subsequently used by the Traffic Institute of Northwestern University. The Los Angeles Chapter of the Greater Los Angeles Safety Council was instrumental in not only promulgating the material developed, but in addition, among other endeavors, conducted an investigation into the possibility of isolating potential accident hazard drivers.

The faculty and students of the Highway Transportation classes, for all practical purposes, were a study and research group that developed original data related to the laws of motion as they applied to motor vehicles and causes of accidents, the mathematics of safety, and a review of the skid-mark theory.

In attendance at the classes were representatives of the Los Angeles Police Department, employees of the Pacific Electric, Los Angeles Motor Coach, and Los Angeles Railway transit companies. Many members of the class later became directors or administrators of safety programs. C. L. Srack and C. Dunbar were safety directors for the Yellow Cab and Airport Transit Company. George Troutwine and E. B. Logsdon are Managers of transit companies, directly in charge of safety programs, and George Goehler and Jack Stewart are administrators of the Safety Program for the Southern California Rapid Transit District.

In 1948, in conjunction with the Supervisor training course under the *direction of M. Edwin Wright, then General Superintendent of Transportation for the Los Angeles Transit Lines, a course was presented for the use of safety formulas and the application of accident statistics with George Goehler as the instructor.*

Since January 1, 1961, much of the material that was developed originally in the Highway Transportation classes has been used on a continuous basis as part of the safety program for the former Los Angeles Metropolitan Transit Authority and now the Southern California Rapid Transit District.

Mr. David D. Canning, who is now a consultant for the Rapid Transit District, and one of the original instructors of the Highway Transportation classes, has prepared a new textbook entitled, "There Is Safety In Numbers", and included is much of the material that was originally developed and updated for present use.

A STUDIED APPROACH TO TRANSIT SAFETY

INTRODUCTION

The Southern California Rapid Transit District each day operates some 1300 buses, 121 automobiles, and 87 trucks on the streets, freeways and highways of Los Angeles, Orange, Riverside and San Bernardino Counties in Southern California, with an annual mileage for buses in excess of 55,000,000 miles. The operations are complex and diversified; for example, a bus on the "35" Line may operate for two miles through congested downtown peak traffic at an average speed of 5 MPH, enter the crowded Hollywood Freeway with varying speeds from 15 to 65 MPH, including the Cahuenga Pass Grade, and for the next fifteen miles operate on surface streets in Suburban San Fernando Valley at speeds ranging from 15 to 40 MPH.

Vehicular traffic in the area moves fast in heavily congested areas, distances traveled are usually lengthy (generally twice those of other metropolitan areas), and while the average motorist is a good driver in Los Angeles, the speeds driven and the stress of going from work to home in a reasonable time contributes to an alarmingly high number of accidents.

In such a climate does our bus Operator drive his transit vehicle and the need for teaching him safe driving techniques is a vital necessity. Before an Operator is taught safe driving, our Instructors and Supervisors must be "experts" in all phases of safety and this Supervisory course, which includes Safety Engineering, the mathematics of safety and their application, a discussion of safety programs and an approach to accident investigations, is designed to make our Staff, Supervisory and Instruction employees more knowledgeable on the subject of safe driving, and to develop teaching techniques that can be used in our Operator training program and evaluation of accidents.

The selected group for this first class includes the Assistant General Superintendent of Transportation, the Chief Special Agent, the Chief Instructor, two Line Supervisors, two Division Instructors, a Staff Assistant, the Supervisor of Schedules, and two Special Agents, all employees of the Southern California Rapid Transit District. From the Transit Casualty Insurance Company are the Safety Director and a member of his staff, and three members of the Claims Department.

The Instructors are Dave Canning, consultant for the S.C.R.T.D.; John Miller, Regional General Claim Manager for the Transit Casualty Company; and George F. Goehler, General Superintendent of Transportation for the S.C.R.T.D.

The textbook used is, "There Is Safety In Numbers", prepared by David Canning, and the principal reference material is the Staff Safety Report for 1965, prepared by the Transportation Department of the S.C.R.T.D.

CLASS SCHEDULE

FIRST SESSION:

INTRODUCTION	GEORGE F. GOEHLER
DISTRIBUTION OF TEXT AND FIRST LECTURE	DAVID CANNING
RECESS	
DISCUSSION OF MR. CANNING'S PRESENTATION	DAVID CANNING
DISTRIBUTION AND DISCUSSION OF STAFF SAFETY REPORT	GEORGE F. GOEHLER
REPORT ON CURRENT ACCIDENT AND CLAIMS STATISTICS	JOHN MILLER
OPEN DISCUSSION	

SECOND SESSION:

REVIEW OF PREVIOUS CLASS PRESENTATION	DAVID CANNING
SECOND LECTURE	DAVID CANNING
RECESS	
DISCUSSION OF MR. CANNING'S PRESENTATION	DAVID CANNING
DISCUSSION OF CERTAIN CRITICAL ACCIDENTS	GEORGE GOEHLER & JOHN MILLER
OPEN DISCUSSION	

THIRD SESSION:

REVIEW OF PREVIOUS CLASS PRESENTATION	DAVID CANNING
THIRD LECTURE	DAVID CANNING
RECESS	
DISCUSSION OF MR. CANNING'S PRESENTATION	DAVID CANNING
DISCUSSION OF SAFETY PROGRAMS FOR 1965	JOE PRUTSMAN
OPEN DISCUSSION	
SLIDE RULE INSTRUCTION (OPTIONAL)	GEORGE GOEHLER & DAVID CANNING

Class Schedule (Cont'd)

FOURTH SESSION:

ILLUSTRATION OF STOPPING DISTANCES (DETONATOR DEMONSTRATION) AND SIMULATED DRIVING CONDITIONS AT THE RIVERBED TRAINING COURSE.

STUDY OF TURNING RADII AND INTERSECTION PROBLEMS.

CONDUCTED BY MARVIN STORER
AND INSTRUCTION DIVISION STAFF

FIFTH SESSION:

REVIEW OF PREVIOUS PRESENTATION	DAVID CANNING
REVIEW OF CONTENTS OF STAFF SAFETY REPORT	GEORGE GOEHLER
RECESS	
SIMULATED COURTROOM PROCEDURE WHEN AN OPERATOR OR SUPERVISORY EMPLOYEE IS REQUIRED TO TESTIFY AT AN ACCIDENT HEARING.	HARRY M. HUNT TRANSIT CASUALTY LEGAL STAFF
OPEN DISCUSSION	
SLIDE RULE INSTRUCTION CLASS (OPTIONAL)	GEORGE GOEHLER & DAVID CANNING

Staff Safety Committee Report

SOUTHERN CALIFORNIA
RTD
RAPID TRANSIT DISTRICT

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT 962 W. 12TH PLACE, LOS ANGELES, CALIFORNIA 90015
C. M. GILLISS, GENERAL MANAGER · TELEPHONE (213) 749-6977
CONE T. BASS, MANAGER OF OPERATIONS

FOREWORD

The Southern California Rapid Transit District's Safety activities are under the direction of its Manager of Operations, Mr. Cone T. Bass, who is a member of the Executive Committee of the National Safety Council.

The coordination of all safety programs of the Operating Departments is handled by the Assistant Manager of Operations, Mr. M. Edwin Wright.

Transportation Department safety activities and the Staff Safety Committee are under the jurisdiction of the writer of this report, the General Superintendent of Transportation, Mr. George F. Goehler, who spearheads the Operators' Safety program. Mr. Jack Stewart, the Assistant General Superintendent of Transportation, is Chairman of the Staff Safety Committee and handles the occupational safety program.

TABLE OF CONTENTS

EXHIBITS

SCRTD STAFF SAFETY COMMITTEE

I. Introduction

The Los Angeles Metropolitan Transit Authority commenced operations on March 3, 1958, by acquiring the two largest transit operations serving Los Angeles, Orange, San Bernardino and Riverside Counties. The former Los Angeles Transit Lines was generally a local carrier and the former Metropolitan Coach Lines and its subsidiary, Asbury Rapid Transit System, rendered local, suburban and interurban service.

The two properties were merged into a single system that had 1,665 one-way route miles, scheduled 1,458 maximum vehicles daily, and carried approximately 500,000 daily passengers. During the Spring of 1964, the California State Legislature approved legislation which created the Southern California Rapid Transit District and the merger date absorbing MTA was November 5, 1964.

By June of 1960, MTA organizational activities had been completed, the California State Conciliation Service had assigned employees to units as a result of a series of hearings held by Archibald Cox, a jurisdictional election resulted in the Operators being placed under the Brotherhood of Railroad Trainmen's Union, and lengthy contract negotiations were completed.

The magnitude of the changes and disruptions to normal operations between March of 1958 and June of 1960 resulted in an alarming accident frequency in both the operating and employee injury categories.

During the year 1960, two significant safety programs were prepared after many months of study and the first, the Operators' Safe-Driving Program, was placed in effect on January 1, 1961, and has been continued as a long-range program since that date, being implemented from time to time with short-term programs. The Industrial Safety Program was placed in effect some time later, and in 1964, the Authority, and subsequently the District, assumed the responsibility of Workmen's Compensation with the Transit Casualty Company as administrators of this activity.

The Staff Safety Committee was tied in with both programs and was the outgrowth of our study group and began functioning on August 25, 1960.

The idea of this committee was first suggested by Carl Sypher of the Transit Casualty Company during his study of our accident problems in June of 1960; and was developed by John Miller and Joe Prutsman of the Los Angeles office of the Transit Casualty Company; George Goehler, the General Superintendent of Transportation, and Jack Stewart, the Assistant General Superintendent of Transportation of the MTA.

II. Purpose of Committee

(a) To utilize the services and knowledge of the operating staff employees of the SCRTD to assist in coordinating the activities of our safety programs.

(b) To investigate equipment, schedules, routing and related problems as they affect safety, and make recommendations for improvements.

(c) To keep our staff informed of our accident incidence, pointing out the areas requiring immediate attention and to acquaint the members with our progress, trends, and to develop an active interest in safety.

III. Functioning of Committee

(a) Committee Personnel

As shown in Exhibit 3, the Committee membership includes staff members from the General Superintendent of Transportation's office, the General Superintendent of Maintenance's office, and the Instruction, Schedule, Supervisory and Stops and Zones Divisions; and also, members of the Safety Engineering Section and Claims Section of the Transit Casualty Company. A few months after the Committee was organized, members were added from the Property Maintenance and Special Agents Departments.

(b) Monthly Meetings

A full Committee meeting is held, generally each month, chairmanned by Jack Stewart, Assistant General Superintendent of Transportation. During these meetings a preliminary review of progress is made, statistical material is distributed to show current conditions, trends and problem areas. Each member reports on the activities under his jurisdiction and new problems that are presented are discussed and assigned to individual members for investigation and action.

(c) Committee Member Assignments

Each item or problem that is brought to the attention of the Committee is assigned to a member or group of members best qualified to handle the assignment. A thorough investigation is made, necessary studies are conducted to determine the possibility of correcting or improving the problem area, and District approval is sought if there is an expenditure involved or any change in District policy. Progress reports are made at subsequent meetings. In the event no solution is obtainable, action is taken where possible to make known the hazard or problem area and solicit the attention of all concerned when operating in the area.

(d) Progress and Statistical Reports.

The Statistical Section of the Transit Casualty Company and the Transportation Department of the SCRTD compile many types of information relating to accidents, accident trends, and information that is kept on a continuing basis. The Staff Safety Committee serves as a "clearing house" for this type of information and it is made available to all individuals and departments who are actively engaged in our Safety Programs. Reports are issued periodically and at the end of each year these reports serve as guide lines for future activities. Included in this presentation are reports reflecting our 1964 activities and five year reports and accompanying trends from January 1, 1960 to December 31, 1964, inclusive.

IV. Matters Investigated by Committee.

(a) A study of traffic and passenger accident frequency and the relationship of individual types of accidents to locations, time of day, and driving conditions.

(b) A study of our long-range safety programs and devising methods to implement them with new and interesting ideas that will keep our Operators informed of safe driving techniques and the results of our accident programs.

(c) Accident hazards of all types including utility poles, newspaper racks, street conditions, intersection problems, traffic flows, routes of lines, etc.

(d) Equipment problems such as glare on windshields, reflection of interior lights, Operators' seats, brakes, mirrors, sun visors, baggage racks, location of fare boxes, zone check boxes, and paddle board holders.

(e) A continuing study of employee accidents and recommendations calculated to reduce them.

(f) The processing of all suggestions referring to safety that originate with any employee of the District. It is noteworthy that many of these originate with the Operators.

V. Brief Summary of Committee Recommendations.

(a) Changes in routes of a number of lines and rerouting of deadhead trips in areas where hazards exist.

(b) Changes in types of equipment to better suit actual operating conditions.

(c) Numerous changes in passenger loading zones and the location of stop signs to eliminate boarding and alighting problems.

(d) New design of zone check boxes and paddle board holders.

(e) Improvement in the lighting of certain Division yards.

(f) Special trainroom employee safety training programs.

VI. Subjects Under Study.

(a) Location of stops (Nearside, farside, and mid-block).

(b) High passenger frequency rates at certain Divisions.

(c) Main Street Station operation.

(d) Accident incidence at specific locations by time of day.

(e) Freeway operation and diversionary routes.

THE 1964 SAFETY STORY

Remarks by G. F. Goehler - General Superintendent of Transportation

The effectiveness of the Joint Safety Program for 1964 cannot be told without relating it to the years of 1962 and 1963. Our long-range Safety Program that was effective January 1, 1961, produced excellent results by 1962 and a reasonably low level of accidents and severity was established that year. On March 31, 1963, we converted our last 164 street cars and 89 trolley coaches to motor buses and were faced with the problem of training some 240 street car Operators to bus Operation. On September 15, 1963, we closed our interurban bus terminal and operated some 14 Lines in a temporary terminal with restricted operating space.

Continuing emphasis of our Safety Program, including frequent visits to our Operating Divisions by Staff members of the Transportation Department to discuss safety facts with our Operators produced a significant reduction in all types of accidents.

The total accidents for 1964 showed a decrease of over 14% compared with 1963, and over 9% with 1962, and our cost of repairs to revenue equipment showed a substantial reduction. Perhaps the greatest decrease was in passenger accidents, where an approximate 20% reduction was made over 1962. While the numerical reductions were excellent, the severity showed even greater decreases. This should, even in the face of inflation, produce monetary reductions in the cost of claims for 1964.

As a result of the excellent and always improving courtesy and safety records, commencing in 1960, the General Manager, in the presentation of the budget for the year 1965, was able to report that from a deficit of more than $400,000 there was a substantial credit available for use by the District.

The success of the program was due to four principal factors:

1. The full cooperation of our Operators' Union, the Brotherhood of Railroad Trainmen, who provided the award plaques, worked at the Division level with our Operators on a day-by-day basis, and publicizing our Safety Program in their Union magazine.

2. The excellent work that was done by the Safety Engineering Department of the Transit Casualty Company, again on a day-by-day basis, preparing elements of our Safety Program, conducting our refresher courses for accident-prone Operators, and preparing a wealth of statistical material that was used effectively by our Staff in determining areas for improvement.

3. By the day-to-day assistance of the Transportation Department Staff and our Division Instructors who made our Safety Program a live, vital part of our daily operations.

4. By a continuing review of our accidents for the purpose of counseling Operators where it was felt such counseling was necessary and would accomplish the purpose, and in other instances by the use of fair discipline.

All of the results accomplished in 1964 by our SCRTD Operators was done in a Metropolitan area where accident incidence showed significant increases and cost of claims were at an all time high.

Remarks by J. W. Prutsman - Safety Director

During 1964, the Transit Casualty Company Safety Engineering Department kept the entire Safety Program at the Operators' level. This was accomplished through a safety program entitled, "Impruv-Ur-Record Contest". The contest covered improvements in 8 major accident and claim categories along with employee on-duty injuries. The contest was divided into 2 groups, due to the difference in size of Divisions and areas served. Seven Divisions composed Group I, five Divisions composed Group II. Three winners were chosen monthly in Group I and two in Group II, based on points of improvement over the same month of the prior year. Each Division competed against its own record. The Division showing the greater over-all improvement was considered a winner. The Brotherhood of Railroad Trainmen's Union supplied rotating plaque-type awards to the winning Divisions each month. At the award presentations, the winning Division Operators were served refreshments (cake, doughnuts and coffee) by a Transit Casualty Company representative, at which time Transit District representatives, Union representatives and Safety Engineers were present to congratulate the Operators for their achievements. This is a continuing program.

Throughout the year Operators made excellent safety suggestions, many at the award meetings. These were submitted to the Staff Safety Committee for consideration and acknowledgement to the Operators. A continuous concentrated safety program was carried on at those Divisions that failed to improve their prior record. Observation rides were made by the Safety Department, Operating Department representatives, and members of the Staff Safety Committee, after which detailed studies were made in order to eliminate and/or reduce accidents. In addition, a study of the individual Operator's record was made in order to point out to the Operator any driving deficiencies.

The Safety Program is much like a wheel; Safety Department is the hub and all other persons and departments are like the spokes. It takes the help of all concerned to accomplish the best results.

Remarks by John G. Miller - Regional General Claim Manager

Accident frequency reduction is the only sure method of reducing or holding accident costs at a stable rate. All expenses connected with accidents, repair costs to damaged property, medical expenses attributable to accidents, lost time from work, along with miscellaneous costs, have been increasing year by year and are items over which the Claims Department has no control. The accident that does not happen costs nothing. Every accident prevented is dollars saved on accident costs. If an active accident prevention program were not in effect, the overall claim costs would follow the upward trend that is constantly increasing casualty insurance rates.

There are certain side effects that also help in reducing accident costs. Operators are able to give better descriptions of occurrences, they are cognizant of after-accident details and because safety is a vital part of their daily work, it carries over to their non-working hours and conduct while off duty; thus, producing not only a stable rate in the accident costs as far as the District is concerned, but also a large step towards reducing the inconvenience of the riding public and the general motoring public. The Operators, the Brotherhood of Railroad Trainmen, the Transportation Department, along with the excellent rapport that we have with all of the other Departments will no doubt show a stability or reduction in over-all cost in spite of the the increase in the individual accident expenses.

DISCUSSION OF EXHIBITS

Exhibits No.	Remarks
1	Traffic and Passenger Accidents, 1960-1964 inclusive: Total Passenger & Traffic Accidents, Total Traffic Accidents & Total Passenger Accidents and accompanying Trend Lines. The Five Year Trend indicates a reduction at the rate of 6.2% per annum.
2	Comparative Statement of Traffic and Passenger Accidents, 1960-1964 inclusive: This shows the numerical and frequency rates of accidents for a 5-year period with certain comparative information.
3	Committee Personnel: An outline of committee personnel as of January 1, 1965.
4	Occupational Accidents, 1960-1964 inclusive: This statement shows comparative figures of our occupational accidents for the 5-year period. The frequency figures are shown on million miles operated as it was felt our passenger information, due to the many changes that have occurred during the 5-year period, is not complete enough for relating frequency to passengers carried.
5	Commendations and Complaints, 1960-1964 inclusive: In all of our safety programs we have endeavored to instill the idea that a safe Operator is a courteous Operator, and have related commendation and Complaint Statistics to accident information. The trend line on this chart closely compares with the trend line of our Total Passenger and Traffic Accidents on Exhibit 1. The Chart indicates a reduction in complaints at the rate of 8.1% per year. Although good deeds are not often report-

ed it is significant that commendations have increased at the rate of 5.0% per year.

6 .... Labor Turnover, 1960-1964 inclusive:

Labor turnover has a significant effect on accident frequency and we believe the somewhat level trend in our Operator turnover since 1961 has contributed to the success of our safety programs.

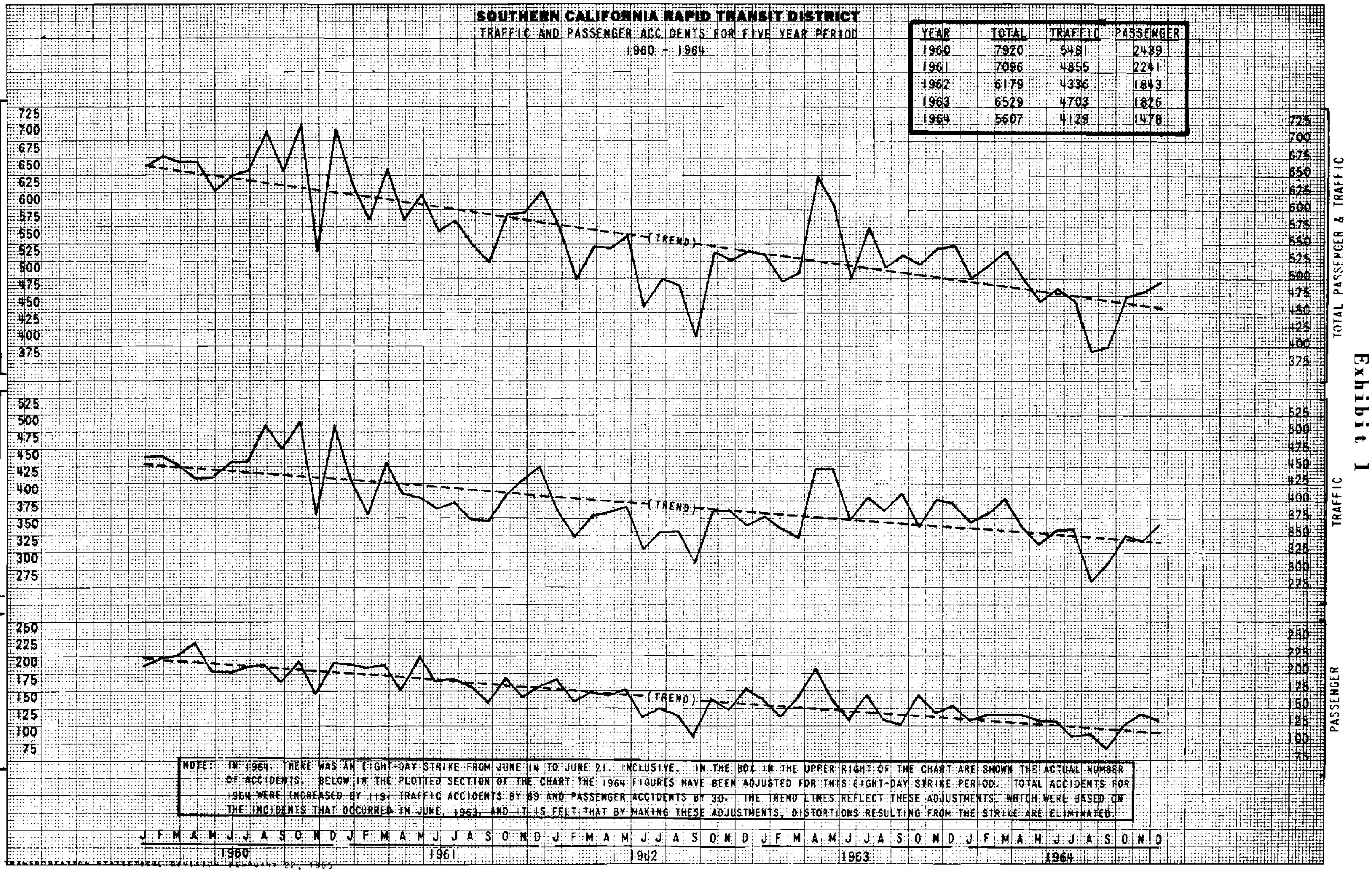
7 .... A message to the Staffs of the Transportation and Equipment Maintenance Departments of the 1964 review of accidents by the Manager of Operations, Mr. Cone T. Bass.

8 .... Comments of Staff Members:

The District's staff members who attend the Staff Safety Committee Meetings have continued their enthusiasm since the inception of this Committee in late 1960 and we are showing a few of their comments.

9 .... Selected Pictures:

Two pictures of projects that have been worked out by the Staff Safety Committee.



YEAR	TOTAL	TRAFFIC	PASSENGER
1960	7920	5481	2439
1961	7096	4855	2241
1962	6179	4336	1843
1963	6529	4703	1826
1964	5607	4129	1478

NOTE: IN 1964, THERE WAS AN EIGHT-DAY STRIKE FROM JUNE 14 TO JUNE 21, INCLUSIVE. IN THE BOX IN THE UPPER RIGHT OF THE CHART ARE SHOWN THE ACTUAL NUMBER OF ACCIDENTS. BELOW IN THE PLOTTED SECTION OF THE CHART THE 1964 FIGURES HAVE BEEN ADJUSTED FOR THIS EIGHT-DAY STRIKE PERIOD. TOTAL ACCIDENTS FOR 1964 WERE INCREASED BY 119, TRAFFIC ACCIDENTS BY 89 AND PASSENGER ACCIDENTS BY 30. THE TREND LINES REFLECT THESE ADJUSTMENTS, WHICH WERE BASED ON THE INCIDENTS THAT OCCURRED IN JUNE, 1963, AND IT IS FELT THAT BY MAKING THESE ADJUSTMENTS, DISTORTIONS RESULTING FROM THE STRIKE ARE ELIMINATED.

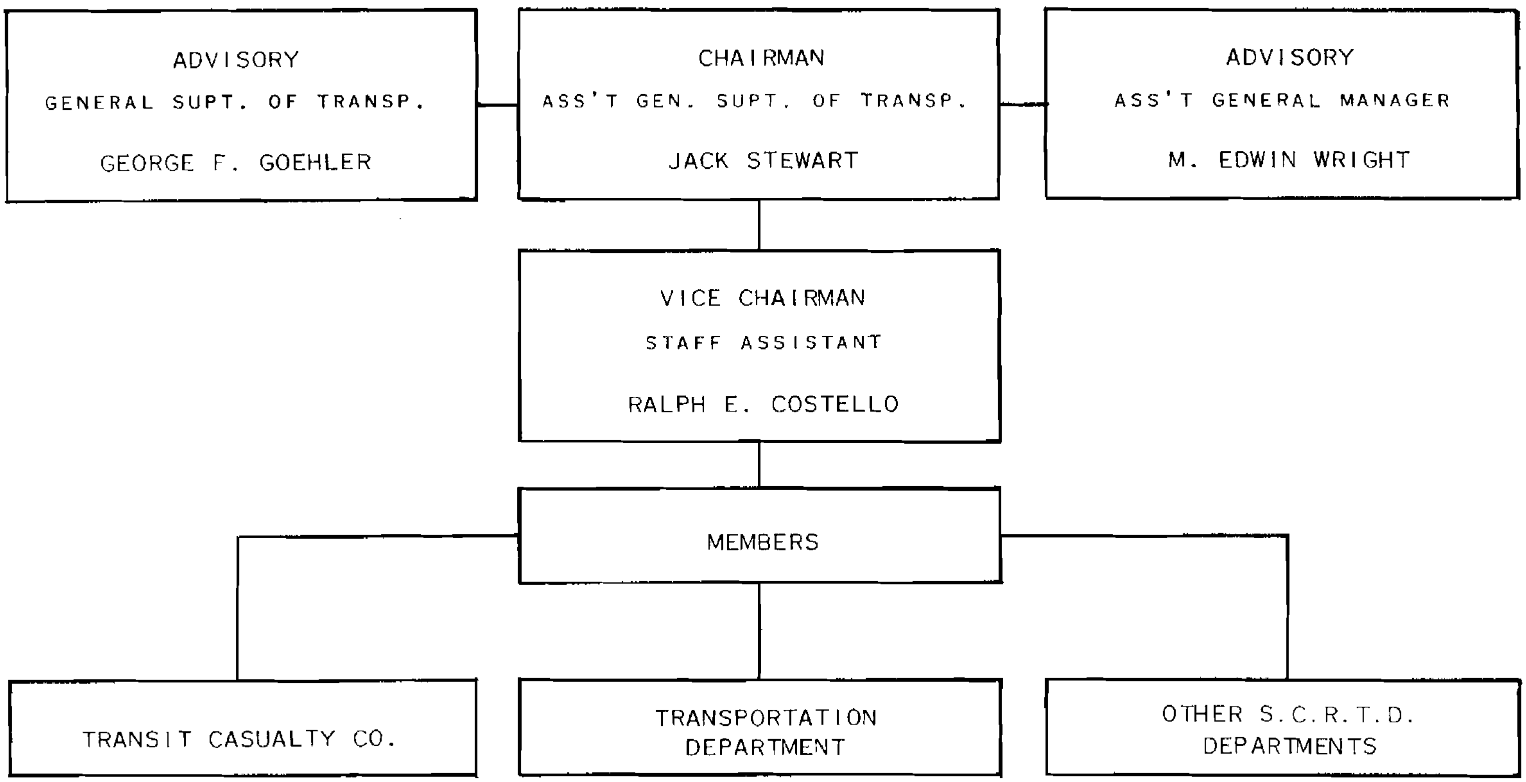
Exhibit 2

FIVE YEAR STUDY OF TRAFFIC AND PASSENGER ACCIDENTS

YEAR	NO. OF ACCIDENTS	% CHANGE FROM PREVIOUS YEAR	FREQUENCY RATE PER 1,000,000 MILES	% CHANGE FROM PREVIOUS YEAR
		TRAFFIC ACCIDENTS		
1960 (A)	5,481	-	95.70	
1961	4,855	- 11.4	83.94	- 12.3
1962	4,336	- 10.7	77.58	- 7.6
1963 (B)	4,703	+ 8.5	84.62	+ 9.1
1964 (C)	4,129	- 12.2	76.52	- 9.6
1964 VS 1960	- 1,352	- 24.7	- 19.18	- 20.0
		PASSENGER ACCIDENTS		
1960 (A)	2,439	-	42.59	-
1961	2,241	- 8.1	38.74	- 9.0
1962	1,843	- 17.8	32.98	- 14.9
1963 (B)	1,826	- 0.9	32.85	- 0.4
1964 (C)	1,478	- 19.1	27.39	- 16.6
1964 VS 1960	- 961	- 39.4	- 15.20	- 35.7
		TOTAL ACCIDENTS		
1960 (A)	7,920	-	138.30	-
1961	7,096	- 10.4	122.68	- 11.3
1962	6,179	- 12.9	110.56	- 9.9
1963 (B)	6,529	+ 5.7	117.47	+ 6.3
1964 (C)	5,607	- 14.1	103.91	- 11.5
1964 VS 1960	- 2,313	- 29.2	- 34.39	- 24.9

NOTES (A) FIGURES HAVE NOT BEEN ADJUSTED FOR (5) DAY STRIKE.
(B) CONVERSION OF 164 STREETCARS AND 89 TROLLEY COACHES TO MOTOR BUSES
(C) FIGURES HAVE NOT BEEN ADJUSTED FOR (8) DAY STRIKE.

Exhibit 3



TRANSIT CASUALTY CO.

REGIONAL
GENERAL CLAIM MANAGER
JOHN MILLER

SAFETY DIRECTOR
SAFETY ENGINEERING DIVISION
J. W. PRUTSMAN

SAFETY ENGINEER
CHARLES HARDY

TRANSPORTATION DEPARTMENT

SUPERINTENDENT OF
SCHEDULES & STATISTICS
D. S. COBURN

CHIEF SUPERVISOR
CARL E. CARLSON

ALTERNATE
FRED H. BUSSE

CHIEF INSTRUCTOR
MARVIN J. STORER

ASS'T. CHIEF INSTRUCTOR
CHARLES C. TEMPLIN

CHIEF CLERK
L. C. KNOLLMILLER

OTHER S.C.R.T.D. DEPARTMENTS

SUPERINTENDENT OF
PROPERTY MAINTENANCE
L. C. THOMPSON

SUPERVISOR
STOPS & ZONES
C. E. FORKNER

ALTERNATE
THEODORE B. ERCKERT

ASS'T GEN. SUPT. OF
MAINTENENCE
GEORGE H. WELLS

CHIEF SPECIAL AGENT
JOE SHAFER

ALTERNATE
WILLIAM R. JORDAN

Exhibit 4

OCCUPATIONAL ACCIDENTS, AND FREQUENCY RATES

YEAR	TRANSPORTATION	MECHANICAL	PROPERTY MAINTENANCE	STORES	OTHERS	TOTAL
			OCCUPATIONAL ACCIDENTS			
1960	157	96	24	4	36	317
1961	156	151	24	7	31	369
1962	132	111	25	6	11	285
1963	156	105	11	8	9	289
1964	135	103	3	5	12	258
			FREQUENCY RATE PER 1,000,000 HOURS WORKED			
1960	14.12	16.74	25.20	21.57	83.77	16.76
1961	22.97	30.87	24.82	21.56	20.94	21.66
1962	12.77	25.50	65.52	7.19	31.41	16.76
1963	14.44	20.91	34.50	14.38	15.71	16.03
1964	14.44	21.06	6.90	7.19	26.18	15.92

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

COMMENDATIONS AND COMPLAINTS FOR FIVE YEAR PERIOD

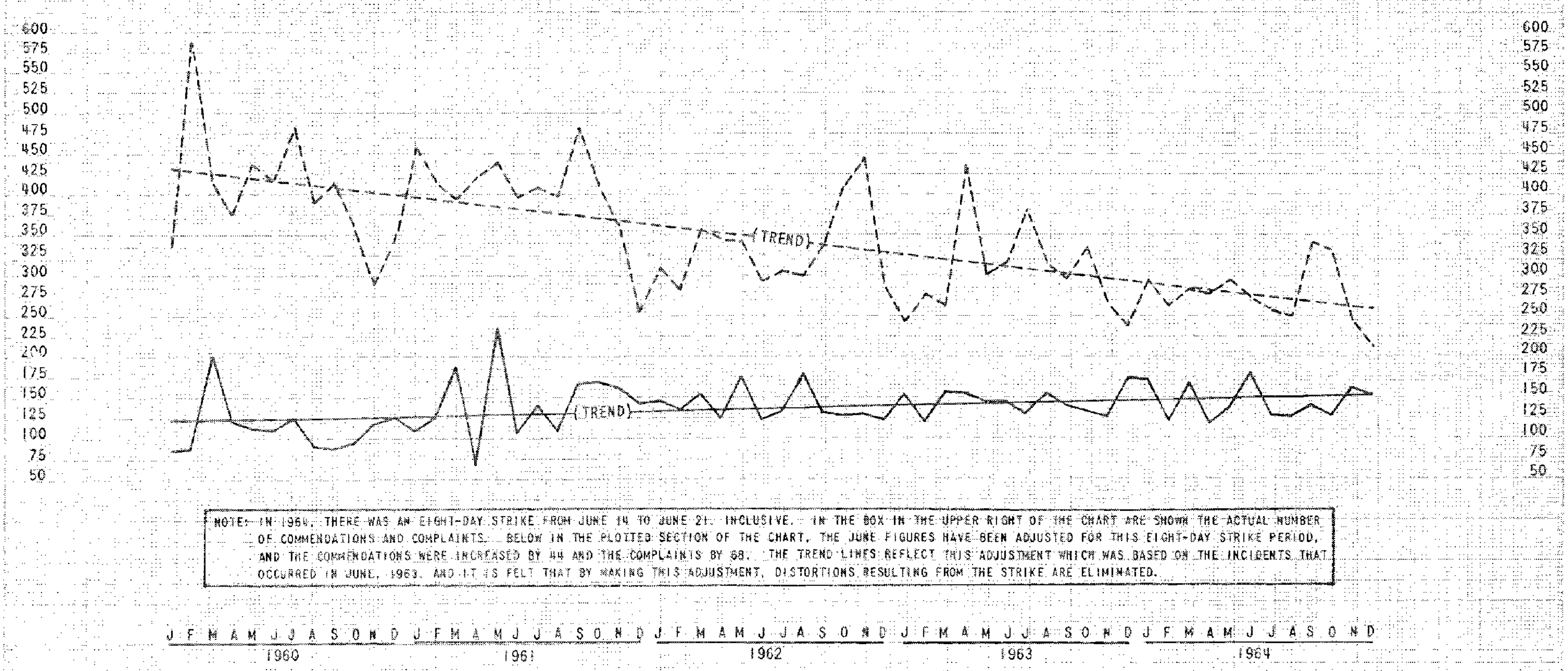
1960 - 1964

LEGEND

——— COMMENDATIONS

– – – – COMPLAINTS

YEAR	COMMENDATIONS	COMPLAINTS
1960	1350	4853
1961	1717	4839
1962	1682	4016
1963	1736	3672
1964	1691	3256



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TRANSPORTATION STATISTICAL DIVISION FEBRUARY 22, 1965

Exhibit 5

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

LABOR TURNOVER FOR FIVE YEAR PERIOD

1960 - 1964

LEGEND

——— OPERATORS ENTERING SERVICE

- - - - OPERATORS LEAVING SERVICE

NUMBER OF OPERATORS

YEAR	ENTERING	LEAVING
1960	566	594
1961	286	322
1962	271	364
1963	310	344
1964	204	279

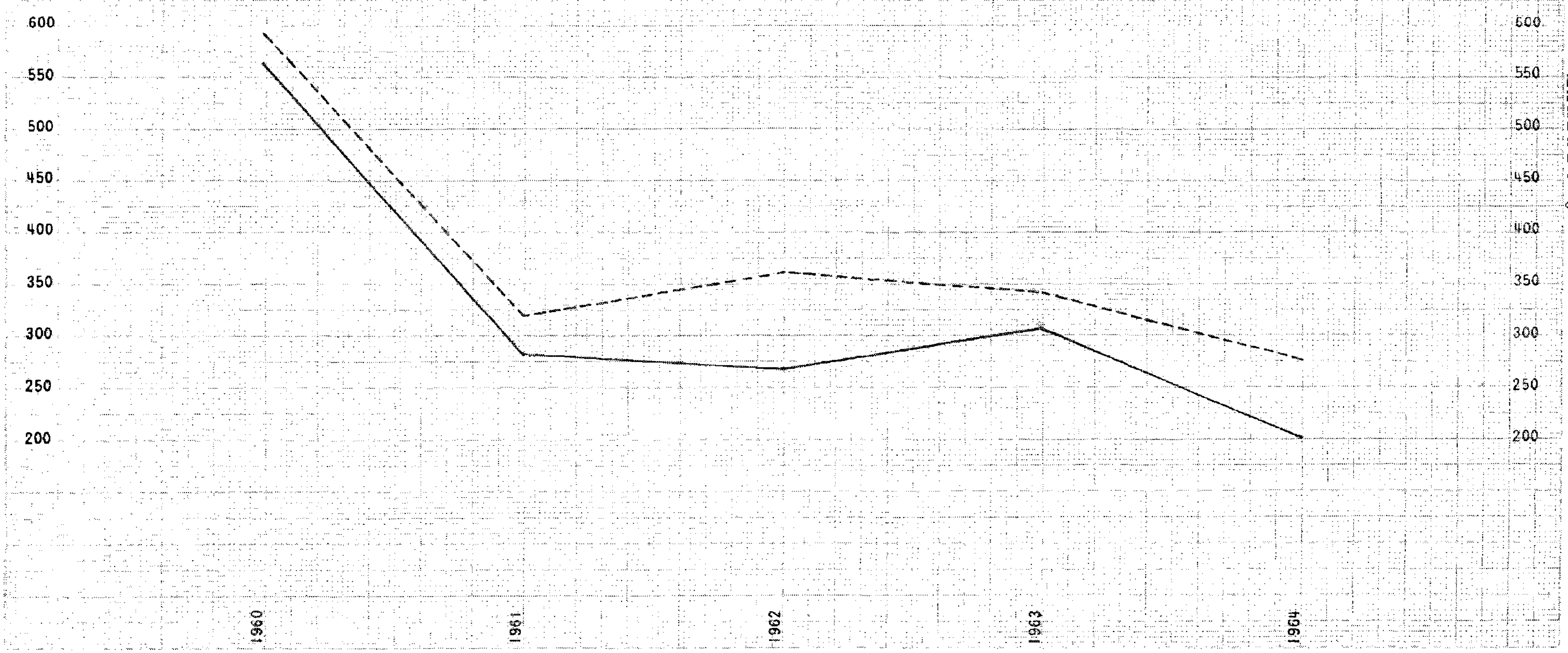


Exhibit 6

TRANSPORTATION STATISTICAL DIVISION, FEBRUARY 12, 1965   NOTE: FIGURES SHOWN ABOVE REPRESENT THE NUMBER OF PERSONS ENTERING OR LEAVING THE TRANSPORTATION DEPARTMENT AS OPERATORS

Exhibit 7

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT 1060 SOUTH BROADWAY, LOS ANGELES, CALIFORNIA 90015
C. M. GILLISS, GENERAL MANAGER · TELEPHONE (213) 749-6977
CONE T. BASS, MANAGER OF OPERATIONS

March 3, 1965

Mr. G. F. Goehler, General Supt. of Transportation
All Division Supts. and Instructors, Transportation Dept.

Mr. G. H. Powell, General Superintendent of Equipment
All Superintendents, Equipment Maintenance Department

Subject: Summary of Accidents, 1964 - Report No. 12-4

It is with a great deal of satisfaction that I have just finished reviewing the subject report. I should like to take this means of expressing to all of you, and finally to all of our individual operators, sincerest thanks for the combined efforts of all concerned that resulted in the reduction of accidents as indicated by this report.

The following listings of reductions are significant:

1964 vs. 1963

Traffic Accidents	-12.2%
Passenger Accidents	-19.1%
Total Operating Accidents	-14.1%
Traffic Accident Frequency	- 9.6%
Passenger Accident Frequency	-16.6%

Nine of the twelve Divisions show a reduction in traffic accident frequency. Eleven Divisions show a reduction in passenger accident frequency. We are most grateful to all concerned for the attainment of such a record.

Our Equipment Maintenance Department works diligently at providing our operators with the safest possible vehicles to operate from a mechanical viewpoint. Everyone to whom a copy of this letter is directed, however, plays a major part in accomplishing the safety record that results from our operations. The operators themselves, of course, are the ones on the firing line and most directly responsible.

We are most grateful also for the efforts and cooperation of the Brotherhood of Railroad Trainmen in accomplishing the 1964 safety record.

The efforts of Transit Casualty Company's Safety Engineering Department certainly played a big part in our safety record and I am sure that all of you would like to join me in expressing appreciation for their efforts.

I am positive that all of you are proud of this record as you have a right to be. I am sure also that everyone concerned will work toward even improving the 1964 record in 1965.

Sincerely,

Cone T. Bass

Cone T. Bass
Manager of Operations

CTB:rkk

cc: Mr. C. M. Gilliss
Mr. D. H. Sheets
Mr. Homer Porcher

Exhibit 8

The Transportation Department Staff Safety Committee has been wholeheartedly endorsed by the Special Agents Department, and this is evidenced by the number of suggestions of safety submitted by my employees.

The response and action taken on suggestions by the employees has given them the feeling of a responsibility to be on the alert and constantly observant of matters pertaining to safety, not only of equipment, but also personnel.

The Committee has favorably acted upon suggestions of Patrolmen at Main Street Station in connection with operation from motor bus exit, and not only has this resulted in safer operation, but also made the work of the Patrolmen much easier.

This Committee has established a policy of taking immediate corrective and remedial action, and its existence will no doubt decrease all types of accidents on and with District equipment, in addition to employee personal injuries.

J. SHAFER
Chief Special Agent

As a result of the Safety Committee meeting, all members from the various departments have realized a better understanding of mutual problems, resulting is a safer operation of Buses.

Many obstructions, such as trees, poles and street conditions, have been brought to the attention of the Committee and corrections have subsequently been made at a saving of many dollars to the District.

It is gratifying to see members of the various departments working together for the common good of all.

GEORGE H. WELLS
Assistant General Superintendent of Equipment Maintenance

Since the inception of the Safety Committee, I feel that real progress has been made, not only the reduction in the number and severity of accidents, but I also feel that real progress has been made in employee relations. During my frequent visits to the Divisions, I make it a point, whenever possible, to talk to the operators in the train room and attempt to lead the conversation into accident statistics and I can report that there is real interest among the operators, as almost invariably, they bring up some traffic hazard, such as poles, driveways, obstructions, etc.

They are always pleased to know that their suggestions are discussed in our meetings and, of course, any written suggestions that they are encouraged to turn in are always answered by letter. This, too, has resulted in favorable comment. Perhaps the most important result of the committee has been the participation of various department heads and the consequent understanding of each other's problems.

While, of course, there is still considerable improvement to be made in our accident situation, I do feel that we are definitely on the right track and with the continued enthusiasm, as shown thus far, our accident frequency, I am convinced, will compare very favorably with similar properties anywhere in the country.

J. STEWART
Asst. Gen. Supt. of Transportation

I think the past record of the Safety Committee has been most gratifying and it is my belief that the Committee will continue to help the District establish an even finer safety record and that it will play a more important role in the future by making all of us more conscious of safety and the importance it plays in our lives and jobs.

C.C. Templin
Assistant Chief Instructor

Perhaps the outstanding achievement of the Safety Committee has been the fact that it has brought management, staff personnel, supervisory, mechanical, and operating personnel closer together for a common objective: safer operations in all District departments by establishing, improving, and maintaining safety activities that will be effective and thereby help personnel to better understand and carry out their responsibilities in the safety program.

M. J. Storer
Chief Instructor

I think the Safety Committee has done a job that could not have been done by any other group or organization, because it has proper representation of all departments, operating and nonoperating alike.

J. W. Prutsman
Transit Casualty Safety Director
Safety Engineering Section

The effect of our successful safety program is reflected in the operation of the schedules and the Schedule Division in the following manner:

1. In the avoidance of an accident, a delay in service is eliminated at the scene and also on the next scheduled trip because of the probability of a turnback to put the vehicle on-time.
2. A savings is made in Operators' cost by eliminating overtime or relay time, also court appearance time.
3. Savings are made in the Schedule Division by eliminating time spent in investigating and answering complaints or preparing statements for court cases.
4. Finally, the avoidance of accidents protects our passengers from injury and delay which in turn is a great factor in holding our passengers and keeping the revenue at a level for a profitable operation.

D. S. COBURN
Superintendent of
Schedules and Statistics

Prior to June 6, 1961, the Safety Committee, functioning as a branch of the Transportation Department Staff, was known to us mainly by the Committee name only.

I have attended only a few of the meetings and have had but a short time to apply precepts and principles of the Committee to our department, but I know that it has rekindled by cognizance of the need for everyday practice of safety-conscious working habits.

The finest trait of the Committee, and each member individually, that has immediately registered with me, has been the cooperation of all members and departments, the interest shown in all problems of all departments, and the impersonal analysis of problems as well as the apparent willingness to accept suggestions for improvement from any member regardless of their department affiliation.

I am confident that much good will accrue to the Maintenance Department by continued service on the Committee and wholehearted cooperation with it and its members.

F. W. Markley
Staff Assistant
Equipment Maintenance Department

In the year 1964, we processed approximately 3100 reports. This included 1119 from the supervisors. The others originated from the public, cities, and other departments. Investigation has brought about the relocation of 149 zones, abandonment of 194 zones, establishment of 889 new zones and extension of 240 zones.

We also ran a series of tests here in Macy Yard when it became evident that our standard 80 feet zone for the 40 feet dreamliner were not adequate. As a result of these tests, the Board of Public Utilities has increased the length of the zone for the dreamliner buses from the standard 80 feet to a minimum of 90 feet and a maximum of 100 feet. This meant the changing of the City Ordinances, which has been done. As indicated above, we have abandoned 194 zones which in most instances were impossible to relocate the zone and/or to eliminate the object we were striking. Red reflector warning tabs were placed at 94 locations where no adjustments could be made.

We have been fortunate in most cities in having them improve their landing where it was unsafe and/or getting permission to make improvements ourselves.

C. E. Forkner
Supervisor of Stops and Zones

Exhibit 9

Photo at left represents Bus Stop with Right Turn Exemption.

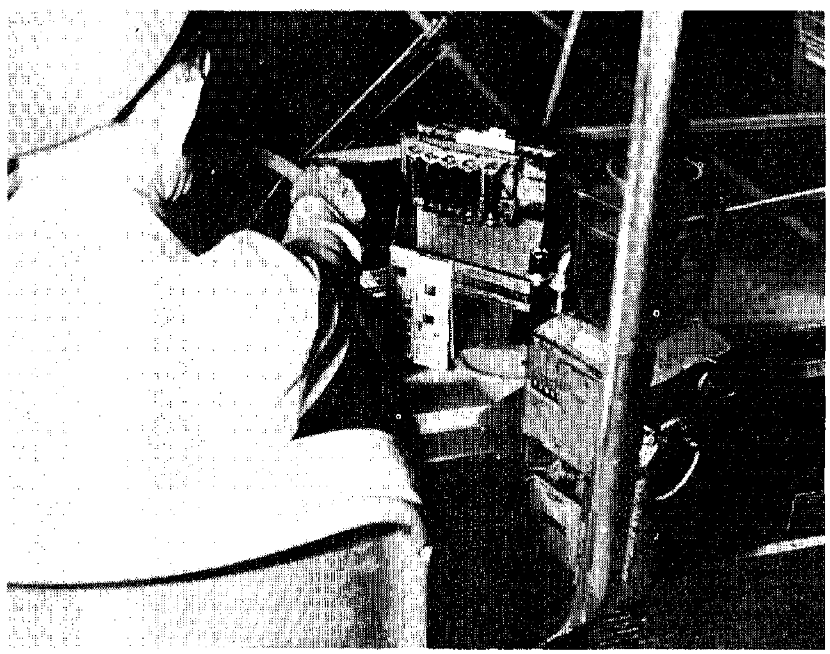


Photo at right represents Design of Fare Box Support, Changer Rack, Zone Check Holder, Transfer Rack and Litter Box, All Convenient to Operator.

T H E R E <u>I S</u> S A F E T Y I N N U M B E R S

Prepared By

DAVID D. CANNING

For

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

TRANSPORTATION DEPARTMENT

Los Angeles, California

January, 1965

PREFACE

This material has been designed particularly for Supervisory Personnel to emphasize the basic concepts of the applicable laws of physics and related formulas insofar as they pertain to certain situations which may arise from day to day in the safe operation of motor vehicles. In addition, it has been the endeavor to illustrate certain examples in such a manner as they may be useful as the need arises long after the details of class presentation have been forgotten.

Certainly the influence of Mr. Leslie H. Appel, who for many years conducted lectures in this field and whose lectures I was privileged to attend and participate in, is responsible for my confidence in undertaking this assignment. Too, I am indebted to him for a critical review of the material included.

In addition, my appreciation to Mr. George F. Goehler for the opportunity to undertake the assignment, for had he not been inspired to initiate a project which includes this material, such opportunity would not have been possible.

David D. Canning

THERE IS SAFETY IN NUMBERS

It has been stated that there are only three basic causes of Motor Vehicle Accidents. They include defective highways--about 6%, defective vehicles--8%, and the remaining, namely human deficiencies, 86%. Of the 86%, the generally accepted categories include inattention--36%, following too closely--15%, taking or failing to yield right of way--33%, and physical deficiencies about 2%.

With respect to highway deficiencies, there is a never-ending program to provide safer roadways.

In the effort to reduce accidents caused by defective equipment, some twenty states have inaugurated programs of compulsory vehicle inspection. Here in California, the Highway Patrol will place in effect in March, 1965, rules and regulations relating to the safety of trucks and buses.

In connection with the largest category, namely human deficiencies, many states have or will step up their programs for licensing and/or driver education. The series of examples and illustrations which follow are designed to relate some of the causes of accidents due to human deficiencies to the laws of motion in so far as vehicles are involved.

LAWS OF MOTION

Applicability of the laws of motion in so far as Motor Vehicles are involved, relate directly to Newton's three Laws of Motion. Substantially they are as follows:

1. Every body remains in its condition of rest or uniform motion in a straight line except as it is acted upon by a force greater than the opposing force.

2. The rate at which the momentum of a body changes is proportional to the impressed force causing the change, and this change takes place in the direction in which the force is applied.

3. For every action there is an equal and opposite reaction.

In the first law we see that a resultant force is necessary to give the body acceleration. The resistance of the body to change its motion is called inertia.

The second law expresses the first law in mathematical form, ie., Force equals mass times acceleration or F = Ma, and $a = \frac{F}{M}$.

The third law refers to the action of one body on another, and the equal and opposite reaction. For example, if a bus strikes a fixed object, it can only exert as much force on the object as the object is able to exert on the bus.

Other terms relating to the illustrations to follow include those identified with work and energy as follows:

Force - Force is determined as the push or pull acting upon a body.

Friction - When a body slides over another body, a force acts upon it which resists its motion. It is related to the force necessary to slide one body over another and the weight of the sliding body. Thus coefficient of friction designated $f = \frac{F}{W}$ where (W) weight is the gravitational (g) pull of the earth exerted on the mass of a body (M). W then equals Mg or $M = \frac{W}{g}$.

Gravity - Gravity (g) is acceleration due to the gravitational pull of the earth and equals approximately 32.16 feet per second per second.

Work - Work is force acting through space or distance and may be expressed as FS.

Kinetic Energy - Kinetic Energy is the capacity of a moving body for doing work and equals $\frac{Wv^2}{2g}$ where (v) velocity is in feet per second. Since work done in stopping a vehicle must be equal to overcoming its Kinetic Energy, it follows that work FS = KE Kinetic Energy, or $\frac{Wv^2}{2g}$.

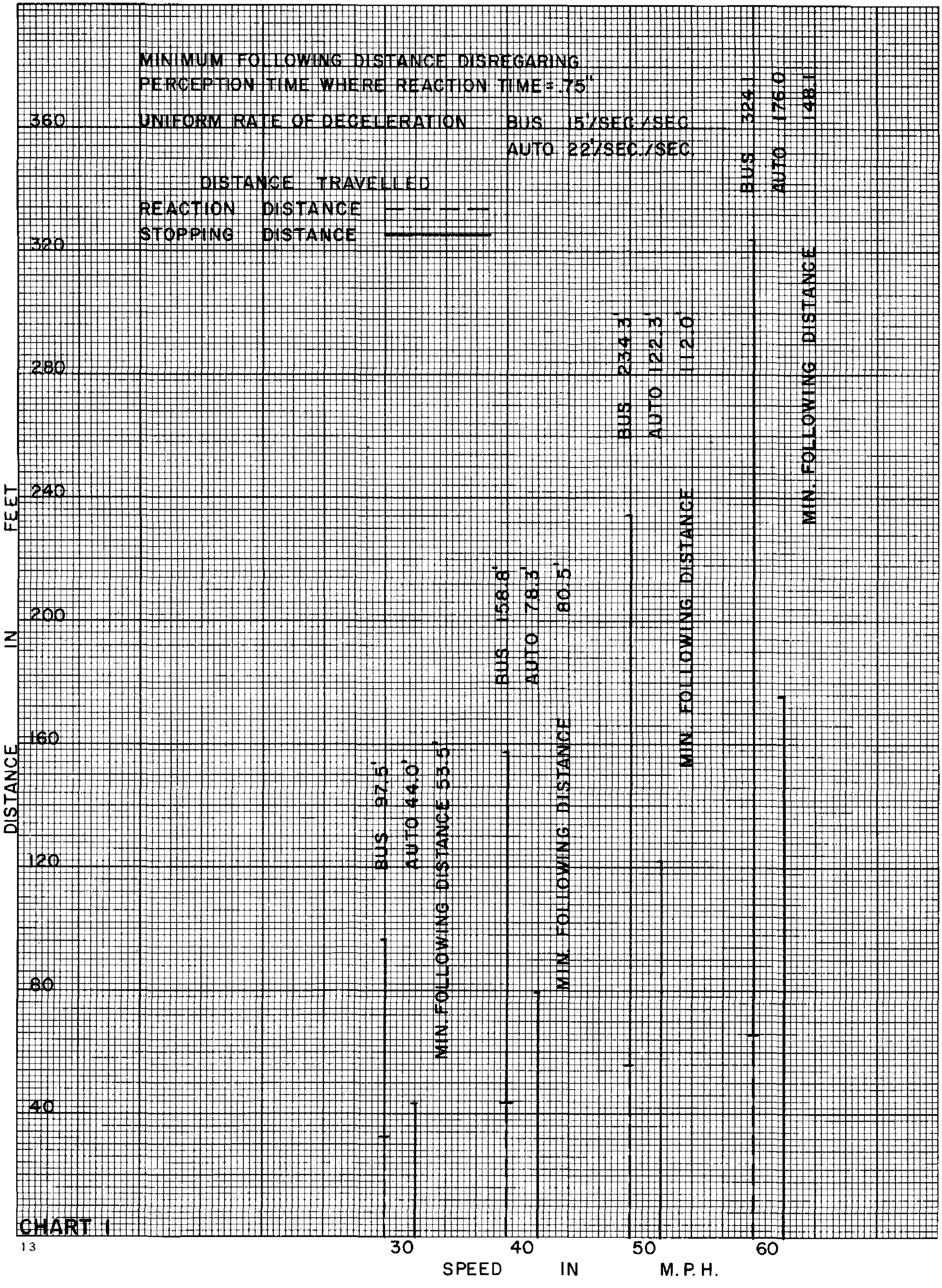
Linear Motion Equations - Linear Motion equations, to which reference will be made in the illustrations to follow, are based on Newton's first law of motion as defined above. They are set forth in the Appendix.

The first of the series of illustrations has to do with following too closely, namely:

Rear-End Collision

Under the heading of Human Deficiencies, following too closely is included as one of the major factors contributing to Motor Vehicle accidents. Although it is generally accepted that to insure minimum safe following distance one car length should be allowed for each 10 miles per hour of speed, ie. at 30 miles per hour, allow 3 car lengths this is not necessarily the minimum standard since several factors enter into what governs minimum safe following distance. They include (a) reaction time of the following driver (b) rate of deceleration of the vehicle being followed (c) rate of deceleration of the following vehicle and (d) speed or velocity. Some authorities advocate that perception time or a combination of perception time and reaction time should also be included. However, in the illustration to follow, perception time is ignored. (See Chart I)

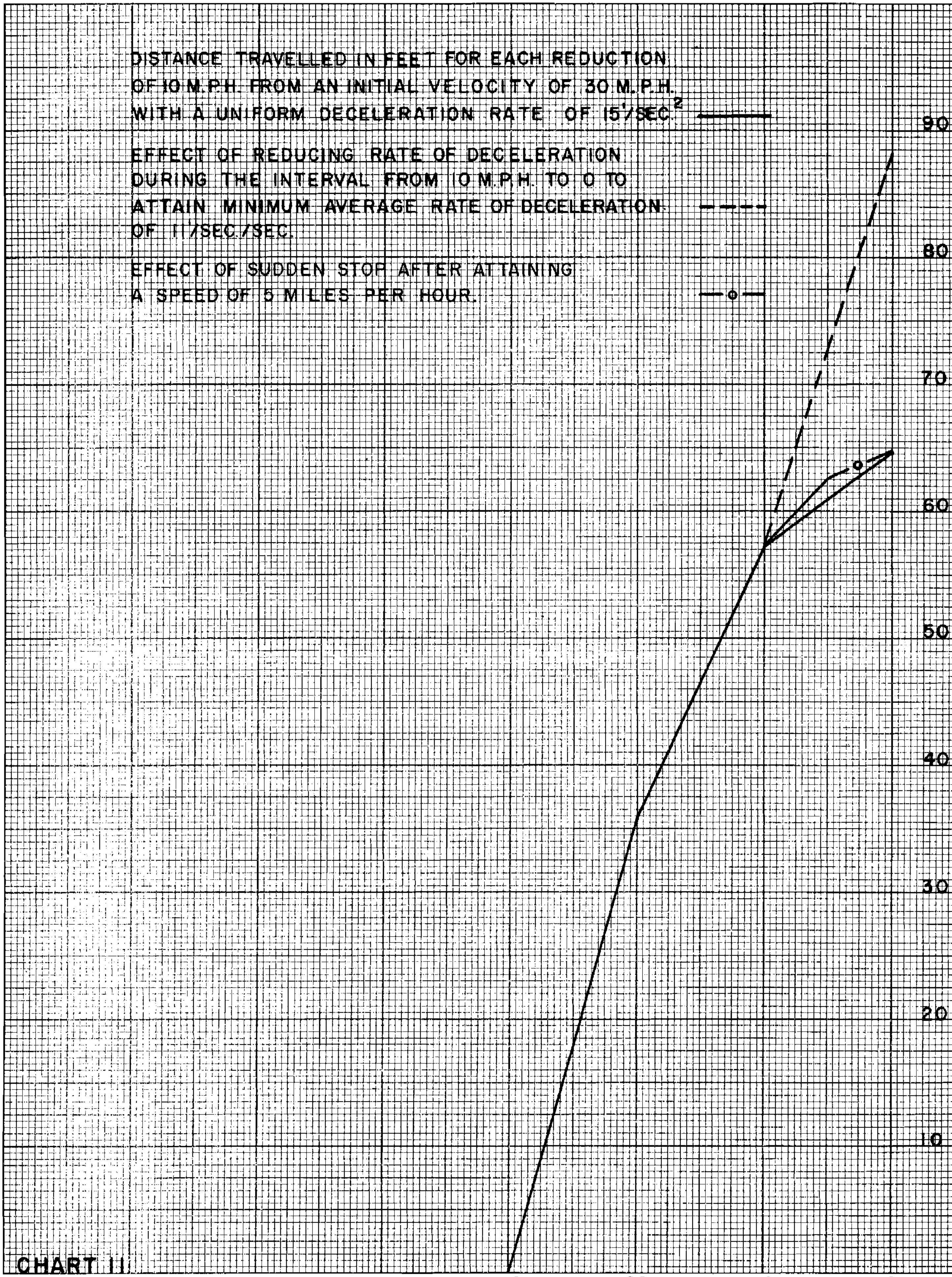
Chart I illustrates typical situations where a bus is following an auto and is required to make an emergency stop in order to avoid a rear-end collision. Reaction time is assumed at .75 seconds, uniform rate of deceleration for the bus, 15'/Sec^2; and for the auto, 22'/Sec^2. First, in order to convert miles per hour to feet per second, miles per hour are multiplied by 1.467. At 30 miles per hour, the vehicles are traveling 44'/Sec which results in a reaction distance of 33'.


MINIMUM FOLLOWING DISTANCE DISREGARING
PERCEPTION TIME WHERE REACTION TIME = .75"
UNIFORM RATE OF DECELERATION BUS 15'/SEC./SEC.
AUTO 22'/SEC./SEC.
DISTANCE TRAVELLED
REACTION DISTANCE
STOPPING DISTANCE
BUS 97.5'
AUTO 44.0'
MIN. FOLLOWING DISTANCE 53.5'
BUS 158.8'
AUTO 78.3'
80.5'
MIN. FOLLOWING DISTANCE
BUS 234.3'
AUTO 122.3'
112.0'
MIN. FOLLOWING DISTANCE
BUS 324.1
AUTO 176.0
148.1
MIN. FOLLOWING DISTANCE
360
320
280
240
200
160
120
80
40
DISTANCE IN FEET
30
40
50
60
SPEED IN M.P.H.
CHART I

By application of fromula $d = \frac{v^2}{2a}$, it can be calculated that the bus can stop in 64.5 feet or a total minimum following distance of 97.5 feet. Since the driver of the car being followed has no reaction distance (in other words he has already applied his brakes), application of the formula for stopping distance indicates that he could stop in 44 feet. This would result in a minimum safe following distance of 53.5 feet (97.5' - 44'). Under the rule of one car length for each 10 miles per hour, the minimum, assuming one car length equals 20 feet, would be 60 feet. Therefore, at 30 miles per hour, there would be a safety margin of 6.5 feet. By the same analysis, the following results: At 40 mph, there would be no margin; at 50 mph, the rule would fall 12' short: at 60 mph, the minimum safe following distance would be short by 28 feet.

Effect of Emergency Stop on Passengers

Tests have been made which indicate that in order to avoid the possibility of injury to passengers, uniform rate of deceleration should not exceed $11'/Sec^2$. Chart II illustrates graphically the distance traveled during the decrease in speed for each 10 mph from an initial speed of 30 mph, under emergency conditions, with a uniform rate of deceleration of $15'/Sec^2$. In addition, there is shown the effect of reducing the braking effort during the period from 10 mph to stop. The formula used in making the calculations is $d = \frac{v_1^2 - v_2^2}{2a}$. The calculations show that: in braking from 30 mph to 20 mph, distance traveled equals 35.8'; from 20 mph to 10 mph, distance traveled equals 21.5'; and from 10 mph to stop, distance traveled equals 7.2'. The severe braking effort from 10 mph to stop in only 7.2' is the major contributing factor to falling passengers, whiplash, etc. Also there is shown the more severe braking effect from 5 mph to stop (less than 2 feet) which occurs principally after starting up, adversely affecting standees. As shown by


DISTANCE TRAVELLED IN FEET FOR EACH REDUCTION OF 10 M.P.H. FROM AN INITIAL VELOCITY OF 30 M.P.H. WITH A UNIFORM DECELERATION RATE OF 15'/SEC²
EFFECT OF REDUCING RATE OF DECELERATION DURING THE INTERVAL FROM 10 M.P.H. TO 0 TO ATTAIN MINIMUM AVERAGE RATE OF DECELERATION OF 11'/SEC./SEC.
EFFECT OF SUDDEN STOP AFTER ATTAINING A SPEED OF 5 MILES PER HOUR.
90
80
70
60
50
40
30
20
10
DISTANCE IN FEET
30
20
10
0
MILES PER HOUR
CHART 11

the dotted line, this can be compensated for somewhat--particularly--- if the braking effort is reduced when decelerating from 10 mph to stop. The minimum average deceleration rate of 11'/Sec^2, would require a total stopping distance of 88 feet. Therefore, in order to attain an average rate of 11'/Sec^2, it would be necessary in braking from 10 mph to stop to reduce the rate of deceleration to 3.5'/Sec^2. In view of these findings, the safe following distance set forth in Chart I does not apply particularly when a standing passenger load is involved.

Inattention

Although following too closely might well be classed in the category of inattention, it has been said that accidents caused by inattention are due largely to failure to make proper use of the eyes. A particularly costly example of this is failure to insure that the front door of the bus is clear before closing. Others include failure to observe cars pulling from the curb, a driver preparing to alight from the left side, pedestrians leaving the curb, failure to observe speed signs particularly on curves, the setting of traffic lights, and many others. Clearest seeing takes place in only a small portion of the visual field. With respect to peripheral vision, tests have shown that in some instances the field is limited to as little as 20 degrees. Even with good peripheral vision, clear vision does not prevail. Therefore, according to at least one theory, if accidents resulting from instances such as outlined above are to be avoided, there must be a continual shifting of the eyes.

In the category of inattention, three illustrations are included. They are (1) determining the speed of a vehicle which leaves the highway, (2) relationships of pedestrian traffic to vehicular traffic, and (3) overtaking and passing.

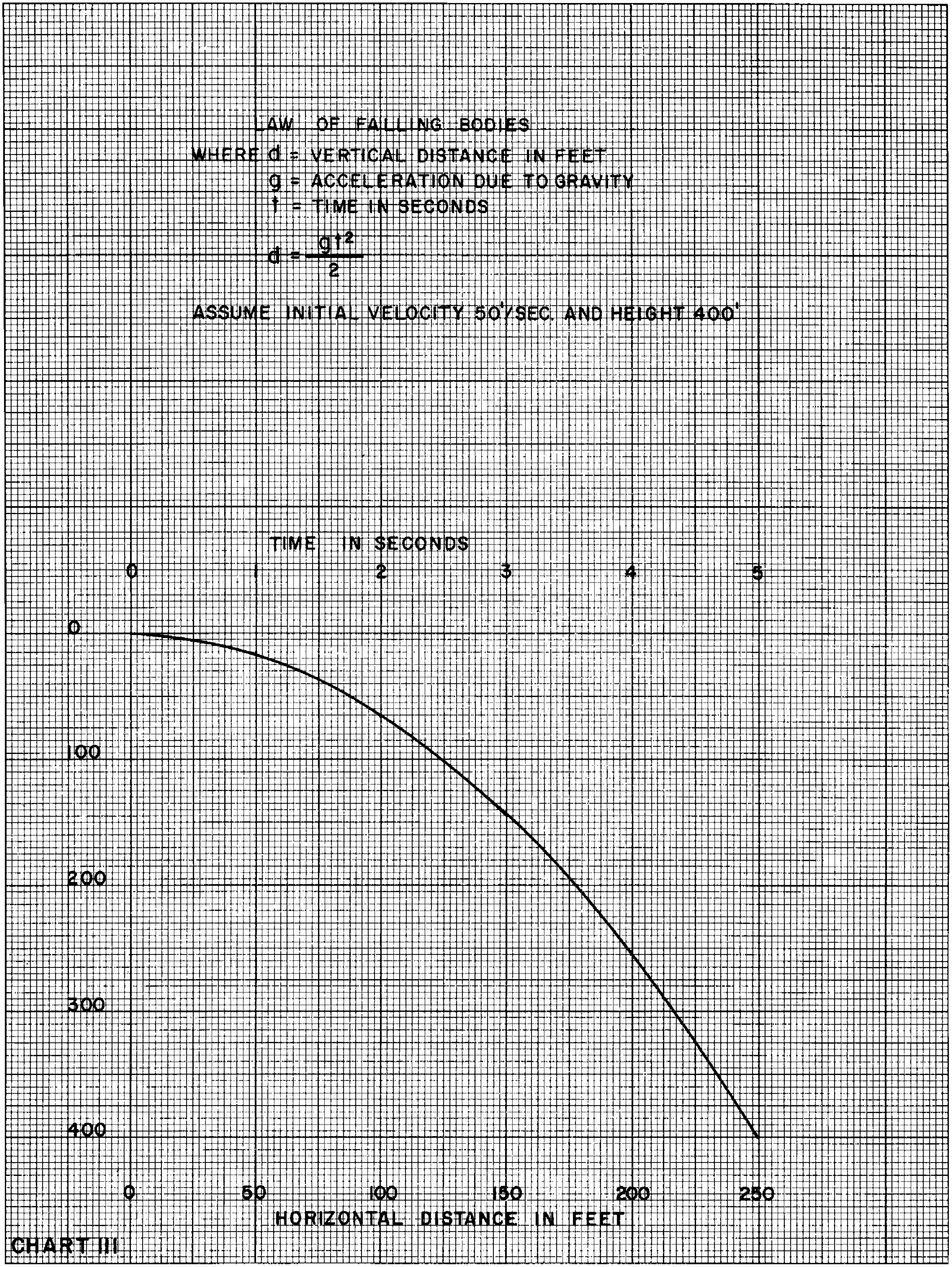
Speed of a Vehicle Leaving the Highway

In instances where vehicles leave the highway, particularly on curves where speed warnings are ignored, it is possible under certain conditions to calculate the speed of the vehicle. For purpose of illustration, the following assumptions are made:

Height of embankment - 21'
Distance of point of landing from highway - 100'

In order to determine the speed of the vehicle as it left the highway, it is necessary to apply the law of falling bodies. Objects fall to the ground because the earth exerts a pull on them. This pull is called the force of gravity identified by the letter (g). As previously stated, (g) by measurement has been determined at $32+'/\text{Sec}^2$. Gravitational pull is always the same whether or not the object is dropped or has horizontal velocity before it commences falling. The law of falling bodies illustrated graphically on Chart III is the basis for determining the speed in the example set forth above. Since the initial velocity remains constant throughout the fall of the object, horizontal distance traveled for each second of fall is always the same. Application of the formula $d = \frac{gt^2}{2}$, indicates that the object will perform as follows:

	FALL	TRAVEL HORIZONTALLY
During the 1st second	16'	50'
For 2 seconds	64'	100'
For 3 seconds	144'	150'
For 4 seconds	256'	200'
For 5 seconds	400'	250'



LAW OF FALLING BODIES
WHERE d = VERTICAL DISTANCE IN FEET
g = ACCELERATION DUE TO GRAVITY
t = TIME IN SECONDS
$d = \frac{gt^2}{2}$
ASSUME INITIAL VELOCITY 50'/SEC. AND HEIGHT 400'
TIME IN SECONDS
0
1
2
3
4
5
0
100
200
300
400
0
50
100
150
200
250
HORIZONTAL DISTANCE IN FEET
CHART III

Since it is necessary to isolate the time it took the vehicle to fall 21 feet, it is necessary to convert the formula $g = \frac{dt^2}{2}$ to time. This becomes, then, $t = \sqrt{\frac{2d}{g}}$. Time for the vehicle to fall 21 feet -- $t = \sqrt{\frac{42}{32}} = 1.14''$. During the time it took the vehicle to fall 21', it also traveled horizontally 100 feet. Speed, by application of the formula $v = \frac{d}{t} = \frac{100'}{1.14''} = 88'/\text{Sec} = 60$ mph. Therefore, under the assumptions made, the vehicle was traveling 60 mph when it left the highway.

Pedestrian Versus Vehicle

Failure to look ahead and to govern speed accordingly, particularly when a pedestrian starts to cross the street from in front of a parked car, can result in a pedestrian collision. Walking speeds of pedestrians crossing a street, generally speaking, vary from 3.5 to 4.5 feet per second. For the purpose of this illustration, a walking speed of 4'/Sec will be used. Other assumptions are as follows:

Width of Street - 60'
Speed of approaching bus - 30 mph
Distance from curblane - 8.5'
Width of bus - 8.5'
Rate of deceleration - $15'/\text{Sec}^2$

The question to be answered is, "How far away from point of possible contact must the driver observe the pedestrian to avoid collision?" The example is illustrated by Chart IV. First the pedestrian must have negotiated at least 17' of the crossing in order to clear the left front corner of the bus. Time to negotiate 17' equals $t = \frac{d}{v} = \frac{17'}{4} = 4.25$ Seconds. From Chart I it was determined that under emergency stopping conditions, the total distance required to stop at 30 mph, including reaction time, is 97.5'. The time required to stop

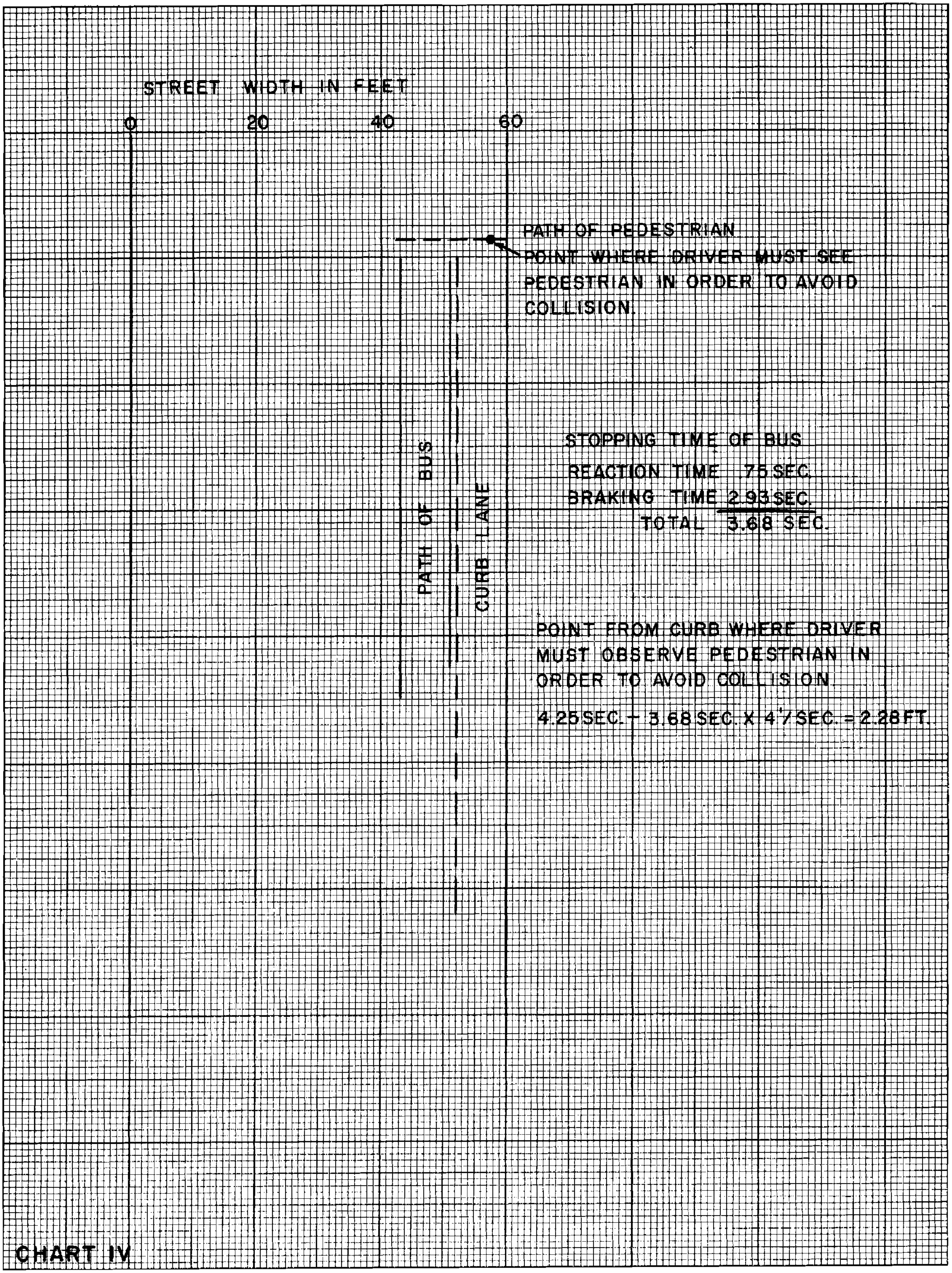

STREET WIDTH IN FEET
0
20
40
60
PATH OF PEDESTRIAN
POINT WHERE DRIVER MUST SEE PEDESTRIAN IN ORDER TO AVOID COLLISION.
PATH OF BUS
CURB LANE
STOPPING TIME OF BUS
REACTION TIME .75 SEC.
BRAKING TIME 2.93 SEC.
TOTAL 3.68 SEC.
POINT FROM CURB WHERE DRIVER MUST OBSERVE PEDESTRIAN IN ORDER TO AVOID COLLISION.
4.25 SEC. − 3.68 SEC. X 4'/SEC. = 2.28 FT.

CHART IV

can be determined from the formula $t = \frac{d}{v}$ for reaction time, and $t = \frac{v}{a}$ for braking time = as follows:

Reaction $t = \frac{d}{v} = \frac{33}{44} = .75$ seconds

Braking $t = \frac{v}{a} = \frac{44}{15} = 2.93$ seconds

Total Stopping Time 3.68 seconds

Since the time for the pedestrian to clear the left front corner of the bus is 4.25 seconds and the driver has only 3.68 seconds in which to stop, the pedestrian must be at least 2.28 feet from the curb when the driver reacts if he is to avoid a collision. This is calculated by 4.25" - 3.68" x 4'/Sec = 2.28'. If for example, the pedestrian steps out from between parked cars, he then has only 8.5' to negotiate to be in the clear. This distance can be negotiated in $\frac{8.5'}{4'/Sec}$ or 2.15 seconds. This means that the driver has only 2.15 seconds in which to avoid a collision. If reaction time is .75 Sec., this leaves a braking time of only 2.15" - .75" or 1.4 Seconds. Further, speed could be no greater than v = at, or 15'/Sec x 1.4"= 21'/Sec or 14.42 mph at the time the pedestrian stepped from between the parked cars if a collision is to be avoided.

To put it another way, the driver must see everything going on ahead of his vehicle whether it be a pedestrian, a car pulling from the curb, etc. within the distance in which he can react and stop.

Overtaking and Passing

Accidents resulting from overtaking and passing are usually associated with head-on collisions--particularly on a two-lane highway. In situations such as this, inattention can well include judgement. Factors involved include judgement of time, speed of opposing vehicles, acceleration characteristics of the passing vehicle, and speed of the vehicle being overtaken.

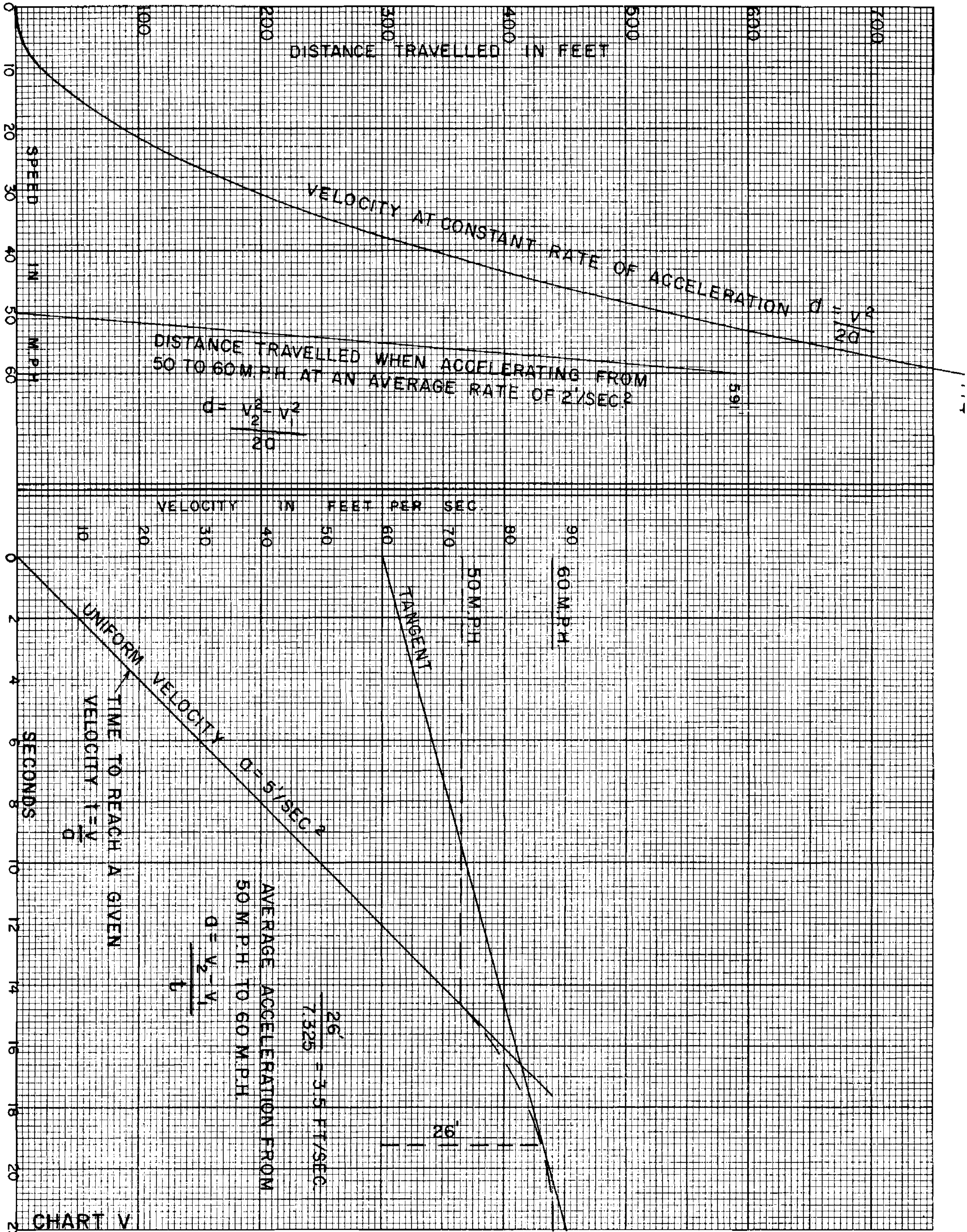
The probability of overtaking and passing safely can apply equally well on multiple-lane highways. The only difference being that the driver can remain in the passing lane in the event the hole ahead closes.

Acceleration

Before illustrating an example of overtaking and passing, it is proper that some of the characteristics of acceleration be examined. While acceleration is usually considered uniform; nevertheless, after attaining certain speeds, acceleration tends to decrease.

Definition: Acceleration is the change in velocity during an interval of time divided by the duration of that interval.

This, if a bus starting from a standstill acquires a velocity of 5'/Sec. by the end of one second, gains an additional 5'/Sec during the second, etc., it is said to have a pick up of $5'/Sec^2$. The lefthand side of Chart V illustrates the distance traveled when accelerating at a uniform rate of $5'/Sec^2$. Immediately to the right in the same block, there is shown the distance traveled when accelerating from 50 mph to 60 mph at an average rate of $2'/Sec^2$. The right hand portion of Chart V shows the time required to reach a given velocity, on the basis of uniform rate of acceleration, and is indicated by the solid diagonal line. The dotted curve line shows what is likely to take place after reaching a given speed, and demonstrates a tailing off when accelerating from 50 mph to 60 mph. Even during this period of time, acceleration is not uniform. In the illustration (not drawn to scale) after 4.5 seconds, the rate of acceleration is $3.5'/Sec^2$. But during the remaining 3 seconds, it drops from $3.5'/Sec^2$ to zero.


DISTANCE TRAVELLED IN FEET
100
200
300
400
500
600
700
SPEED IN M.P.H
0
10
20
30
40
50
60
VELOCITY AT CONSTANT RATE OF ACCELERATION d = V2/2a
DISTANCE TRAVELLED WHEN ACCELERATING FROM 50 TO 60 M.P.H. AT AN AVERAGE RATE OF 2'/SEC.2
591'
d = V2 - V2 / 2a
VELOCITY IN FEET PER SEC.
10
20
30
40
50
60
70
80
90
50 M.P.H
60 M.P.H
TANGENT
UNIFORM VELOCITY
a = 5'/SEC.2
TIME TO REACH A GIVEN VELOCITY t = V/a
SECONDS
0
2
4
6
8
10
12
14
16
18
20
22
AVERAGE ACCELERATION FROM 50 M.P.H. TO 60 M.P.H.
a = V2 - V1 / t
26' / 7.325 = 3.5 FT/SEC.
26'
CHART V

Example of Overtaking and Passing

The various distances involved in overtaking and passing are depicted on Chart VI and are based on the following assumptions:

Initial and constant speed of car being overtaken.	50 mph
Length of car.	20 ft.
Maximum rate of deceleration of car.	22'/Sec²
Initial speed of overtaking bus.	50 mph
Maximum speed of overtaking bus.	60 mph
Length of bus.	40 ft.
Average acceleration of bus from 50 to 60 mph. . .	2'/Sec²
Speed of opposing vehicle.	65 mph

The distance required to accelerate from 50 to 60 mph is determined from the formula $d = \frac{V_2^2 - V_1^2}{2a} = \frac{88^2 - 73.35^2}{4} = 591'$

Length of Bus	40'
Front of bus from zero (rear of bus).	631'

The time for bus to accelerate from 50 mph to 60 mph equals

$t = \frac{V_2 - V_1}{a} = \frac{88 - 73.35}{2} = 7.325$ seconds

Distance traveled by auto while bus is accelerating from 50 mph to 60 mph equals $d = vt = 73.35'/\text{Sec} \times 7.325\ \text{Sec} = 537'$

Location of front of car from zero at time bus started accelerating length of bus	40'
From Chart I -- following distance	112'
Length of Car.	20'
Location of front of car from zero when bus reaches speed of 60 mph.	709'

The distance the bus must overcome at 60 mph to overtake, pass, and return to original lane is the sum of 709' - 631' or 78'; plus the minimum stopping distance of car at 50 mph--122'; plus length of the bus--40'; or a total distance to be overcome of 240'. The time to overcome is calculated from the formula $t = \frac{d}{V_2 - V_1} = 16.38$ Seconds, where V_2 is speed of bus and V_1 is speed of car.

The distance, then that the bus must move to pick up the 240 feet is d = at = 88'/Sec x 16.38 seconds = 1,441 feet. The distance the bus traveled in accelerating to 60 mph (591') plus the length of the bus (40') equals 631 feet. The total distance involved, then, equals 1441' + 631' or 2,072 feet. The length of time required to overtake and pass equals 7.325 seconds plus 16.38 seconds = 23.7 seconds. The sight distance, then required to avoid a head-on collision with an opposing vehicle traveling at 65 mph is the distance the bus traveled in overtaking (2072') plus the distance opposing vehicle traveled in 23.7 seconds at 65 mph equals d = vt = 95.35'/Sec x 23.7 seconds equals 2,260'. This makes the total sight distance 4,332 feet or approximately .8 mile. It is significant that this example of overtaking and passing results in a time saving of less than 4 seconds.

Failure to Yield Right of Way

Failure to yield right of way is usually associated with intersection accidents. Here, again, the following factors are involved; sight distance, reaction time, velocity, and rates of deceleration. Consider the following situations:

Bus "B" is traveling at 30 mph five feet from center line of a 60 foot street. Bus is 40 feet long. Bus has a maximum rate of deceleration of 15'/Sec^2. Drivers reaction time is .75 second. Auto "A", 20 feet long, is approaching from the left at 30 mph traveling five feet from the center of an 80-foot street. Auto has a maximum rate of deceleration of 22'/Sec^2, and driver has a reaction time of .75 second. The driver of bus has a sight distance indicated by S. The front of the bus is 84 feet from a point 5 feet south of the east-west center line when he observes auto approaching 76 feet distant from a point 5 feet east of the center line of the north-south street.

The following questions are raised:

1. Can the bus driver avoid hitting the auto provided the auto maintains its speed of 30 mph?

2. (a) Will a collision occur if both vehicles simultaneously make emergency stops?
   (b) At what speed would bus strike the auto?
   (c) What would be the maximum speed of bus in order to avoid striking auto provided auto makes an emergency stop?

Question 1

Referring to Chart VII, it is evident, first, that auto would have to travel 96 feet in order to avoid being struck (76' + 20'). Since Auto is traveling 30 mph (44'/Sec), it will take Auto $t = \frac{d}{v} = \frac{96}{44}$ or 2.18 seconds to clear the possible point of impact. Thus it is evident that the bus driver has 2.18 seconds to react and slow down his bus in order to avoid striking the auto. The question, then, is how far will the bus travel during the 2.18 seconds. Since reaction time is .75 second, the driver has 2.18 seconds minus .75 seconds or 1.43 seconds to slow down his bus. The formula $v_2 = v_1 - at = 44 - 15 \times 1.43 = 22.55$'/Sec. indicates that the bus has slowed down to 22.55'/Sec at the end of 1.43 seconds. The formula $d = \frac{v_1^2 - v_2^2}{2a} = \frac{1936 - 508.5}{30}$ equals 47.6 feet which is the distance the bus traveled slowing down in 1.43". To this distance the reaction distance, 44'/Sec x .75 seconds equals 33 feet, indicates that the bus traveled 80.6 feet during 2.18 seconds. Since distance available was 84 feet, the bus missed striking the auto by 3.4 feet.

Question 2a

From Chart I, it is evident that the auto would stop with its front end one foot westerly of the path of the bus as shown on Chart VIII. This is determined as follows:

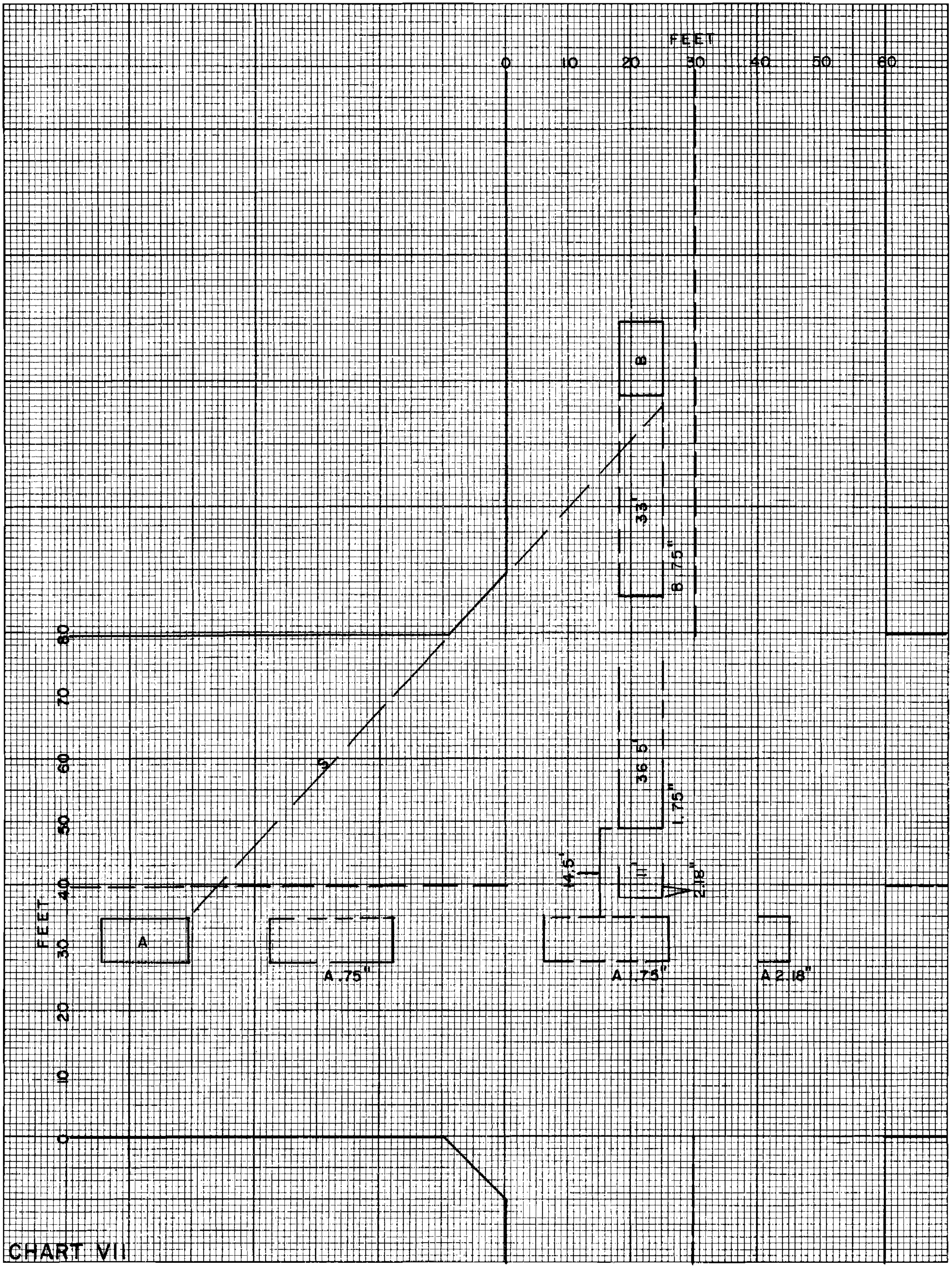
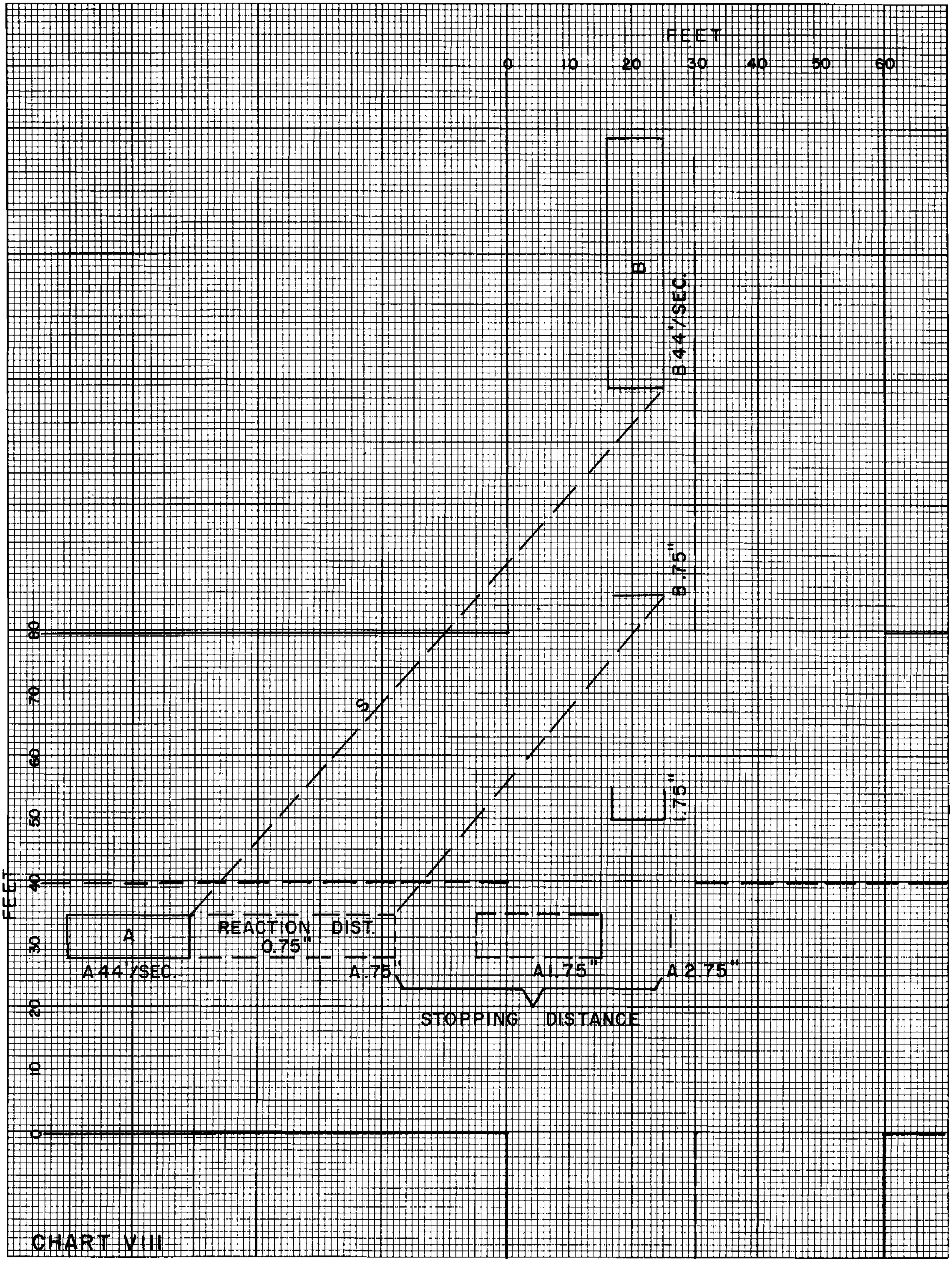

FEET
0
10
20
30
40
50
60
FEET
80
70
60
50
40
30
20
10
0
B
33'
B .75"
36.5'
1.75"
14.5'
11'
2.18"
A
A .75"
A .75"
A 2.18"

CHART VII



FEET
0
10
20
30
40
50
60
B
B 44'/SEC.
B .75"
1.75"
S
FEET
80
70
60
50
40
30
20
10
0
A
A 44'/SEC.
REACTION DIST.
0.75"
A .75"
A 1.75"
A 2.75"
STOPPING DISTANCE

CHART VIII

Reaction distance is 33 feet; plus stopping distance, $\frac{v_2^2}{2a} = \frac{1936}{44}$ = 44 feet or a total of 77 feet. The bus, however, has a total stopping distance of 97.5' including reaction distance of 33 feet plus stopping distance of $\frac{v_2^2}{2a} = \frac{1936}{30}$ = 64.5 feet. Since the maximum available distance is 84 feet, the bus would be 13.5 feet short of avoiding the collision.

Question 2b

The speed at which the bus would strike the auto can be determined as follows: Since the bus has only 84 feet in which to stop, the actual braking distance is 84' - 33' or 51'. In the formula $d = \frac{v_2^2 - v_1^2}{2a}$, v_1 can be isolated and $v_1 = \sqrt{v_2^2 - 2ad} = \sqrt{1936 - 1530} = \sqrt{406}$ = 20'/Sec = 13.7 mph.

Question 2c

The maximum speed that bus could be traveling in order to avoid striking auto is determined from the formula $v_2^2 = 2ad$. However, in order to apply the formula, reaction distance must also be taken into consideration. This can only be done if the initial speed of the bus is known. Since reaction time is .75 second, reaction distance, d, equals .75"v. Therefore stopping distance equals 84' - .75"v. Substituting $v_2^2 = 2a\,(84' - .75''v)$ or $v_2^2 = 2520 - 22.5v$. v is isolated by the use of a quadratic equation in which $v_2^2 + 22.5v = 2520$.

The steps are as follows:

(1) $v_2^2 + 22.5v + 126.5625 = 2520 + 126.5625$

(2) $v_2^2 + 22.5v + 126.5625 = 2646.5625$

(3) $(v_2 + 11.25)^2 = 2646.5625$

(4) $v_2 + 11.25 = \sqrt{2646.5625}$

(5) $v_2 + 11.25 = 51.4445$

$v_2 = 51.4445 - 11.25 = 40.1945$'/Sec or 27.6 mph

Proof:

Stopping, $d = \frac{v_2^2}{2a} = \frac{1615.6}{30}$ = 53.85 feet

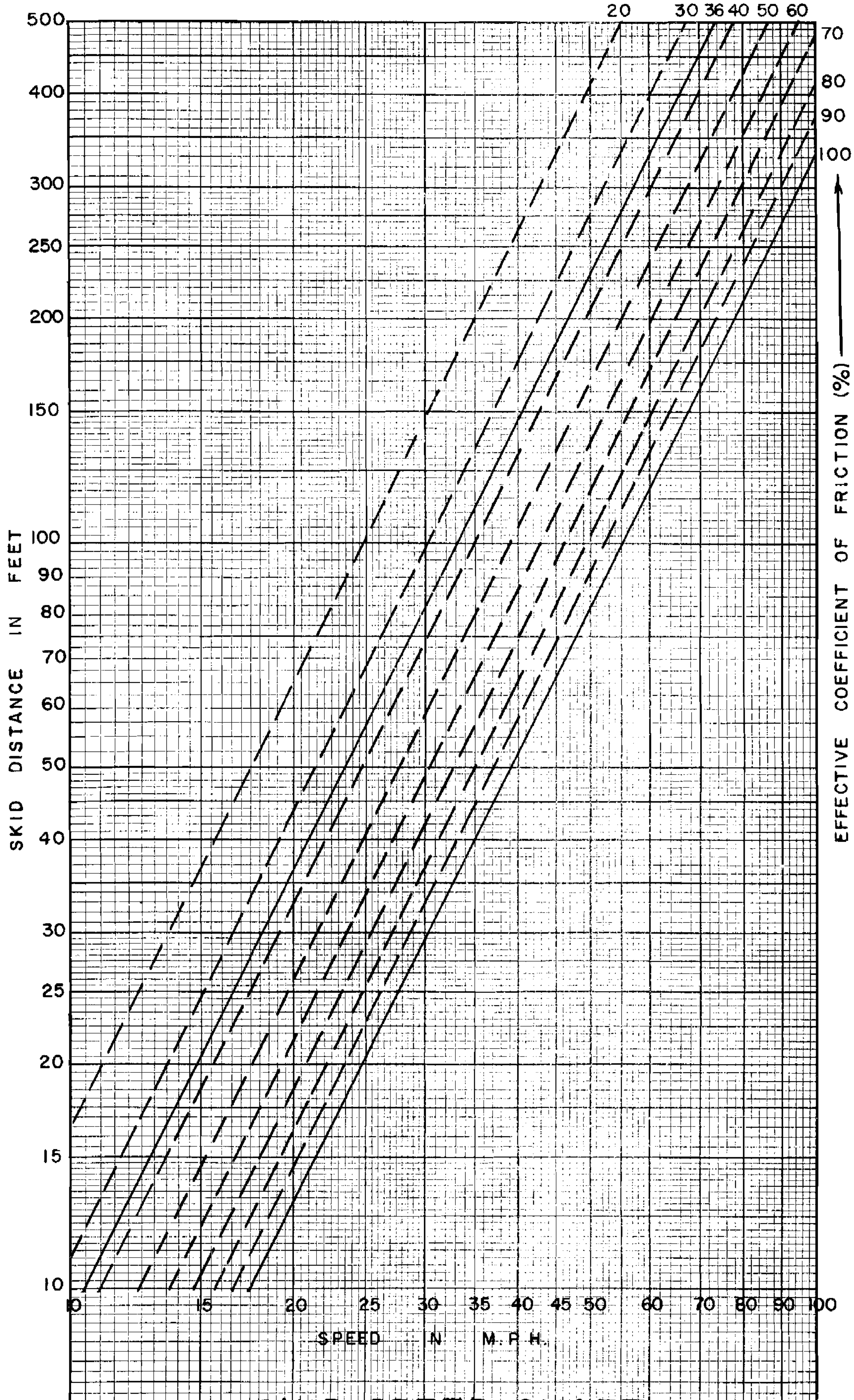
Reaction, d = 40.1945'/Sec x .75" = 30.15 feet

Total Distance = 84.00 feet

Estimating Speed From Skidmarks

When a vehicle skids or slides, the only force which acts upon it to retard its motion is the force of friction. The coefficient of friction (f) is defined as the ratio between the force (F) necessary to slide the vehicle over the surface and the weight (W) of the vehicle. Therefore, $f = \frac{F}{W}$. Force is the push or pull acting upon a body which causes it to accelerate in the direction of the force (Newton's 2nd Law of Motion). This acceleration is directly proportional to the force applied. For example, $\frac{F}{F_1} = \frac{a}{a_1}$. In the event of a body in free fall, the force acting would be its weight (W), and the acceleration or rate of change of motion would be that due to gravity (g)-- See Chart III. Substituting (W) for (F_1) and (g) for (a_1) the proportion above becomes $\frac{F}{W} = \frac{a}{g}$. From which F becomes $\frac{Wa}{g}$. Suppose that a vehicle of weight (W) is at rest on a horizontal surface and that a steady horizontal force (F) is exerted on it through a distance, d. The work performed on it in moving the vehicle is then Fd. If there is no friction, F causes the vehicle to accelerate uniformily; in accordance $F = \frac{Wa}{g}$. Since the uniform laws of motion show that $d = \frac{v^2}{2a}$, the Kinetic Energy acquired by the vehicle can be obtained by substitution of equal values. Thus $Fd = \frac{Wa}{g} \times \frac{v^2}{2a}$ or $\frac{Wv^2}{2g}$. However, since friction is involved, the coefficient of friction (f) must be introduced into the formula Fd which then becomes Ffd. Substituting W, the weight of the vehicle, for F, the equation then becomes $Wfd = \frac{Wv^2}{2g}$ or $fd = \frac{v^2}{2g}$. By transposition, $v^2 = fd2g$, and $v = \sqrt{fd2g}$. Since 2g is always constant, $v = 8.02\sqrt{fd}$. In the event grades are involved, $v = 8.02\sqrt{fd - p}$ where p equals percent of grade.

For example, if a vehicle skids 48 feet on level pavement known to have a coefficient of friction of .7, the minimum speed is $v = 8.02\sqrt{48 \times .7} = 8.02 \times 5.8 = 46.5$'/Sec or 31.9 mph. By use of Logarithmic Scales, it is possible to plot mph under various coefficients of friction and length of skid. On Chart IX, by locating where the length of skid crosses the dotted lines horizontally and reading down, mph may be determined.



SKID-SPEED CHART

CHART IX

APPENDIX

Glossary Of Terms

a	Acceleration - or Deceleration
d	Distance in Feet
f	Coefficient of Friction
g	Gravity (32.16 Feet per second per second)
p	Percent of Grade
t	Time in seconds
v	Velocity in Feet
v_1	Initial Velocity
v_2	Final Velocity
F	Force
KE	Kinetic Energy = $\frac{Wv^2}{2g}$
M	Pounds Mass
W	Weight in Pounds
mph	Miles Per Hour
$\sqrt{}$	Square Root
'	Feet
"	Seconds
Sec	Seconds
'/Sec	Feet Per Second
'/Sec^2	Feet Per Second Squared

APPENDIX

Formulas

UNIFORM AND UNIFORMLY VARYING MOTION

$$a = \frac{v_2 - v_1}{t} ; \frac{v_2}{t} ; \frac{v_2^2}{2d}$$

$$d = vt ; \frac{v_1 + v_2}{2}(t) ; v_2 t - \frac{at^2}{2} ; v_1 t + \frac{at^2}{2} ; \frac{at^2}{2} ; \frac{v_2^2 - v_1^2}{2a} ; \frac{v_2^2}{2a}$$

$$t = \frac{d}{v} ; \frac{2d}{v_1 + v_2} ; \frac{2d}{v_2} ; \frac{v_2 - v_1}{a} ; \frac{v_2}{a}$$

$$v = \frac{d}{t}$$

~~$v_1 = v_2 - at$; at~~

$$v_2 = v_1 + at ; at$$

STOPPING DISTANCE

$$a = \frac{v_2^2}{2d} ; \frac{v_1^2 - v_2^2}{2d}$$

$$d = \frac{v_2^2}{2a} ; \frac{v_1^2 - v_2^2}{2a}$$

$$t = \frac{2d}{v_2} ; \frac{v_2}{a}$$

DECELERATION

$$v_2 = v_1 - at$$

Conversion Factors

mph = '/Sec x .6818

ft/Sec = mph x 1.467

mph	'/Sec	'/Sec²	mph	'/Sec	'/Sec²
5	7.34	53.88	35	51.35	2636.82
10	14.67	215.21	40	58.68	3443.34
15	22.00	484.00	45	66.00	4356.00
20	29.34	860.84	50	73.35	5380.22
25	36.68	1345.42	55	80.69	6510.88
30	44.00	1936.00	60	88.00	7744.00