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REPORT TO CONGRESS

RAILROAD-HIGHWAY SAFETY PART I: A COMPREHENSIVE STATEMENT OF THE PROBLEM

U.S. DEPARTMENT OF TRANSPORTATION

PREPARED BY THE STAFF OF

THE FEDERAL RAILROAD ADMINISTRATION
THE FEDERAL HIGHWAY ADMINISTRATION

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This report presents Part I of the combined study effort of the Federal Railroad Administration and Federal Highway Administration, and was submitted to the Congress in October 1971 in response to the Railroad Safety Act of 1970. It identifies the extent and nature of the safety problem associated with railroad - highway intersections nationwide and to pedestrians along railroad rights-of-way, particularly within and near urban areas. A cost-benefit analysis is employed to present the problem in order of magnitude. Part II of the report will be submitted in July, 1972, in response to the Highway Safety Act of 1970.

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CONTENTS

EXECUTIVE SUMMARY

I. INTRODUCTION 1

II. HISTORY AND TRENDS 5

Accidents and Casualties
Financial Responsibility
Regulatory Jurisdictions

III. THE CURRENT PROBLEM 23

Mileage and Travel
Number and Classification of Public Crossings
Private Crossings
Number and Severity of Accidents
Economic Analysis

IV. IMPROVEMENT PROGRAMS - PAST AND PRESENT 37

Records of Past and Present Programs
Department of Transportation Activities
National Conferences
Research Projects Related to Grade Crossing Safety
Crossings on High-Speed Rail Lines
Demonstration Projects Authorized by 1970 Acts

V. THE DRIVER 51

Engineering
Education
Enforcement
Coordinated Community Program

VI. THE WARNING SYSTEM 59

Standards and Guides
Existing Active Systems
New Technology in Active Systems
Existing Passive Systems
Potential Improvements to Passive Systems
Location of Devices
Maintenance
Exempt Crossing Issue

VII. THE TRAIN 77

Visibility and Audibility of Trains Approaching Railroad-Highway Grade Crossings
Beacon-Reflector Warning Device
Reflectorization of Railroad Cars
Impact Attentuation on Trains

VIII. PEDESTRIAN PROTECTION 83

Definitions
Statistical Procedures
Scope of the Problem
Statistical Trends
Preventative Measures
Special Issues

APPENDIX A - A Legal-Historical Review of the Division of Responsibility for the Elimination and Protection of Railroad-Highway Grade Crossings

EXECUTIVE SUMMARY

Problems associated with railroad and highway traffic intersecting at grade crossings are as old as the Nation's transportation system. From 1830, the birth of the railroad industry in the United States, to the present day--141 years later--the hazards that grade crossings present to both highway and railroad users categorize the problem as a major public safety issue.

Scope

Over the years the composition of this traffic has changed to the point where motor vehicle travel of one trillion vehicle miles annually far exceeds rail transportation which is 500 million train miles annually.

Until recent years there has not been a fully accurate count of the number of grade crossings. However, the average of one crossing per mile of railroad has held fairly constant since the peak of railroad building. Of the 232,000 crossings inventoried for this report, 155,000 are in rural areas and 77,000 in urban areas. About 20 percent, or 47,000, have train-activated protective devices. As to highway classification, 47,000 crossings are part of the Federal-aid highway system and 185,000 are off the system. Of those on the system, 45 percent have automatic protective devices. Off the system, 15 percent of the crossings have such protection.

At the low end of the volume spectrum, more than 70,000 crossings have no more than two trains per day and less than 500 motor vehicles per day; some 4,000 crossings have 10 or more trains and 5,000 or more motor vehicles per day at the high-volume level. There are 140,000 private road grade crossings. These have an accident rate of only 4 percent of the public grade crossing toll.

Accident statistics complied since 1920 show that 86,000 persons have been killed, the vast majority in motor vehicle-train collisions. Annual fatalities varied from the 1928 high of 2,568 to a low in 1959 of 1,203. The more severe accidents at public grade crossings involving trains are reported by the railroads to the Federal Railroad Administration under its rules and regulations and total about 4,000 per year. However, all train-involved grade crossing accidents are reported to State governments by police or drivers, and the total accident experience involving trains is estimated at about 12,000 per year. Nearly 1,500 fatalities and 7,000 injuries result annually from these accidents. The high ratio of fatalities and injuries to the number of train-involved

grade crossing accidents ranks these accidents among the most severe in the public safety area. While more train-involved accidents occur in urban areas, the higher casualty rate is in rural grade-crossing accidents.

Anotner accident category is the estimated 28,000 accidents which occur in the vicinity of and are directly related to the existence of a crossing but do not involve impact with or by a train. These are much less severe than the train-involved category and result in an estimated 280 fatalities.

In addition to the number of grade crossings and the accident experience, the grade crossing problem is a significant economic issue. An economic analysis has been employed in this report to provide an economic order of magnitude measure of the problem; and the results should not be interpreted as a program recommendation. The results indicate that if 15,000 crossings were provided with improved protection, accident costs would be reduced by nearly three times the installation and maintenance cost of the improvement. The analysis also indicates that there would be a greater relative benefit in urban areas than in rural areas.

On an individual crossing basis, it appears that 500 to 1,000 crossings might economically warrant grade separation, primarily on the basis of reduced motor vehicle operating and delay costs. However, most grade separations will probably continue to be constructed as part of a systems approach. In addition to highway system improvements, these include high-speed rail lines and urban rail system improvements.

Responsibility

In exercising authority over safety at railroad-highway intersections, many States have by statute delegated part or all of this authority to State regulatory commissions. In other States the responsibility and authority to determine the location and type of improvement required at a grade crossing is lodged in the State highway departments for projects located on highways under State jurisdiction, and for projects on other roads and streets it is lodged in local county or municipal agencies. Without a separate regulatory commission, the regulatory function is performed by the same agency that performs the construction and maintenance function on the highway.

Typically, the State agency performing the regulatory function for railroad-highway crossing safety, after proper notice and public hearing, determines the need for safety improvement, if any; determines the appropriate type of improvement; determines the agency to carry out the work; and allocates the cost of the improvement among the parties, railroad and public agency, involved in the instant proceeding.

Railroad-highway intersection improvements are currently financed in several ways. Federal-aid highway funds may be used to assist in financing improvements at the 47,000 crossings on the Federal-aid highway system. All crossings off the system must be financed with State, local and railroad funds, and these are also sometimes used to finance improvements on the Federal-aid system. Financing by State and local governments is usually accomplished through highway funds or other general funds. However, several States have established special categories of funds to be used specifically to share in the cost of railroad-highway intersection improvement projects.

An issue as old as the grade crossing safety problem itself is that of financial responsibility. Historically, the division of responsibility for financing the elimination and protection of railroad crossings of public streets and highways has shifted from time to time since the early beginnings of highway and railroad transportation networks. Currently, the division of responsibility varies widely from State to State and whether Federal-aid highway funds assist in financing the improvement. Under current legislation the railroad share does not exceed 10 percent of the cost of the improvement when Federal-aid highway funds are involved. Although there is a wide variation in division of cost among the States in non-Federal-aid projects, 50-50 division is often used. In most States railroads have paid a smaller portion of the cost in recent years than in years when railroads were the dominant mode. Railroads pay annual maintenance costs of approximately $35 million.

Improvements

The total cost of railroad-highway intersection improvements is about $200 to $250 million annually. This includes $100 to $150 million of Federal funds which are mostly spent on grade separations, including those to "eliminate" potential crossings on the Interstate highway system. State and local funds contribute approximately $100 million annually, including about $10 million from the special funds. Railroad expenditures are about $10 million annually. These funds result in the construction of over 400 grade separations and installation of about 900 automatic protective devices annually for all highway systems.

Costs associated with improvements at grade crossings include initial (installation) and recurring (maintenance) costs. The initial cost of installation of protective devices ranges from approximately $15,000 for installation of flashing lights at a single track location, to approximately $25,000 for installation of automatic gates at a multiple track crossing. More sophisticated devices that measure the speed of the train represent an additional, higher cost. Annual maintenance costs range from $750 to $1,250. Grade separations have an average cost range of $320,000 for low-volume rural roads, to $930,000 for high-volume urban street separations.

Historically, many grade crossings have been improved as a part of a highway improvement. Highway improvements have been made on a system basis with Federal assistance limited to a designated system of more important highways. If a similar systems approach were applied to railroad-highway intersections, consideration would be given to all of the crossings in an area constituted as a unit by its geographical, political, or operational features. Use of this approach is considered a necessary prerequisite to resolution of the grade crossing problem in a specific area.

Application of the systems approach includes treating a single rail line in an urban area by a mix of closures, protection improvements and grade separations. The Highway Safety Act of 1970 included demonstration projects involving two examples of the systems approach--high-speed rail lines and urban railroad relocation. These are the elimination of all 49 public grade crossings along the Washington to Boston high-speed rail line and track relocation in Greenwood, South Carolina. The Washington-Boston project brings the freeway design concept to the rail system.

In urban areas, the best solution in a systems approach to the grade crossing problem may be railroad relocation. The Greenwood demonstration will include combining the operations of more than one railroad on a single track by relocation and consolidation of several miles of track, closure and protection of at-grade crossings along the relocated track and construction of grade separations at crossings of arterial highways. About 35 crossings will be eliminated.

The Driver

Nearly all grade crossing accidents can be said to be attributable to some degree of "driver error." Thus, any effective program for improving safety at railroad-highway grade crossings should be oriented around the driver and his needs in approaching, traversing and leaving the crossing site as safely and efficiently as possible.

When the driver approaches a crossing, he needs to know if there is a train (1) on the crossing, (2) approaching the crossing, or (3) not in the vicinity of the crossing. This can be satisfied in part by providing improvements such as (1) more effective and informative passive signing, (2) improved sight distance along the highway, and (3) better visibility of the crossing area and of the train on or approaching the crossing. However, all of these improvements still leave the basic responsibility for determining the hazard with the driver and may require almost simultaneous tasks of him. At a crossing protected with

an automatic device, the driver's primary responsibility is to observe and respond to the message conveyed by that device. Thus, automatic devices which give the driver a uniform warning time prior to arrival of the train significantly simplify the driver's task and substantially reduce motor vehicle-train collisions.

The Warning System

The warning system consists of a combination of passive and active devices, as well as environmental conditions to provide the driver with knowledge of the presence of a grade crossing, and, in certain cases, positive advice as to the approach or presence of a train. The warning system includes advance warning signs, passive or active devices at the crossing, the ability to see or hear the approach of a train, either through adequate sight distance or on-train warning devices, such as lights, horns and bells. The national standards for the devices along the highway, at and approaching the crossing, are provided in the Manual on Uniform Traffic Control Devices which is applicable to all highways. In addition, requirements regarding crossing protection devices are contained in Association of American Railroads Bulletin No. 6.

With more than three-fourths of the public grade crossings nationwide protected only with static signs, it is most important for these signs to be as effective as possible. Furthermore, at the 70,000 or more crossings in the lowest classification for both highway and railroad traffic volumes--500 or less vehicles per day and two or less trains per day--there is but a remote possibility of finding adequate justification for other than minimum protection of the static sign type.

Currently available active crossing devices are either flashing lights or automatic gates. These fail-safe devices are effective in reducing accidents but their cost has resulted in their generally being used at only those crossings with high train and motor vehicle volumes.

Technology

Treatment of the grade crossing problem would be greatly aided by the availability of a wider range of warning system devices. Because of the importance of the passive signs used in railroad-highway grade crossing warning systems, testing is being conducted to develop more effective signs. Due to the demonstrated advantages of active devices, research is under way attempting to develop a lower-cost active device for use at many crossings where the high cost of existing types of active devices would discourage their installation.

At the same time there is a need for more reasonably priced devices to measure train speed and provide the driver a uniform warning time prior to arrival of the train. This would permit wider usage of these devices which have the dual function of providing more credibility to the signal's warning and of reducing motor vehicle delay and operating cost caused by unnecessary stopping and standing at the crossing.

Modifications to the train are being evaluated as likely aids to the driver in detecting the approach or presence of a train, including visibility and audibility modifications to the locomotive such as high-intensity zenon lights and more effective use of paint.

The Pedestrian

A related, but separate issue, addressed in this report concerns pedestrian safety as it is affected by railroad operations in densely populated areas. The most definitive body of accident data available on pedestrians is the accident reporting system of the Federal Railroad Administration's Bureau of Railroad Safety. The data reveal an annual casualty count of 1,350 persons involved in railroad right-of-way accidents. Of these, 838 occur in densely-populated areas. The casualty figures break down into 353 fatalities and 485 injuries distributed over approximately 30,000 railroad route miles in urban areas. Juveniles, under age 20, account for nearly half the total accident experience. In most cases, pedestrians injured on railroad rights-of-way are considered trespassers. Preventative measures include fencing, more effective warning signs, separated pedestrian crossings, education and law enforcement.

Conclusion

This analysis of the grade crossing problem and subsequent program recommendations which will be addressed in Part II, are in response to the requirements of the Railroad Safety Act of 1970 and the Highway Safety Act of 1970. As this summary indicates briefly and the report presents in detail, there are many facets and complexities to the grade crossing issue. The difficult questions of financial responsibility, divided jurisdiction, high cost of improvements, legal liability, and limited sources of funding have had a major impact on the ability to achieve new breakthroughs in solving the grade crossing problem. Safety has always been the major public issue. However, with the tremendous growth in motor vehicle miles, serious congestion on urban streets, and increasing interest in high-speed rail service as an alternative mode in transportation planning, improved highway and railway mobility has assumed new importance. Effective resolution of the grade crossing problem should consider both increased safety and more efficient use of the highway and railroad systems.

INTRODUCTION

Legislative Requirements

Under the provisions of separate legislative acts, the Railroad Safety Act of 1970 and the Highway Safety Act of 1970, the Secretary is to make comprehensive studies on railroad-highway grade crossing safety nationwide and to report his recommendations to the Congress.

Railroad Safety Act of 1970

Section 204 of this act provides in part -

(a) The Secretary shall submit to the President for transmittal to the Congress, within one year after the date of enactment of this title, a comprehensive study of the problem of eliminating and protecting railroad grade crossings, including a study of measures to protect pedestrians in densely populated areas along railroad rights-of-way, together with his recommendations for appropriate action including, if relevant, a recommendation for equitable allocation of the economic costs of any program proposed as a result of such study.

Highway Safety Act of 1970

Section 205(a) of this act provides in part (23 U.S.C. 322) -

(e) The Secretary, in cooperation with State highway departments, shall conduct a full and complete investigation and study of the problem of providing increased highway safety at public and private ground-level rail-highway crossings on a nationwide basis through the elimination of such crossings or otherwise, including specifically high-speed rail operations in all parts of the country, and report to Congress his recommendations resulting from such investigation and study not later than July 1, 1972, including an estimate of the cost of such a program. Funds authorized to carry out section 307 of this title are authorized to be used to carry out the investigation and study required by this subsection.

Combined Study

In carrying out the foregoing provisions of law, the Secretary delegated the responsibility for implementing the provisions of section 204(a) of the Railroad Safety Act to the Federal Railroad Administrator and of subsection 322(e) of title 23, U.S.C. to the Federal Highway Administrator. He also directed that the study requirements under both acts be advanced under a single study concept representing the combined efforts and expertise of the two Administrations. The Secretary further proposed to the Chairmen of the Commerce and Public Works Committees in the Senate and House that to meet the different reporting dates under the separate acts, he would provide the Congress with Part I of the Grade Crossing Safety Report on October 16, 1971, and Part II by July 1, 1972.

Report

This report presents Part I of the combined study effort and is submitted in response to the Railroad Safety Act of 1970. It identifies the extent and nature of the safety problem associated with railroad-highway intersections nationwide and to pedestrians along railroad rights-of-way, particularly within and near urban areas. A cost-benefit analysis is employed to present the problem in order of magnitude. Part II of the report will be submitted in response to the Highway Safety Act of 1970.

Terminology

Clarification of some terminology may be helpful.

The Railroad Safety Act requires a study of railroad grade crossings and the Highway Safety Act calls for a study of ground-level rail-highway crossings. These snyonymous terms embrace the at-grade major problem areas of the more encompassing railroad-highway intersections frequently used in this report to characterize the total spectrum of the bimodal points of crossing of highway traffic and railroad operations.

Grade separation will be the term employed to distinguish an intersection where the channels of traffic flow of the two modes are at different levels, thereby avoiding the direct conflicts which occur at grade crossings, where intersecting traffic movements of the modes are at the same level. An overpass is used to signify a grade separation where highway traffic uses the upper level above the railroad, whereas underpass is used to signify a grade separation with the railroad above a lower level highway.

Grade crossing elimination is commonly used to describe the construction of a grade separation. However, the term is hardly correct when it is used to indicate a grade separation at a new intersection without the consequent abandonment of any existing grade crossing either as a result of the construction of a grade separation or as the result of relocation or abandonment of the railroad or the highway at the point of intersection.

Grade crossing protection is provided at grade crossings to assist the highway traveler - a driver of a vehicle or a pedestrian - in making a safe crossing of the railroad. Active protection, such as flashing light signals or crossing gates, provides a warning indication to the traveler when a train or other railroad movement approaches or occupies the crossing. Passive protection, such as crossbuck signs or similar fixed signs without flashing light signals or gates, merely designates the location of the crossing, sometimes with appropriate supplemental information on the number of tracks or other significant facts.

The term casualties is employed to include collectively persons killed outright, persons fatally injured, and persons who sustain injuries and are recorded as a personal injury in an accident report.

II

HISTORY AND TRENDS

Accidents and Casualties

The birth of the railroad industry in this country occurred in 1830. Up until 1870 there were few streets or highways in the areas of railroad development; consequently, grade crossings were few in number. By 1890 there were 163,605 miles of railroad in the Nation. This large increase in railroad mileage plus the population growth and associated need for new roads created a corresponding increase in the number of grade crossings. Accidents were becoming more frequent. By 1900 motor vehicles began to influence and add to the safety problem at railroad-highway grade crossings.

Under the requirements of the Accident Reports Act of 1910, rail carriers submit reports of accidents involving railroad personnel and railroad equipment, including those which occur at grade crossings. Over the years, this information has been summarized by the Bureau of Railroad Safety, Federal Railroad Administration, in annual "Accident Bulletins." In addition, statistics on grade crossing accidents involving trains at public crossings are published separately in annual reports entitled "Rail-Highway Grade-Crossing Accidents."

This does not provide information on all accidents occurring at railroad-highway intersections involving trains for the reason that the railroads are required to report only those accidents which result either in (1) a fatality, (2) injury to a person sufficient to incapacitate him or her for a period of 24 hours in the aggregate during the 10 days immediately following, or (3) more than $750 damage to railroad equipment, track or roadbed. However, a very large majority of the severe accidents at grade crossings are included in these Bureau of Railroad Safety reports and, starting with the year 1920, statistics from this source are available to indicate the magnitude and the trends in grade crossing accidents. A 51-year summary of this data is set forth in Table 1 and is illustrated in Chart I.

TABLE 1

Number of Accidents and Casualties Involving Trains at Public Railroad-Highway Grade Crossings Reported Under the Accident Reports Act of 1910 - Years 1920 to 1970, Inclusive

Year	Number of Accidents	Number of People Killed			Number of People Injured			Total Number of Casualties		
		In Accidents Involving Motor Vehicles	In Other Accidents	Total	In Accidents Involving Motor Vehicles	In Other Accidents	Total	In Accidents Involving Motor Vehicles	In Other Accidents	Total
1920	4,287	1,273	518	1,791	3,977	1,100	5,077	5,250	1,618	6,868
1921	4,019	1,262	443	1,705	4,025	843	4,868	5,287	1,286	6,573
1922	4,361	1,359	451	1,810	4,493	890	5,383	5,852	1,341	7,193
1923	5,218	1,759	509	2,268	5,416	898	6,314	7,175	1,407	8,582
1924	5,127	1,688	461	2,149	5,550	875	6,525	7,338	1,336	8,674
1925	5,479	1,784	422	2,206	5,916	639	6,555	7,700	1,061	8,761
1926	5,862	2,062	429	2,491	6,358	633	6,991	8,420	1,062	9,482
1927	5,640	1,974	397	2,371	6,068	545	6,613	8,042	942	8,984
1928	5,800	2,165	403	2,568	6,218	448	6,666	8,383	851	9,234
1929	5,975	2,085	400	2,485	6,347	457	6,804	8,432	857	9,289
1930	4,853	1,695	325	2,020	5,206	311	5,517	6,901	636	7,537
1931	4,106	1,580	231	1,811	4,336	321	4,657	5,916	552	6,468
1932	3,499	1,310	215	1,525	3,778	211	3,989	5,088	426	5,514
1933	3,236	1,305	206	1,511	3,496	201	3,697	4,801	407	5,208
1934	3,728	1,320	234	1,554	4,099	201	4,300	5,419	435	5,854
1935	3,933	1,445	235	1,680	4,442	216	4,658	5,887	451	6,338
1936	4,277	1,526	260	1,786	4,669	261	4,930	6,195	521	6,716
1937	4,489	1,613	262	1,875	4,915	221	5,136	6,528	483	7,011
1938	3,694	1,311	206	1,517	3,799	219	4,018	5,110	425	5,535
1939	3,476	1,197	201	1,398	3,753	246	3,999	4,950	447	5,397
1940	4,104	1,588	220	1,808	4,446	186	4,632	6,034	406	6,440
1941	4,320	1,691	240	1,931	4,680	205	4,885	6,371	445	6,816
1942	4,150	1,635	335	1,970	4,399	217	4,616	6,034	552	6,586
1943	3,781	1,396	336	1,732	3,960	257	4,217	5,356	593	5,949
1944	3,811	1,520	320	1,840	3,998	218	4,216	5,518	538	6,056
1945	4,100	1,591	312	1,903	4,141	305	4,446	5,732	617	6,349
1946	4,001	1,575	276	1,851	4,160	237	4,397	5,735	513	6,248
1947	4,015	1,536	254	1,790	4,086	165	4,251	5,622	419	6,041
1948	3,964	1,379	233	1,612	4,092	163	4,255	5,471	396	5,867
1949	3,523	1,323	184	1,507	3,636	138	3,774	4,959	322	5,281
1950	4,000	1,410	166	1,576	4,226	142	4,368	5,636	308	5,944
1951	3,995	1,407	171	1,578	4,180	155	4,335	5,587	326	5,913
1952	3,592	1,257	150	1,407	3,774	130	3,904	5,031	280	5,311
1953	3,675	1,328	166	1,494	3,698	117	3,815	5,026	283	5,309
1954	3,336	1,161	142	1,303	3,323	103	3,426	4,484	245	4,729
1955	3,846	1,322	124	1,446	3,904	110	4,014	5,226	234	5,460
1956	3,639	1,213	128	1,338	3,648	107	3,755	4,858	235	5,093
1957	3,569	1,222	149	1,371	3,629	138	3,767	4,851	287	5,138
1958	3,099	1,141	130	1,271	3,045	116	3,161	4,186	246	4,432
1959	3,075	1,073	130	1,203	3,139	108	3,247	4,212	238	4,450
1960	3,195	1,261	103	1,364	3,287	137	3,424	4,548	240	4,788
1961	3,204	1,173	118	1,291	3,301	213	3,514	4,474	331	4,805
1962	3,149	1,132	109	1,241	3,094	98	3,192	4,226	207	4,433
1963	3,373	1,217	85	1,302	3,435	89	3,524	4,652	174	4,826
1964	3,755	1,432	111	1,543	3,676	107	3,783	5,108	218	5,326
1965	3,820	1,434	100	1,534	3,663	138	3,801	5,097	238	5,335
1966	4,097	1,657	123	1,780	3,927	116	4,043	5,584	239	5,823
1967	3,932	1,520	112	1,632	3,726	86	3,812	5,246	198	5,444
1968	3,816	1,448	98	1,546	3,665	109	3,774	5,113	207	5,320
1969	3,774	1,381	109	1,490	3,578	91	3,669	4,959	200	5,159
1970	3,559	1,362	78	1,440	3,237	99	3,336	4,599	177	4,776
Totals	205,928	74,495	12,120	86,615	213,714	14,336	228,050	288,209	26,456	314,665

GRADE CROSSING CASUALTIES REPORTED UNDER THE ACCIDENT REPORTS ACT OF 1910

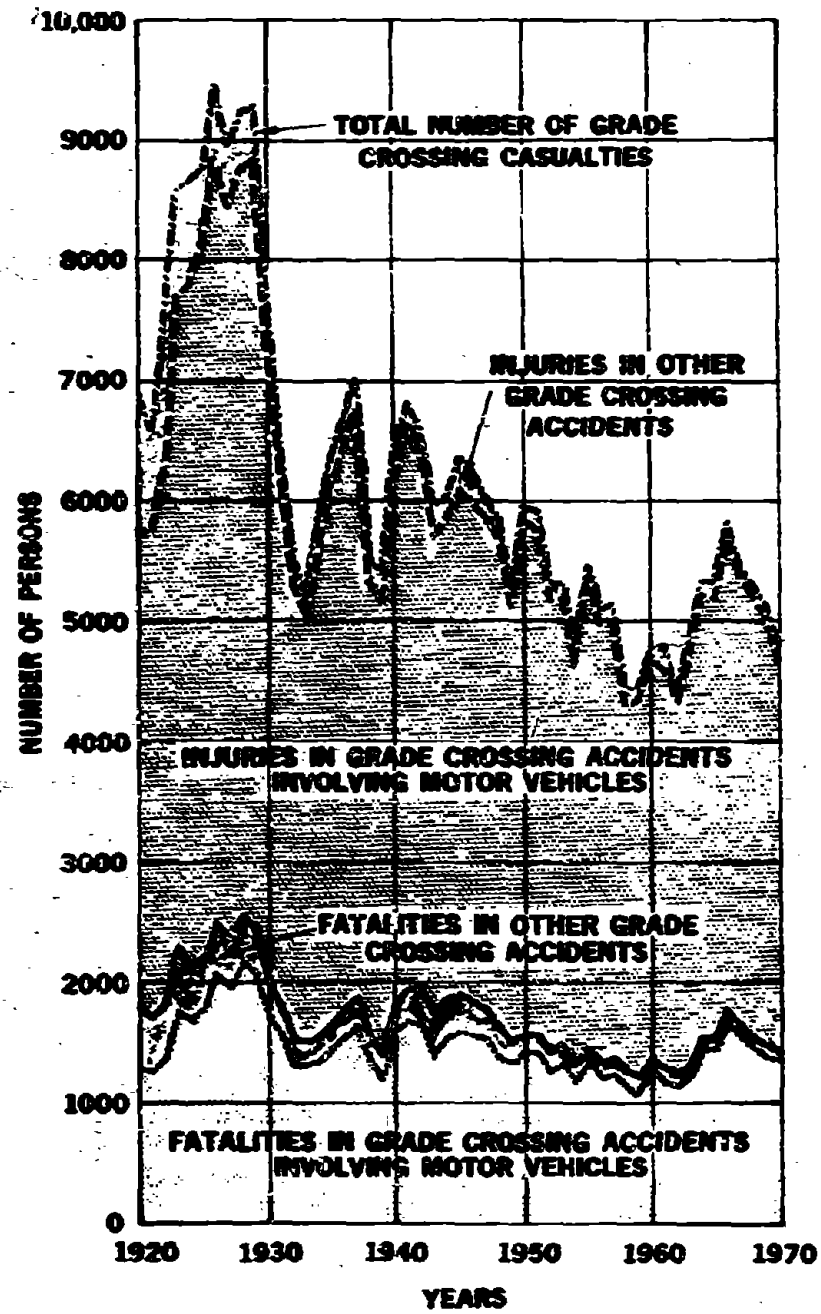

CHART 1

As shown by these statistics a large majority of grade crossing casualties - deaths and personal injuries - result from accidents involving motor vehicles. In the year 1970 more than 94 percent of the fatalities and 97 percent of the injuries were so involved and even in 1920 more than 71 percent of the grade crossing deaths and 78 percent of the injuries resulted from accidents involving motor vehicles. In 1970, 62 percent of the grade crossing casualties not involving motor vehicles were pedestrians. In 1920 there were numerous accidents involving horse-drawn vehicles also. Between 1920 and 1970 the grade crossing casualties in accidents not involving motor vehicles declined by almost 90 percent.

The series of charts, II through VII, illustrate the trend of grade crossing accidents and their relationship to the trends in the amount of motor vehicle travel and the amount of railroad traffic. They also indicate that benefits accrue from grade crossing improvements.

Chart II repeats the year-by-year record of casualties resulting from highway-railroad grade crossing accidents from 1920 through 1970. The lower line shows the number of fatalities, varying from a high of 2,568 in 1928 to a low of 1,203 in 1959. The middle line shows the number of people injured, varying from a high of 6,991 in 1926 to a low of 3,161 in 1958. The upper line shows the total number of casualties, the number of people killed plus the number of people injured, varying from a high of 9,482 in 1926 to a low of 4,432 in 1958.

The number of casualties has been used as a measure of accident occurrence rather than the actual number of reported accidents for two reasons: (1) Reduction in casualties would be the prime objective of any expanded program of grade crossing safety, and (2) the minimum monetary amount of damage to equipment, track, or roadbed (now $750) which qualifies a non-casualty accident as reportable has been increased at irregular intervals, whereas the requirements for reporting accidents involving casualties have remained relatively constant.

The lines on this chart have two quite significant features. Over the 51-year period the general trend of these casualties has been downward, but in each of the 12 years since 1958 there have been more grade crossing casualties than there were at that low point in the record.

RECORD OF CASUALTIES RESULTING FROM RAILROAD-HIGHWAY GRADE CROSSING ACCIDENTS

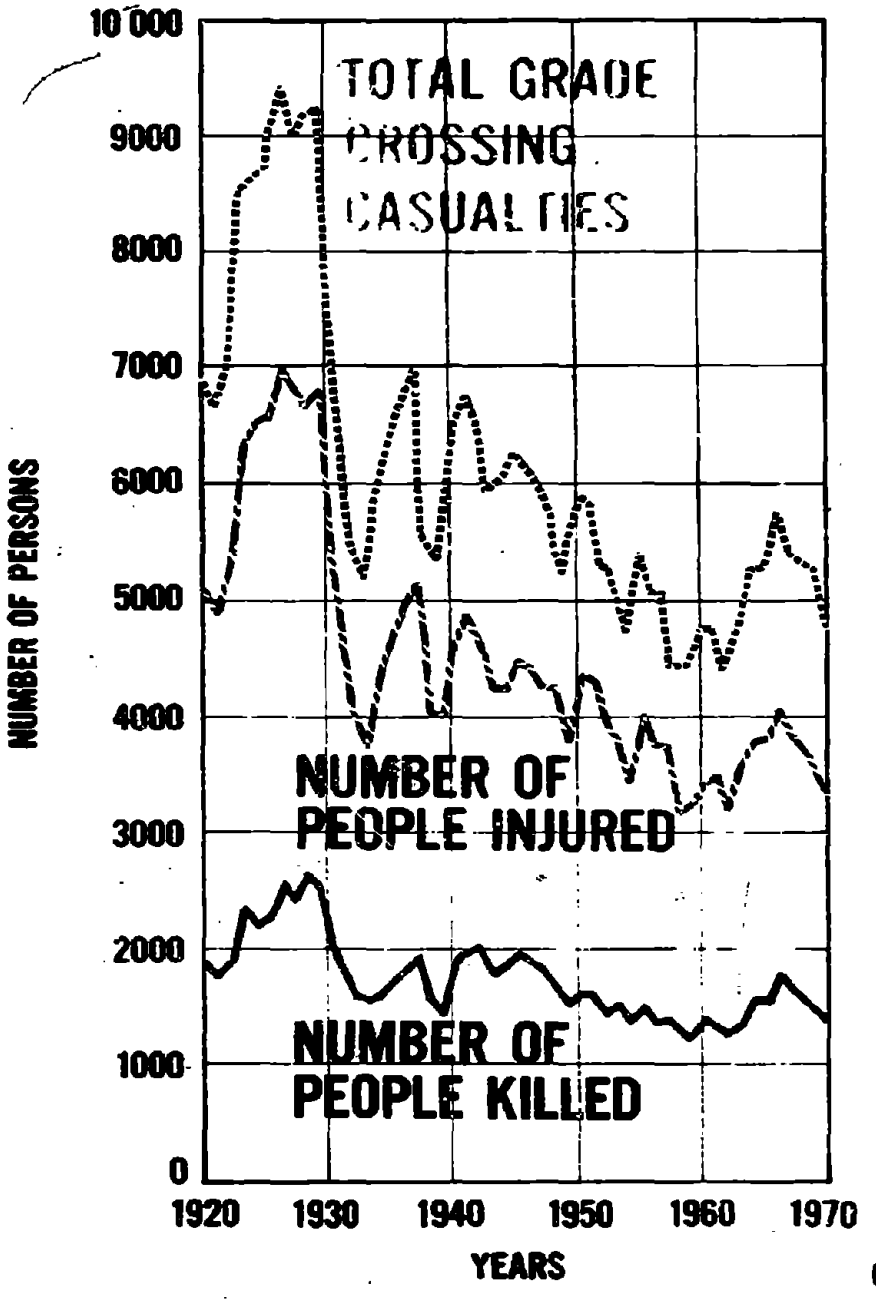

CHART II

It has long been recognized that the number of grade crossing accidents and the number of resulting casualties have been influenced by the amount of traffic flow, both on the railroads and on the highways.

On Chart III the line extending from the upper left downward to the right is the same as that on Chart II showing the number of casualties. The line below it shows the year-by-year variation in the number of train miles operated on Class I and Class II railroads of the United States, with a peak of 1 billion, 241 million in 1926 to a low point of 529 million in 1970. The general trend of this line is downward with a major downward fluctuation in the depression period of the 1930's and a major upward bulge in the period of World War II.

The line extending from the lower left to the upper right shows the year-by-year record of the estimated number of miles of motor vehicle travel in the United States, starting from the low point of about 45 billion in 1920 and rising to the top figure of 1 trillion, 120 billion in 1970. There were only two variations from the continual upward trend in motor vehicle travel; (1) a slight decline in the early part of the depression period of the 1930's and (2) a substantial decline during the gasoline rationing period of World War II.

There is a close correlation between the total number of train miles operated and the number of times these trains move over grade crossings on the railroad system and a similar high degree of correlation between the number of vehicle miles of travel on the highway system and the number of vehicle crossings of railroad tracks. In the absence of direct statistical information showing the number of trains and the number of vehicles moving over railroad-highway grade crossings, these total train mile and vehicle mile figures are employed to show variations in the incidence of exposure.

The influence of these traffic variations on grade crossing casualties is fairly evident. The great decline in casualties from 1929 to 1933 followed along with the marked decrease in the number of train miles operated and the slight decline in vehicle miles traveled. In the period of World War II the increase in train miles offset the decrease in motor vehicle miles, hence, there was no significant decline in the number of casualties.

In the earlier years of the 51-year period the general downward trend of casualties seems to have followed the general downward trend of train miles, but since 1958 the influence of this downward trend has been offset somewhat by the increased upward trend in motor vehicle miles.

GRADE CROSSING CASUALTIES RELATED TO TRAFFIC MOVEMENTS

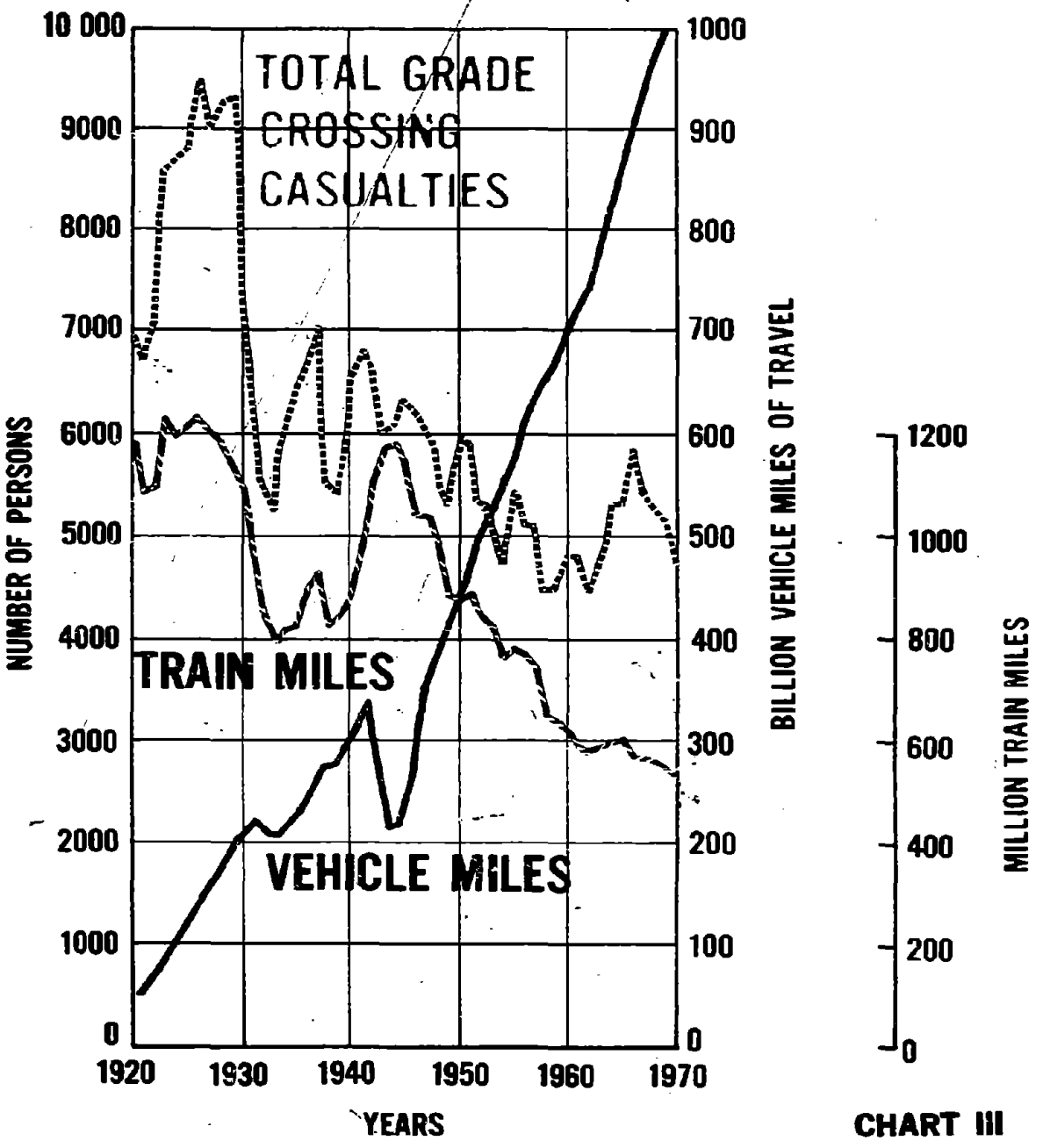

CHART III

In analyzing these relationships between motor vehicle miles and casualties it is desirable to use the record of casualties resulting from accidents involving trains and motor vehicles only. Chart IV shows those casualties in comparison with total grade crossing casualties. The 1929 peak for casualties resulting from motor vehicle involved accidents was 8,432 and the 1958 low was 4,186.

Chart V shows the variations year-by-year in grade crossing casualties in accidents involving motor vehicles and their relationship to an exposure factor, which is the product of train miles multiplied by vehicle miles. For convenience, the product is divided by 10 to the 18th power. It appears axiomatic that if other conditions remain undisturbed and the number of trains operated over a line is doubled, the accident potential is doubled. Likewise, if highway traffic is increased two-fold, the possibility of accidents is doubled. If these increases in volume of the two conflicting streams of traffic are concurrent, the accident potential is increased four-fold. The close relationship between the exposure factor and casualties becomes evident by a careful examination of the year-by-year variations. The peaks and valleys in the two lines generally occur in the same years, even though the general trend in casualties is downward while there is a general upward trend in the exposure factor.

There are several reasons why the downward trend in grade crossing casualties over the years should go counter to the upward trend in vehicular traffic and the upward trend in the exposure factor. Programs of construction of safety-improvements at grade crossings have had a direct influence. Concurrently, extensive programs of highway construction have improved general travel conditions on the highways, motor vehicles have been made safer and more reliable, more driver education and training have improved the capabilities of motor vehicle operators, and many safety programs have alerted people to the importance of care and caution in the use of motor vehicles and occupancy of the highway environment. All of these have had an effect on improving the total highway safety record.

Chart VI depicts the progress which has been made over the years both in total highway safety and in grade crossing safety. Between the year 1923, which is the first year for which the National Safety Council has been able to develop a meaningful death ratio or rate per 100,000,000 vehicle miles of travel, and the year 1970, this death rate declined 77 percent. A comparable casualty ratio for grade crossings, utilizing both highway traffic volumes and railroad traffic, is obtained by dividing the number of grade crossing casualties involving motor vehicles for any given year by the exposure factor, introduced in Chart V, for the same year. The decline in the grade crossing casualty ratio during the same period, 1923 through 1970, was more than 88 percent. Although the death rate for highway accidents generally and the casualty ratio for grade crossing accidents differ somewhat one from the other, each serves adequately to establish the trend in its own accident group.

TOTAL GRADE CROSSING CASUALTIES RELATED TO THOSE INVOLVING MOTOR VEHICLES

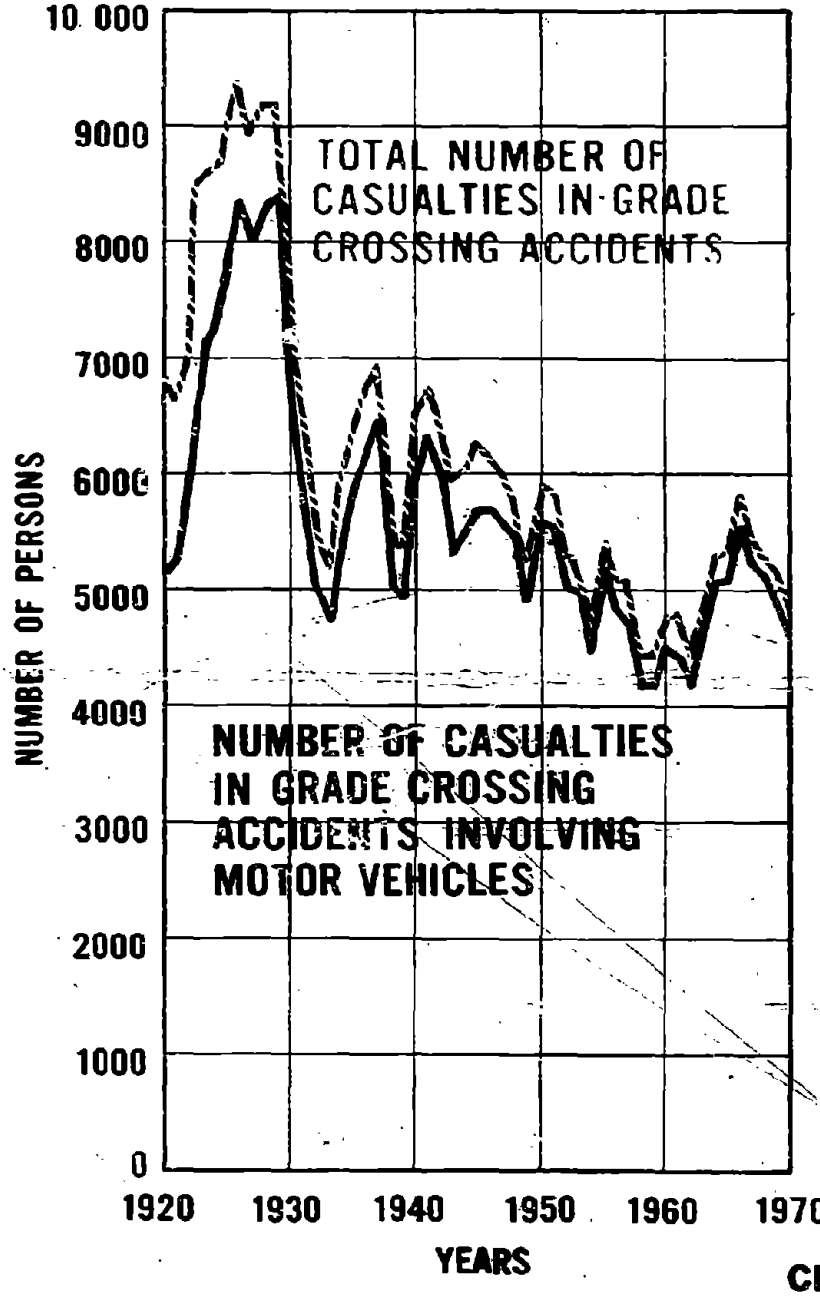

CHART IV

GRADE CROSSING CASUALTIES RELATED TO EXPOSURE FACTOR

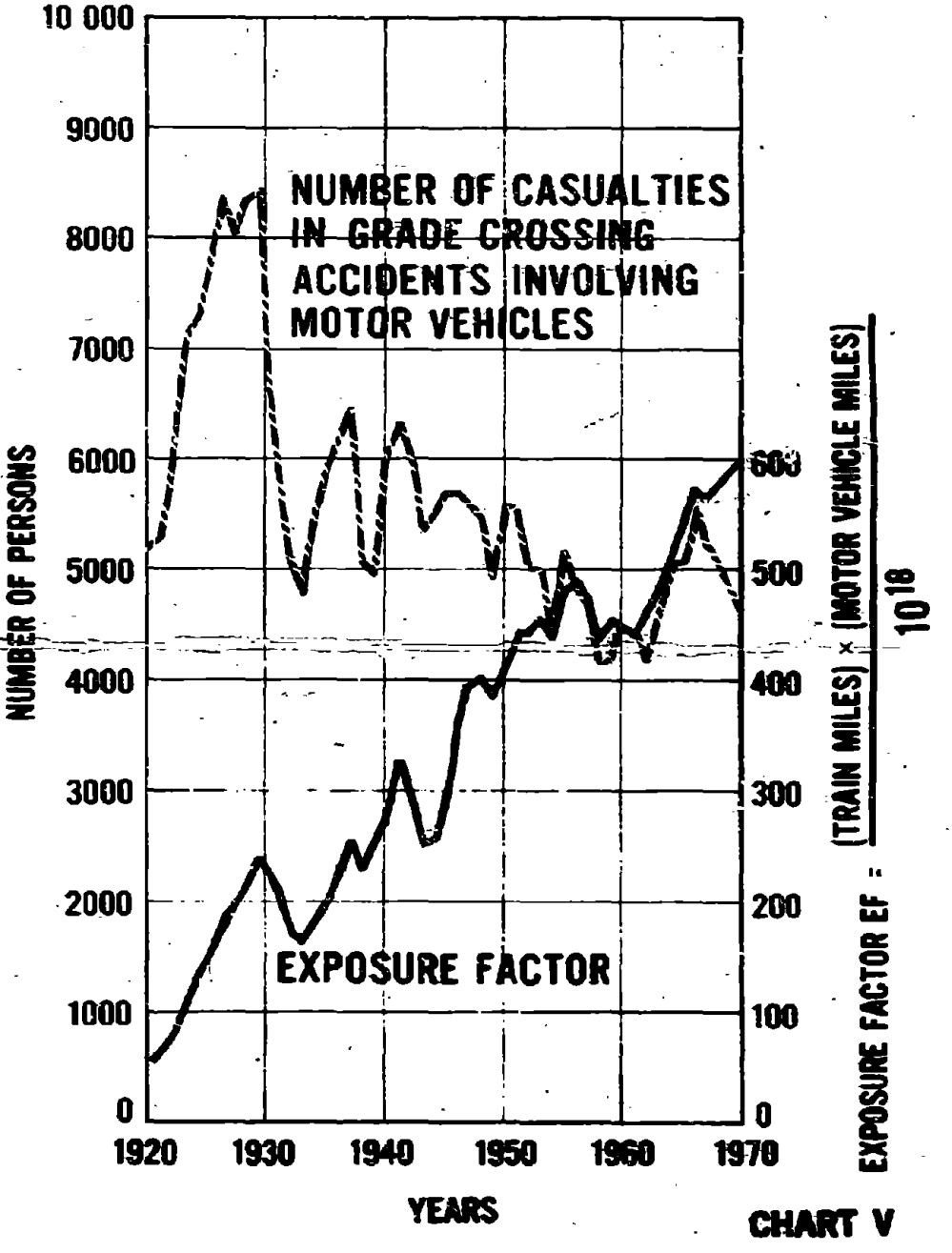

CHART V

COMPARISON OF GRADE CROSSING CASUALTY RATIO WITH GENERAL HIGHWAY ACCIDENT DEATH RATE

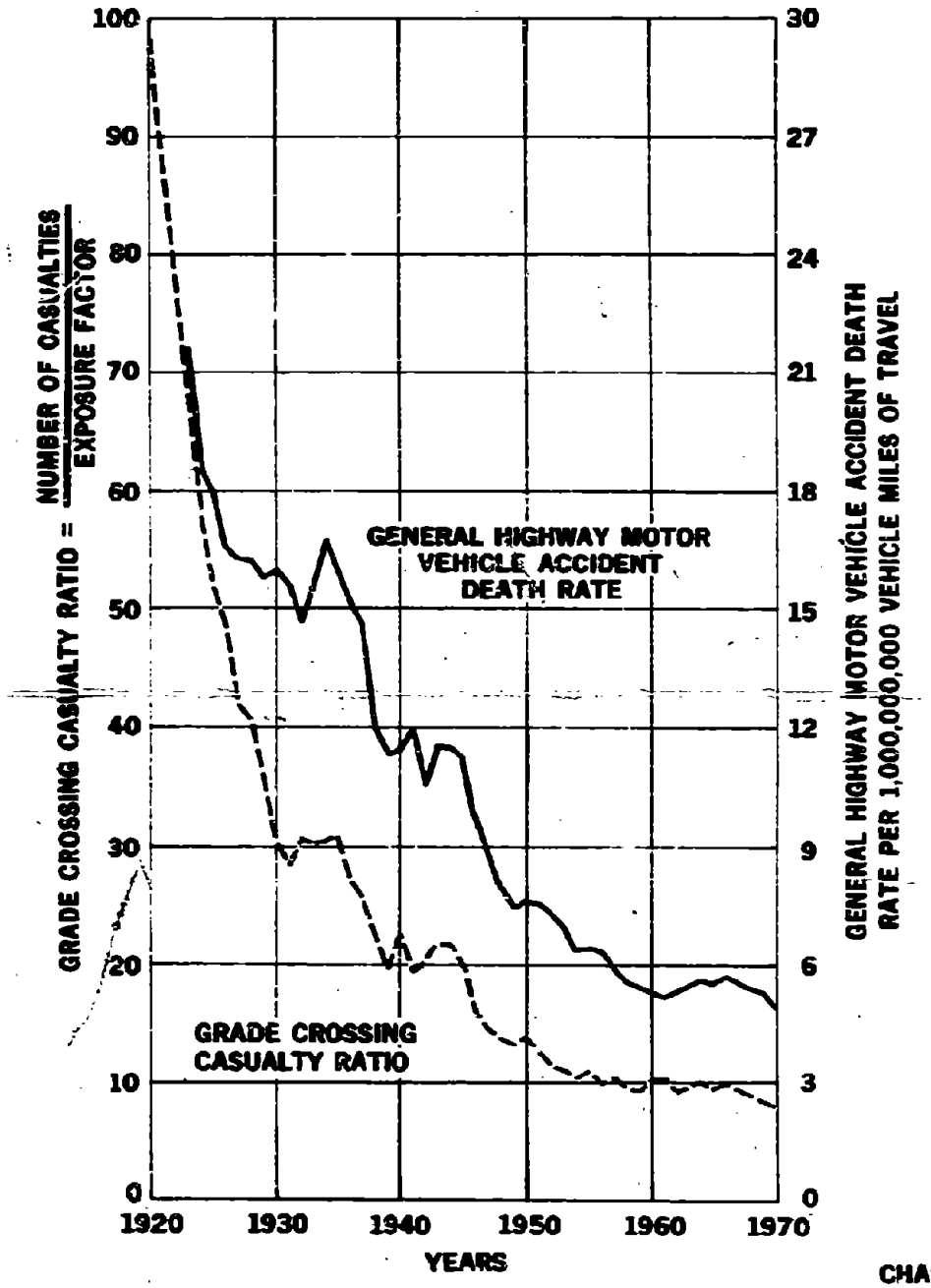

CHART VI

On Chart VII are set forth some of the facts which seem to account for some of the trends and variations in the casualty ratio over the years. There was a precipitous decline in the grade crossing casualty ratio from 1920 to 1930. In this latter year the casualty ratio was 30.4, only 31 percent of the 1920 figure of 98.3. Probably there were several influences that brought about this decline but certainly one of the most important was the extensive program of grade separations and grade crossing protection carried out during this decade when railroad expenditures for improvements were very high.

After 1930 there was a 4-year period when the railroads stopped spending and almost nothing was done in grade crossing improvement work. This period is indicated by circled numeral 1. The improvement in the casualty ratio was stopped cold.

Starting in 1935 some special Federal programs to improve safety at railroad-highway grade crossings were initiated and carried forward to the war period. As indicated on this chart, there was an immediate and significant improvement in the casualty ratio.

Then during the war period of the early 1940's, at the location of circled figure 2, grade crossing improvement work was greatly reduced and the trend of the casualty ratio flattened out.

After the war grade crossing work was again resumed, utilizing very substantial amounts of money from the Federal-aid highway programs. Again there was a reduction in the casualty ratio. Between 1945 and 1958 this reduction was 52 percent.

In the 9 years between 1958 and 1967 the casualty ratio remained almost constant, as shown by the line near circled figure 3. This is true in spite of the fact that grade separation and grade crossing protection programs have continued under the Federal-aid highway acts, utilizing Highway Trust funds together with matching funds from other sources. This flattening out of the casualty ratio curve coincides with the upward trend of grade crossing casualties during those years. Since 1967 there has been some decrease in grade crossing accidents and casualties and a decline in the casualty ratio. However, this trend was reversed during the first 7 months of 1971 when these casualties increased 7 percent over the similar period of 1970.

These statistics and this analysis indicate two things:

1. Over the past 50 years grade crossing protection programs have demonstrated an effectiveness in reducing railroad-highway grade crossing casualties.

2. During the past 15 years the total effort to reduce grade crossing casualties, including the expanded Federal-aid program, has managed to hold the casualty ratio almost constant but has failed to establish a clear trend toward further improvement.

HISTORICAL PHASES OF RAILROAD-HIGHWAY GRADE CROSSING SAFETY PROGRAMS

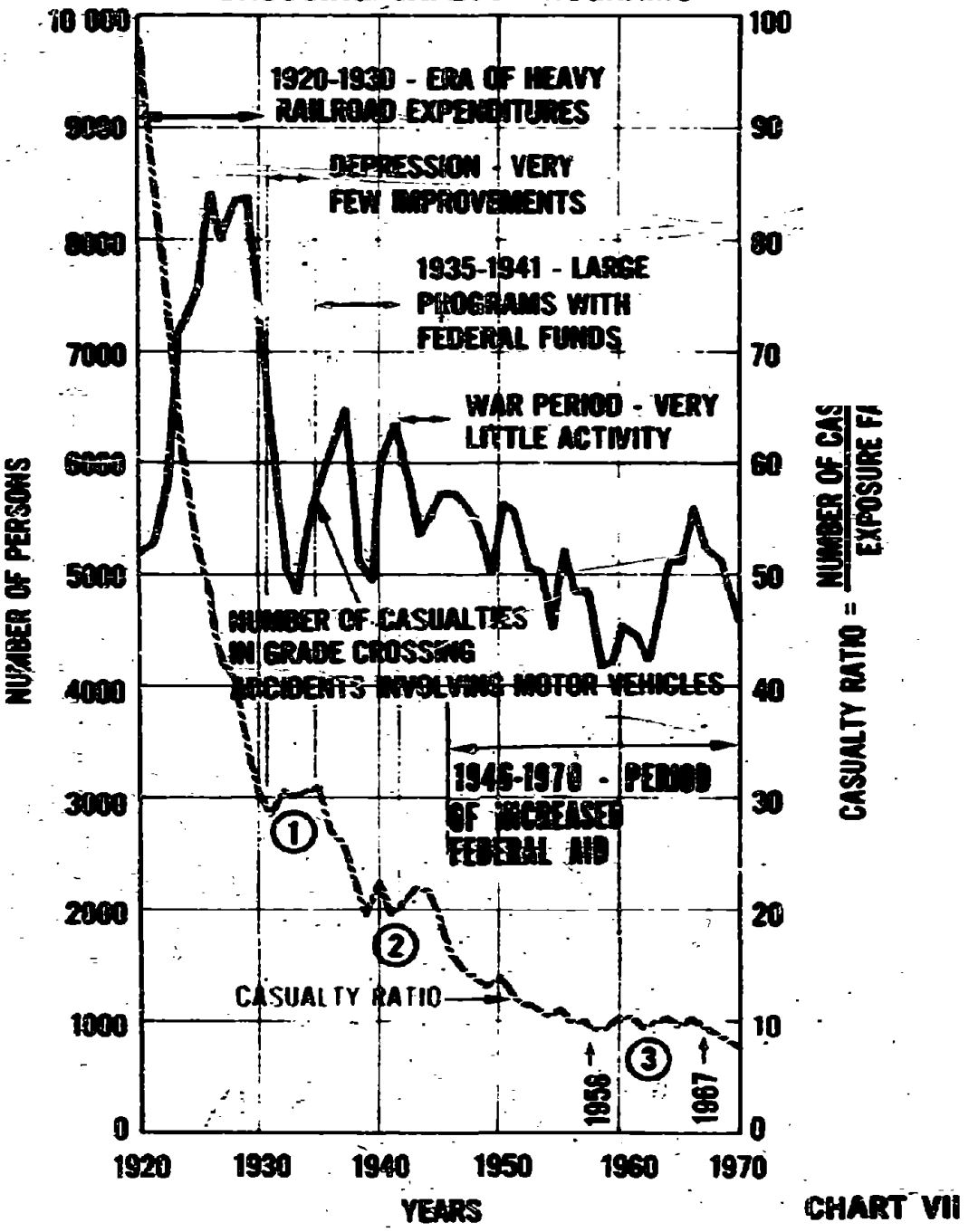

CHART VII

Financial Responsibility

An issue which is as old as the grade crossing safety problem itself is that of financial responsibility. Historically, the division of responsibility for financing the elimination and protection of railroad crossings of public streets and highways has shifted from time to time since the early beginnings of highway and railroad transportation networks. The construction of railroads in the United States began in 1830. For many years citizens from both urban and rural areas were anxious to receive the benefits of railroad transportation and there was no objection to railroads crossing streets and roads at grade level.

Initially, the incidence of accidents was low, but it progressively increased with the growth of population and expansion of railroad and highway networks. In a case involving a grade crossing collision of a train and a wagon, the United States Supreme Court in 1877 said that the duties, rights and obligations of a railroad company and those of a traveler on the highway at public grade crossings were "mutual and reciprocal". It also said that a train had preference and had the right-of-way over grade crossings but that the railroad was bound to give due, reasonable and timely warning of the train's approach. The Court further stated that "those who are crossing a railroad track are bound to exercise ordinary care and diligence to ascertain whether a train is approaching".

The advent of the automobile changed and added to the safety problem. In court cases in the 1920's, which were appealed to the Supreme Court of the United States, the railroads were held liable for the entire expense of construction of grade crossing separations and improvements, as ordered by the various States. The theory was that the railroads had the primary or sole responsibility for the elimination or protection of dangerous grade crossings because of the predominant financial interest of the railroads in transporting commodities and people across the United States.

It wasn't until the case of Nashville, C. & St. L. Ry. v. Walters, 294 U.S. 405 (1935) that the Supreme Court of the United States recognized the significant increase in highway transportation, principally on the new Federal-aid systems. The Court concluded that traffic interruptions incident to crossing railroads at grade level had become of far greater importance to the highway users than to the railroad being crossed. With this shift in emphasis, the Supreme Court concluded there should be a shift of responsibility for safety at grade crossings to the States.

The Federal-Aid Highway Act of 1944 and subsequent acts established a financial responsibility on the part of railroads where grade crossing improvements are financed with Federal-aid funds participating in the costs. Under the acts, a railroad is not held responsible for more than the benefits it receives from the construction or reconstruction of any highway grade separations or the installation of any protective devices at grade crossings. However, the railroad liability in such cases is not to exceed 10 percent of the cost of the improvement.

Federal-aid highway funds are available generally only for highway improvement projects on highways that have been designated as part of the Federal-aid highway system. An exception is made in Federal funding under the Highway Safety Act of 1970, in which two demonstration projects are authorized for the elimination or protection of certain ground-level railroad highway crossings some of which are off the Federal-aid system. On these projects, funds are provided from the Highway Trust Fund to finance improvements for crossings on the Federal-aid system and from the General Fund for crossings off the system. The division of financial responsibility for improvements to crossings on the system is 90 percent Federal and 10 percent railroad. On crossings off the system, this division of responsibility is 80 percent Federal, 10 percent railroad, and 10 percent State.

Starting with California in 1953, several States have established special funds to be used to pay the cost of railroad-highway grade crossing improvements on non-Federal-aid roads and streets. In recent years some States have assumed part of the cost of maintaining grade crossing protective devices, a responsibility originally assigned entirely to the railroads.

The actual performance of the work of installing and maintaining grade crossing protective devices, both active and passive, located adjacent to the crossing is assigned to the railroad organization, regardless of the division of cost, and the work of installing and maintaining the advance warning signs and other devices along the highway approaching the crossing is currently assigned to the public authority having jurisdiction over the highway.

The financial responsibility of the parties - the railroads and the public highway authorities - having an interest in railroad-highway intersections is governed by State laws and regulations, except to the extent that improvement projects utilizing Federal-aid highway funds to pay a part or all of the cost are governed by Federal laws, rules and regulations. In many States the duty of assigning financial responsibility to the parties is lodged with a regulatory commission. The division of cost of non-Federal-aid crossing improvement projects, including the construction or reconstruction of grade separations and the installation of protective devices, varies widely. In some situations highway authorities bear the entire cost, while in other instances the total cost is borne by the railroad. A 50-50 division of cost is sometimes used. In most States the railroads have paid a much smaller portion of the cost in recent years than they paid in earlier years when railroad transportation was the dominant mode. Nevertheless, court decisions make clear that if the States so choose they may assign to the railroad total responsibility for safety - as distinguished from convenience and economy - at railroad-highway intersections. This subject is covered in considerable detail in "A Legal-Historical Review of the Division of Responsibility for the Elimination and Protection of Railroad-Highway Crossings", Appendix A of this report.

Regulatory Jurisdictions

Divided responsibility is a major feature of the railroad-highway intersection problem. In decisions on controversies in this bimodal transportation area the courts have placed on State and local governments much of the highway traveler's responsibility. Through court decisions and State legislative actions those responsibilities have been assigned to numerous financing and regulatory agencies.

As is set forth in this report the costs of constructing and maintaining grade separations and of installing, maintaining, and operating grade crossing protective devices are borne in varying proportions from place to place by railroads, State highway departments, and county and municipal governments, sometimes with assistance from the Federal government. But in many jurisdictions, none of these financially involved parties has any responsibility or authority to determine what improvements should be made, when they should be made, by whom they should be made, or at whose expense they should be made.

The Interstate Commerce Commission

As is pointed out in Appendix A of this report the Interstate Commerce Commission has no jurisdiction over railroad operations at grade crossings or over the protective devices at those crossings. Jurisdiction to establish safety regulations at railroad-highway intersections resides exclusively in the States.

Nevertheless, on February 6, 1961, ICC instituted a proceeding, No. 33440, in which it conducted extensive hearings on the safety problem at railroad-highway grade crossings. In its report served February 10, 1964, the Commission made eight recommendations which, stated briefly, were as follows:

(1) That an organization be created to formulate uniform standards to be referred to State and local officials for use in evaluating the need for grade crossing elimination and improved protection and for restrictions against the use of crossings by certain vehicles.

(2) That Congress give serious consideration to the enactment of legislation to provide public funds for the installation and maintenance of grade crossing protective devices.

(3) That State legislatures give consideration to enactment of laws providing that highways cannot be used in interstate commerce except in compliance with ICC regulations.

(4) That State legislatures consider adoption of rigid driver liscensing laws and regulations for operators of motor vehicles transporting hazardous materials and that such vehicles be routed over grade crossings where hazards are at a minimum.

(5) That State and local authorities carefully investigate and screen applications for employment as school bus drivers.

(6) That railroads take prompt action to improve maintenance of railroad rights-of-way at grade crossings to provide adequate sight distance.

(7) That railroads establish adequate uniform warning time of not less than 20 seconds to operators of motor vehicles of the approach of a train to a grade crossing.

(8) That the organization referred to in Recommendation No. 1 adopt standards by which to classify certain railroad-highway crossings as "exempt" crossings for vehicles normally required to stop at all grade crossings.

State Regulatory Agencies

In exercising their authority over safety at railroad-highway intersections many States have by statute delegated part or all of this authority to State regulatory commissions, variously named: Public Service Commission, Public Utilities Commission, Commerce Commission, Corporation Commission, Railroad Commission, or other similar word combinations. In other States the responsibility and authority to determine the location and type of improvement required at a grade crossing is lodged in the State highway departments for projects located on highways under State jurisdiction, and for projects on other roads and streets lodged in local county or municipal agencies. Without a separate regulatory commission, the regulatory function is performed by the same agency that performs the construction and maintenance function on the highway.

Typically, the State agency performing the regulatory function for railroad-highway crossing safety, after proper notice and public hearing, determines the need for safety improvement, if any, determines the appropriate type of improvement, determines the agency to carry out the work, and allocates the cost of the improvement among the parties, railroad and public agency, involved in the instant proceeding.


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III

THE CURRENT PROBLEM

The current problem may be measured in terms of railroad mileage, highway mileage, amount of train travel, amount of motor vehicle travel, number of grade crossings, and number of accidents occurring at those grade crossings. To further define the problem it is appropriate to show the distribution of these data by highway system (Federal-aid or Non-Federal-aid) and by location (urban and rural) where possible.

Mileage and Travel

Based on 1969 statistics there are approximately 220,000 miles of railroad line with over 500 million train miles of travel on those lines. These statistics also indicate approximately 3.7 million miles of roads and streets carrying over 1 trillion vehicle-miles of travel. Percentage distribution of the highway mileage and travel by highway system and location are shown in Table 2 below. This indicates that while the Federal-aid system includes only approximately 24 percent of the mileage, it includes 66 percent of the travel.

TABLE 2

Percentage Distribution of Mileage and Travel

	Federal-aid			Non-Federal-aid			
	Urban	Rural	Total	Urban	Rural	Total	Total
Mileage (Miles)	1.4	22.4	23.8	13.3	62.9	76.2	100
Travel (Vehicle-miles)	26.5	39.6	66.1	24.5	9.4	33.9	100

Number and Classification of Public Crossings

There are approximately 232,000 public railroad-highway grade crossings in the United States. About 50,000 of these have some type of protection which is activated by the approach of a train. Table 3, which provides a summary of the public grade crossings, shows further

that there are about 47,000 crossings on the Federal-aid highway system and that about 155,000 crossings are located in rural areas. Also, as can be noted from Table 3, the passive protection class includes 13,650 crossings with no signs. In addition to the 232,000 grade crossings, there are approximately 35,000 grade separations. Information used in estimating the number and classification of these crossings comes from several sources.

Inventories

Under established practices of several State highway departments, inventories of public railroad-highway grade crossings are made regularly on a continuing cycle as part of the total road inventory work. Recently, there has been a special effort concentrating solely on grade crossings, in response to Department of Transportation encouragement. Generally, the scope of these regular inventories is limited to crossings of highways under State jurisdiction. Thus, far more information is available on crossings on State highways which are on the Federal-aid highway system.

Railroads, as part of their annual reports to the Interstate Commerce Commission, report the number of public crossings in each State by type of protection as well as the number of overpasses and underpasses. Summaries of this information are available annually for class I railroads only.

Other inventory data are maintained by State regulatory agencies, counties and municipalities.

Inventory Procedures

The total number and associated classifications of railroad-highway grade crossings in this report were developed by expansion and reconciliation of highway and railroad furnished data.

The primary data base for establishing the number of public crossings is a special inventory of grade crossings conducted by State highway departments in 48 States (excluding Alaska and Hawaii). These data classify crossings by type of protection and group them by volume ranges of highway traffic and railroad traffic, utilizing six volume ranges for each. Crossings are also divided between urban and rural locations and are indicated as being either on or off the Federal-aid highway system. These several classifications provide a base for the analysis in this study and report and for the further analysis contemplated in Part II. When this report was drafted, these inventories were available for 43 of the 48 States. Also available were other summary totals of all crossings in each of the 48 States, without the detail of the inventory classifications. The State highway department

TABLE 3

ESTIMATED NUMBER OF PUBLIC RAILROAD-HIGHWAY GRADE CROSSINGS
BY ADMINISTRATIVE SYSTEM AND PROTECTION TYPE

System	Passive Protection				Active Protection				
	None	Crossbuck	Stop Signs	Total Passive	Flashing Lights	Automatic Gates	Other Types 1/	Total Active	Total
Federal-aid									
Urban	650	4,270	490	5,410	5,580	1,650	1,190	8,420	13,830
Rural	220	19,680	960	20,860	9,080	1,700	1,530	12,310	33,170
Subtotal	870	23,950	1,450	26,270	14,660	3,350	2,720	20,730	47,000
Non Federal-aid									
Urban	7,560	33,060	3,170	43,790	12,290	2,910	3,070	18,270	62,060
Rural	5,220	99,040	10,090	114,350	5,750	1,050	1,540	8,340	122,690
Subtotal	12,780	132,100	13,260	158,140	18,040	3,960	4,610	26,610	184,750
Federal-aid and Non Federal-aid									
Urban	8,210	37,330	3,660	49,200	17,870	4,560	4,260	26,690	75,890
Rural	5,440	118,720	11,050	135,210	14,830	2,750	3,070	20,650	155,860
Total	13,650	156,050	14,710	184,410	32,700	7,310	7,330	47,340	231,750

1/ Wigwags, bells, watchmen, manual gates.

inventories were correlated with (1) the latest reports of all Class I railroads to the ICC plus (2) an expansion of sample reports of public grade crossings by Class II railroads to the American Short Line Railroad Association. The highway department inventories provided the basis for all Federal-aid inventory information.

The total of 232,000 public crossings is slightly larger than previously estimated. In addition to the fact that the inventory has been the most extensive made to date, the larger figure may in part be due to some crossings being included which are not considered public crossings by all interested parties. As a case in point, many such crossings were originally opened as private crossings but are now being used and, in some instances, maintained by the public. Also, there is some duplication likely in the reporting of crossings by the railroads where two or more lines use the same or adjoining tracks.

It should be noted that the number of crossings is constantly changing, with new ones being opened and existing crossings eliminated. Thus, as additional data are made available, the number of crossings may require some modification and refinement under Part II of the combined study effort, to be submitted by July 1, 1972.

Tables 4 and 5 illustrate the percentage distribution of these crossings by administrative system, location and protection class. More than 65 percent of the crossings are located in rural areas. Although only about 20 percent of the crossings are on the Federal-aid highway system, about 45 percent of the crossings in the Federal-aid group are protected with some type of train-activated device. However, only slightly more than 15 percent of those crossings located off the Federal-aid system are provided with active protection.

TABLE 4

Percentage Distribution of Estimated 232,000 Public Railroad-Highway Grade Crossings by Administrative, System, Location, and Protection Class

Protection Class	Federal-aid			Non-Federal-aid			Total
	Urban	Rural	Total	Urban	Rural	Total	
Passive	2.3	9.0	11.3	18.9	49.4	68.3	79.6
Active	3.6	5.3	8.9	7.9	3.6	11.5	20.4
Total	5.9	14.3	20.2	26.8	53.0	79.8	100.0

TABLE 5

Percentage of Crossings with Passive and Active Protection

System	Passive Protection	Active Protection
Federal-aid		
Urban	39.1	60.9
Rural	62.9	37.1
Combined	55.9	44.1
Non-Federal-aid		
Urban	70.6	29.4
Rural	93.2	6.8
Combined	84.6	15.4
Federal-aid and Non-Federal-aid		
Urban	64.8	35.2
Rural	86.8	13.2
Combined	79.6	20.4

Private Crossings

There are an estimated 140,000 private crossings of railroads, based upon data supplied by the railroad companies as a voluntary effort under the sponsorship of the Association of American Railroads, the American Short Line Railroad Association, and the Federal Railroad Administration.

The railroad reports represent a little over 20 percent of the railroad mileage. The frequency of private crossings per mile of railroad operated varies greatly from company to company and from State to State.

The railroad companies also reported the type of protective devices in place at private crossings, although this reporting was not on a uniform basis. Nevertheless, it is possible to estimate roughly the percentages with active devices, passive devices, and no protection. The 140,000 crossings on both classes of railroad can be divided somewhat as follows: 1,000 with active devices, 129,000 with signs of various types, and 10,000 with no devices.

Number and Severity of Accidents

There are two general categories of accidents which occur at grade crossings: train-involved and non-train-involved. Train-involved accidents are those in which a train is struck by, or strikes a highway vehicle. The non-train-involved category includes those motor vehicle accidents which occur in the vicinity of and are directly related to the existence of a crossing, but do not involve impact with or by a train.

Train-involved accidents at public grade crossings total approximately 12,000 per year and result in about 1,500 fatalities and 7,000 injuries. The estimated 28,000 non-train-involved accidents at public grade crossings can be expected to result in an additional 280 fatalities.

Train-Involved Accidents at Public Grade Crossings

Until recently, the only nationwide data bank for railroad-highway grade crossing accidents was maintained by the Bureau of Railroad Safety (BRS) of FRA. A discussion of the constraints imposed on that accident data collection, along with the resulting limitations in data, has been previously indicated in the History and Trends section of this report.

The National Highway Traffic Safety Administration (NHTSA) now serves as a data bank for all traffic accident data reported to State agencies, including railroad-highway grade crossing accident data. Criteria for reportable accidents to BRS and NHTSA are quite different. The NHTSA data are obtained from driver and police reports to the State governments. Generally there is a criterion of an injury to one or more persons or a minimum property damage criterion which is based upon damage to one or both vehicles. The result is that more property damage and injury accidents are included in NHTSA statistics than in BRS statistics.

The NHTSA report requirements, compared with those of BRS, result in recording larger numbers of accidents, but the data are far less uniform from State to State. However, the NHTSA data permit more complete estimates of the number of accidents and casualties which occur at crossings.

NHTSA statistics on train-involved accidents in 13 selected States within which occur about one-third of the national total of train-involved accidents were made available for use in this report. The average ratio of NHTSA reported accidents to BRS reported accidents in these States was applied to the BRS totals for each of the other States. This yielded an estimated national total of about 12,000 train-involved accidents per year.

Using formulae for predicting accidents as developed and reported in NCHRP 50 1/, and modified in "A Program Definition Study for Rail-Highway Grade Crossing Improvement," 2/ train-involved accidents were distributed to groups of crossings. This distribution in percentages is as follows:

Urban			Rural			
Federal-aid	Non-Federal-aid	Total	Federal-aid	Non-Federal-aid	Total	Total
17.2	41.7	58.9	12.1	29.0	41.1	100

Non-Train-Involved Accidents at Public Crossings

Those accidents which are related to the crossing but do not involve a train are rather difficult to identify. They may be rear-end collisions triggered by a venicle stopping at the crossing, vehicles hitting a fixed object such as the protective devices or vehicles losing control in traversing the crossing surface and consequently running off the road. Accident reports often cannot be correlated with the crossing and sometimes are not sufficiently descriptive to identify the grade crossing roadway element as leading to the accident.

There are no national statistics compiled to identify the number and severity of these types of accidents. Using formulae in NCHRP 50, which are based on very limited data, a national total of 28,000 such accidents has been estimated.

Private Grade Crossing Accidents

Although railroads are required to report accidents at private railroad-highway grade crossings, these accidents are not included in the BRS railroad-highway grade crossing accident totals but are listed under another category.

1/ National Cooperative Research Program Report 50, Factors Influencing Safety at Highway-Rail Grade Crossings, by Alan M. Voorhees and Associates (1968).

2/ Prepared by Alan M. Voorhees and Associates for the Federal Railroad Administration (October 1969).

A summary of the information obtained from the Bureau of Railroad Safety files of private rail-highway grade crossing accidents during 1969 is shown below. The 146 accidents and resulting 49 deaths and 137 injuries at private grade crossings amount to less than 4 percent of the corresponding number of accidents and casualties reported in the BRS public grade crossing accident data.

Number of Accidents	Severity		Type of Vehicle		
	Injured	Killed	Automobile	Truck	Other
146	137	49	76	61	9

These accident statistics include only those reported to BRS. If the public crossing ratio of NHTSA reported accidents is applied to BRS reported accidents, the total number of private crossing train-involved accidents would be an estimated 425 to 450 per year.

Economic Analysis

The Benefit-Cost Approach

The use of benefit-cost analysis as an aid to public agencies in formulating decisions on public investments is well established. In order to provide the Congress with an order of the economic magnitude of the railroad-highway grade crossing problem, a benefit-cost analysis has been employed in this study. Essentially it provides a framework for the construction of a ranking system or economic priority index for railroad-highway grade crossing improvements. It should be emphasized that the objective of this initial analysis is to establish the magnitude of the problem and is not a program recommendation.

Methodology

Economic theory is concerned with the efficient allocation of scarce resources so as to insure the greatest social welfare. This concept requires that the expenditure decisions of all economic units be evaluated at the margin. In other words, the marginal (incremental) benefits must equal the marginal (incremental) costs of the transaction or investment. This will insure the greatest net benefit.

Ideally, therefore, the investment and expenditure decisions of public agencies should also be made at the margin with each alternative forced to compete for funds on the basis of its respective costs and benefits. (An example relating to grade crossing improvements would

be the changing of crossbuck protection to flashing lights.) Of course, this is often not the case in the "real world" where social criteria, as well as economic criteria, must be given appropriate consideration.

Assuming all benefits and costs are properly identified and measured, the use of marginal benefit-cost analysis will determine the funds required to maximize the benefits from some specific program such as reducing highway vehicle-train collisions and their resulting accident costs.

Procedure

Using accident prediction equations, known annual train-involved accidents and estimated non-train-involved accidents were allocated to the inventory of public grade crossings included elsewhere in this report. From this, total accident costs were computed for all crossings grouped according to train and vehicle volume, type of protective device, urban vs. rural location, and Federal-aid vs. non-Federal-aid highway systems. The next step was to identify the initial and recurring costs associated with each of the alternative improvements applicable to each group of crossings. Using the accident reduction effectiveness rating for each protective device included in the alternative improvement decisions, it was then possible to relate incremental cost of improvement with incremental cost reduction resulting from that improvement alternative. In other words, each type of improvement of crossing protection results in an additional increment of cost and also yields benefits due to reduced accident cost. For certain groups of railroad-highway grade crossings, the incremental benefits resulting from the alternative improvement exceed the incremental cost of the improvement.

Accepting this "economic" measure as justification for crossing protection improvement, any such case constitutes a "warrant" for grade crossing protection improvement. If more than one form of improvement for a particular class of crossings is warranted, the selection criterion then becomes that of maximum net benefit. Given no investment constraint, it should be pointed out that a net benefit analysis will produce the same results as the incremental benefit-cost analysis.

The Economic Data Base

Accident Costs. Accident costs used in this analysis were derived for both train-involved grade crossing accidents and non-train-involved highway vehicle accidents occurring at or near the grade crossing. The comprehensive accident cost factors for each of these two types of accidents include cost of loss of life, injuries and property damage. The cost of train-involved accidents used in this

analysis range from slightly less than $12,000 per accident in urban areas to approximately $25,000 per accident in rural areas. Non-train-involved accidents are less severe, with an approximate cost of $1,750 per accident.

Improvement Costs. In this analysis, improvement costs of different forms of protective devices include both initial and recurring costs. The initial cost of installation of protective devices ranges from approximately $15,000 for installation of flashing lights at a single track location to approximately $25,000 for installation of automatic gates at a multiple track location. No provision was made for the cost of the more sophisticated devices that measure the speed of the approaching train. The annual maintenance cost of the devices ranges from approximately $750 to $1,250 per annum. Installation and maintenance costs of static signs, such as crossbucks and stop signs, are included in the analysis.

Grade separations were included in the improvement alternatives. Those costs range from more than one quarter million dollars at low-volume highways in rural areas, to almost a million dollars at high-volume highways in urban areas.

Discounting. The discounting technique was used in the analysis for converting values accruing at future points in time to present value equivalents. The process is accomplished by multiplying the values by factors representing a discount rate of 10 percent, compounded annually, using an analysis period of 50 years. The values discounted in the analysis include train and highway vehicle accident costs, operating and delay costs, future replacement costs of improvements where the service life is less than the total period discounted, and maintenance costs over the period discounted. The discount rate for accident, delay and operating costs was adjusted to compensate for the expected growth in highway traffic.

Warranted Improvements

There are three basic types of improvements which are made at railroad-highway intersections--installation of automatic grade crossing protective devices, construction of new grade separations, and reconstruction of existing grade separations.

The nature of grade crossing protection programs and grade separation construction programs differs in terms of initial costs and recurring costs and in terms of the types of benefits which result.

Automatic grade crossing protective devices, in the form of either flashing lights or automatic gates, are installed primarily to improve safety by reducing the potential for vehicle-train collisions. The primary justification for the construction of new grade separation

structures on an individual crossing basis is generally to improve the flow of traffic although significant safety benefit also results since grade separations completely eliminate the potential for vehicle-train collisions. Existing grade separations become deficient and are reconstructed to maintain the integrity of the highway as traffic volumes increase and design and construction standards are modified.

Completion of the benefit-cost analysis results in an estimated number of railroad-highway grade crossings that would be "warranted" for improvement. Of the grade crossings warranting improvement, about 95 percent would justify some form of protective device improvement. The other 5 percent would justify elimination by grade separation. The protective device improvement and grade separation improvement decision alternatives were calculated concurrently. However, due to differences in costs involved, types of benefits and data employed, the results of the analysis for crossing protection and grade separation are discussed separately.

Protective Device Improvement. Table 6 provides the results of the economic analysis for protective device improvements only. It may be seen from this table that, given the assumptions, data, and procedures used in the analysis, an investment of some $445 million in railroad-highway protective devices could result in an accident cost reduction, over the discounted period, of more than $1 billion. Deducting improvement cost from the reduction in accident cost, the improvements could result in a net benefit to society over the discount period of some $775 million.

Assuming that individual crossings would be identified for improvement, the warranted improvement cost would translate into approximately 15,000 crossing improvements, which, in turn, should result in a reduction in current annual accident cost of approximately 50 percent.

By distributing the data resulting from the economic analysis according to the location and type of highway systems involved in the warranted improvements the relative effectiveness of investment decisions between those classes may be observed. For example, some 45 percent of the total cost of warranted improvements is assigned to urban areas. From the analysis it is estimated that approximately 65 percent of net benefits from all improvements would be assigned to urban areas. On the other hand, rural areas would account for more than 55 percent of the improvement cost but would return less than 40 percent of the net benefits from all improvements. A similar observation may be made using the Federal-aid and non-Federal-aid data.

Grade Separations. Costs and benefits associated with crossings at which a grade separation is the "warranted" improvement alternative are not reported. Reconstruction of existing grade separation structures was not included in the economic analysis.

In existing programs it appears that slightly less than one-fourth of the total number of improvements involve the construction of new grade separations. This relationship would indicate that as many as 3,500 grade separations could be constructed along with the 15,000 grade crossing protection improvements if this same mix were to continue.

On an individual crossing basis it appears that 500 to 1,000 crossings would economically warrant grade separation, primarily on the basis of reduced motor vehicle operating and delay costs.

A great many of the existing grade separations have been constructed as part of a systems-type improvement. The most common example of this has been the grade separation of all crossings on the Interstate highway system. Most grade separations will likely continue to be constructed as part of a systems approach. In addition to highway system improvements, these include high-speed rail lines and urban rail system improvements.

Summary. The procedure used in this analysis is quite flexible in application. Essentially it provides a framework for the construction of a ranking system, or economic priority index, for railroad-highway grade crossing protection improvements according to their relative effectiveness as investment alternatives. Given this framework and the rationale implicit within it, those charged with implementation of future programs may make those changes which "best" suit their purposes. The components of the accident cost calculation may be changed to reflect differing weights that might be placed upon society's cost of life or loss of earnings due to injury or disability. Similarly, the cost of protection can be revised to allow for more sophisticated devices or new low-cost devices that may be available from current technological studies. For example, an estimated 16,000 more crossings could warrant improvement to automatic devices if installation and recurring costs were reduced to the $10,000 range. Consideration may also be given to the effectiveness of current devices, vehicle delay associated with excessive activation of devices, and other components of the procedures that warrant further refinement.

It should again be emphasized that the procedure described has not dealt with all of the factors involved in the evaluation of grade crossing improvement. Safety considerations alone will often be the controlling factor at a hazardous crossing regardless of economic payoff. Thus, no attempt should be made to relate these data to any potential program recommendation at this stage. That point will be fully addressed, with alternatives, in Part II.

TABLE 6

RESULTS OF ECONOMIC ANALYSIS

Estimated: Total Cost of Warranted Improvements;
Total Accident Reduction Cost from Warranted Improvements;
and Net Benefits from Warranted Improvements

Costs and Benefits 1/		Percentage Distribution by Location and Administrative Highway System						
		Urban			Rural			
		Federal-Aid	Non-Federal-Aid	Total	Federal-Aid	Non-Federal-Aid	Total	Total
Total Cost of Improvements 2/	$445	10.9	33.4	44.3	18.0	37.7	55.7	100
Total Accident Reduction Cost	1,220	17.3	39.7	57.0	15.9	27.1	43.0	100
Net Benefits from Improvements 3/	775	20.9	43.4	64.3	14.7	21.0	35.7	100

1/ Costs and benefits shown are the present value of costs and benefits accumulated over the 50-year analysis period in millions of dollars.
2/ Improvements include only flashing lights and automatic gates.
3/ Net benefits are total accident reduction cost less total cost of improvements.

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IV

IMPROVEMENT PROGRAMS - PAST AND PRESENT

Records of Past and Present Programs

Federal Assistance for the Elimination of Hazards at Railroad-Highway Intersections

From the onset of the Federal-aid highway program in 1916 some of the appropriated Federal funds have been used for projects to eliminate hazards at railroad-highway intersections. In the early years of these programs and likewise in recent years these Federal-aid funds have been expended only on crossings located on the Federal-aid highway system. During the depression period of the 1930's, however, some special appropriations of funds were made available for grade separation and grade crossing protection improvements on any appropriate crossing either on or off the Federal-aid highway system.

A 37-year summary of the expenditures and accomplishments for railroad-highway intersection improvement under the Federal-aid highway program is set forth in Table 7. During the 37-year period - 1934 to 1970, inclusive - 10,603 existing and potential grade crossings were eliminated, 1,572 grade separation bridges were reconstructed, and 12,873 grade crossings were provided with improved protection; a total of 25,048 railroad-highway intersections improved with Federal-aid highway funds together with some matching funds from the States and railroads.

Starting with fiscal year 1959, Federal-aid highway fund expenditures for railroad-highway grade crossing elimination and protection projects, together with reconstruction of existing grade separations, have been stepped up to a higher level, averaging $150 million annually during the 12-year period through 1970. Coupled with $30 million annually of matching railroad and State and local government funds, an average of $180 million per year has been expended under this program during the past 12 years to eliminate a total of 4,439 existing and potential grade crossings, reconstruct 498 grade separations and provide improved protection for 3,724 grade crossings.

State, Local and Railroad Financed Railroad-Highway Intersection Improvement Projects

In addition to the Federal-aid projects summarized in Table 7, there are many projects carried out each year with the cost borne entirely by the railroads and State and local governments. Financing by State and local governments is usually accomplished through their general highway funds or other general funds. However, as stated before, along with the gradual shifting of financial responsibility for railroad-highway intersection improvement work from the railroads to the public, several States have established special categories of funds to be used specifically to

TABLE 7

Annual Summaries of Expenditures and Accomplishments of
Federal-Aid Projects for Elimination of Hazards
at Railroad-Highway Intersections
Fiscal Years 1934 to 1970, Inclusive

Fiscal Year	Expenditures		Accomplishments		
	Total Cost	Federal Funds	Number of* Crossings Eliminated	Number of Structures Rebuilt	Number of Crossings Protected
1934	$2,270,977	$1,925,543	67		3
1935	14,226,129	13,348,202	340		34
1936	16,484,465	15,582,126	322	19	188
1937	82,026,570	79,034,814	1,099	187	332
1938	82,225,204	78,884,940	736	138	955
1939	40,568,092	38,270,764	389	81	445
1940	41,841,068	39,154,137	418	86	1,187
1941	32,431,809	30,153,092	311	66	930
1942	28,939,973	27,176,601	229	78	581
1943	26,859,729	25,008,302	181	31	189
1944	15,848,355	13,961,455	104	9	95
1945	3,567,015	3,101,158	20	4	55
1946	4,890,663	4,205,369	29	3	65
1947	7,057,847	6,165,446	36	19	132
1948	17,441,553	13,908,240	78	27	359
1949	46,276,104	35,194,953	149	34	466
1950	61,829,533	46,580,075	153	48	414
1951	47,161,425	33,928,685	125	48	357
1952	54,165,284	37,515,641	133	32	341
1953	47,896,532	32,992,112	125	22	356
1954	68,548,156	47,791,528	193	21	311
1955	93,711,237	61,968,500	216	38	317
1956	57,208,816	41,963,054	209	27	305
1957	90,104,159	57,614,513	230	27	349
1958	71,135,105	66,760,254	272	29	383
1959	173,422,082	129,514,926	391	36	402
1960	226,014,140	186,809,888	421	23	366
1961	146,275,352	121,825,466	361	18	389
1962	192,872,256	161,830,011	430	44	378
1963	161,415,884	130,594,002	382	80	324
1964	187,769,479	159,087,443	415	60	284
1965	215,096,245	185,848,377	421	35	317
1966	195,640,396	165,384,476	377	45	286
1967	162,370,184	140,298,099	398	48	294
1968	175,690,265	149,157,015	319	27	276
1969	178,826,058	148,059,294	282	39	221
1970	143,249,929	120,952,022	242	43	187
Total	$3,213,798,070	$2,651,450,533	10,603	1,572	12,873

*Includes crossings constructed initially as grade separations, as is done on freeway projects on new locations. These potential grade crossings are "eliminated" in the initial planning and construction.

share in the cost of such improvement projects. Money from these special State funds is generally used on selected projects not located on the Federal-aid highway system, inasmuch as Federal funds are not available for participation in the cost of improvements at railroad-highway intersections off the Federal-aid highway system. From the special State funds, originated in California and now established in 12 States, grade crossing improvement expenditures are being made in amounts aggregating more than $10 million per year.

Improvement and Maintenance Costs

Complete statistics are not available on the total number of crossings improved without Federal financial assistance or on the cost of these improvements. However, utilizing the information which is available, Tables 8 and 9 summarize the accomplishments during recent years from both Federal-aid and non-Federal-aid projects.

Table 8 also shows the estimated total costs and the estimated costs incurred by the railroads and by State and local governments for grade separations and new automatic protection installations completed during the 4-year period, 1967-1970. Table 9 supplements this information by showing the additional number of crossings at which upgrading of existing protection was completed during calendar years 1968-1970, together with the railroad costs incurred for such work.

TABLE 8
Grade Crossing Improvement Projects
State, Local, and Railroad Expenditures
Summary for Calendar Years 1967-1970, Inclusive

Type of Project	Number of Crossings		Estimated Expenditures		
	Federal-Aid Projects	Non-Federal-Aid Projects	Total Cost	Estimated Railroad Funds	Estimated State and Local Funds
Grade Separations*					
4-Year Total	1,305	400	$889,600,000	$15,400,000	$329,200,000
Annual Average	326	100	222,400,000	3,850,000	82,300,000
Automatic Protection**					
4-Year Total	852	2,600	50,800,000	12,160,000	27,120,000
Annual Average	213	650	12,700,000	3,040,000	6,780,000

*Includes construction of grade separations at new and existing crossings, reconstruction of existing grade separations, and railroad relocations.

**At locations where no protection other than fixed signs previously existed. About two-thirds are automatic flashing light signals and one-third are automatic gates supplemented with flashing lights, with a very few other devices.

TABLE 9

Grade Crossing Improvement Projects Involving
Upgrading of Existing Manual Protection or Automatic Devices
Railroad Expenditures Only
Summary for Calendar Years 1968-1970, Inclusive

Type of Improvement	Number of Crossings		Estimated Expenditures		
	Federal-aid Projects	Non-Federal-aid Projects	Total cost	Railroad Funds	State and Local Funds
Watchmen to flashing lights	3	18	*	$245,000	*
Watchmen to automatic gates	5	52	*	978,000	*
Flashing lights to automatic gates	100	640	*	6,319,000	*
3-year total	108	710	*	$7,542,000	*
Annual average	36	237	*	$2,514,000	*

*Not available.

In addition to the expenditures for grade separations and other grade crossing improvement work, the railroads have continuing obligations for maintenance and operation of grade crossing protection facilities. Table 10 includes a 3-year summary and annual average of the estimated expenditures for maintaining automatic grade crossing protective devices. Of this $36 million total annual expenditure, slightly more than 3 percent is reimbursed by State and local contributions, leaving $35 million net railroad cost.

As shown in Table 11, the railroads have two other categories of substantial expenditures for grade crossing protection: (1) The railroad cost for providing crossing watchman service at 615 crossings is $8.5 million annually, and (2) during the 3 years 1968-1970 an annual average of approximately $0.5 million was spent to provide reflectorized crossbuck signs at an average 8,300 crossings. Reflectorization of crossing signs has been an ongoing program for several years.

During these recent years, the total of these average estimated costs to the railroads for grade crossing improvements, maintenance and operation was $53.5 million annually.

TABLE 10

Estimated Total Railroad Expenditures and State and Local Reimbursement for Maintaining Automatic Grade Crossing Protection
Summary for Calendar Years 1968-1970, Inclusive

	Total Expenditures	State and Local Reimbursement	Railroad Cost
3-Year Total	$108,612,000	$3,456,000	$105,156,000
Annual Average	36,204,000	1,152,000	35,052,000

TABLE 11

Estimated Railroad Costs for Maintaining and Operating Grade Crossing Protection
Summary for Calendar Years 1968-1970, Inclusive

	Maintenance of Automatic Protective Devices		Providing Watchmen at Crossings		Installing Reflectorized Crossing Signs	
	Number of Cross-ings	Railroad Cost	Number of Cross-ings	Railroad Cost	Number of Cross-ings	Railroad Cost
3-Year Total		$105,156,000		$25,704,000	24,900	$1,455,000
Annual Average	45,800	35,052,000	615	8,568,000	8,300	485,000

Changes in Number of Crossings

In Table 12 are listed the major categories of changes made in railroad-highway intersections on Class I railroads during calendar year 1969. During the year there was a net decrease of 1,931 in the number of grade crossings on Class I railroads because of the large number eliminated by railroad abandonments. The number of grade separations increased by a net of 157.

TABLE 12

Changes in Number of Railroad-Highway Intersections on Class I Railroads Calendar Year 1969

	Number of	
	Grade Crossings	Grade Separations
Number at Beginning of Year	213,671	33,689
Additions		
By new or relocated highway	613	197
By new or relocated railroad	479	21
By elimination of grade crossing	-	43
Total Additions	1,092	261
Eliminations		
By closing or relocation of highway	350	23
By relocation or abandonment of railroad	2,630	81
By construction of grade separation	43	-
Total Eliminations	3,023	104
Number at Close of Year	211,740 1/	33,846 1/

Source: Transport Statistics in the United States, Interstate Commerce Commission

1/ These are not comparable to the nationwide totals shown elsewhere in this report since they are not based on State highway department inventories and do not include Class II railroads.

Department of Transportation Activities

Establishment of the U.S. Department of Transportation brought into close association the two Federal agencies having primary interest and responsibility for the bimodal railroad-highway grade crossing problem. Joining forces were the already established Bureau of Public Roads (now Federal Highway Administration) and the new Federal Railroad Administration.

Directive of the Secretary

On August 4, 1967, the Secretary of the newly organized Department directed the Federal Highway Administrator and the Federal Railroad Administrator to jointly initiate and pursue an expanded program of action to reduce hazards at grade crossings, stating:

> "The railway-highway grade crossing problem is a railroad, highway, and public problem which requires an intensive attack on all factors which contribute to such accidents. An immediate program should be started."

The directive outlined an immediate action program for improved guidelines and teamwork in diagnosing grade crossing hazards; for a significant test and demonstration program of installation of grade crossing protective devices; for rehabilitation of existing devices; for more intensive accident investigative procedures; for the identification of crossings with a high incidence of use by school buses, by vehicles carrying hazardous materials, and by high-speed trains; and for a research and development program designed to bring forth more effective measures and devices to reduce accidents at grade crossings.

The Secretary also directed that attention be given to longer range considerations of the relationship of grade crossing safety to other highway safety problems and to the possible need for an expanded program of grade crossing safety requiring new legislation and additional funding.

Joint Action Group

To implement the Secretary's directive, a Joint Action Group on Grade Crossing Safety was organized by FHWA and FRA. Membership of this group has included representatives of various offices of the two administrations plus the National Highway Traffic Safety Administration, with advisory representation from the Office of the Secretary and an observer from the National Transportation Safety Board.

Acting through committees and scheduled monthly meetings, this group established and maintained liaison, encouraged and promoted attention to grade crossing safety matters, and coordinated and provided guidance to many Departmental undertakings in the field of grade crossing safety. Several meetings have included guest representation from selected State highway departments, State regulatory commissions and the Association of American Railroads.

Instructional Memorandum Issued to the States. Under date of January 5, 1968, the Director of Public Roads and the Federal Highway Administrator jointly issued Instructional Memorandum 21-1-68 requesting: (1) An updating of inventory information on railroad-highway grade crossings; (2) the formation of diagnostic teams comprised of representatives of appropriate State agencies, railroad companies, the Bureau of Public Roads (now FHWA), and other agencies interested in specific situations; and (3) conduct of a test and demonstration program in each State for the installation of the most suitable known system of protection at selected grade crossings to the extent of one crossing for each 4,000 miles of the Federal-aid highway system. The memorandum contained guidelines for use by the diagnostic teams and for the selection of locations and conduct of the test and demonstration program.

Identification System. From experience gained in the conduct of various inventories, it has become evident that an identification code that would uniquely identify each intersection would be of great assistance. A small number of States, either through a highway identification system or in cooperation with railroad companies, have recently instituted railroad-highway intersection identification systems. In general these systems provide the ability to: (1) Distinguish between public and private crossings, (2) uniquely identify each intersection for the exchange of information with regard to construction, improvement, and maintenance, and (3) provide for the specific identification of railroad-highway accidents with the actual physical features of the intersection.

A proposal was developed for establishing an eight (or nine) digit identification numbering system on a national basis to uniquely identify each railroad-highway intersection. These digits would be allocated to State, county (or separate urban areas) and a number assigned to each intersection. The appropriate numbered designation would be placed at a conspicuous point at the intersection by paint and stencil or attached plate.

The action group held several discussions on this subject and submitted the proposal to the Association of American Railroads and the American Association of State Highway Officials for consideration. A continuing joint effort is expected to devise a satisfactory system for general use.

Special Use Crossings. Efforts have been extended to identify for special treatment grade crossings heavily used by commercial vehicles transporting hazardous materials and by school buses was aided by cooperation from the Council of Safety Supervisors of National Tank Truck Carriers, Inc., American Petroleum Institute, the then National Highway Safety Bureau's Advisory Committee on School Bus Operations Safety, and the National Commission on Safety Education of the National Education Association.

Legal-Historical Review. A legal-historical review was prepared by the FRA staff in association with the Action Group. This document, completed in February 1969, furnished the basis for "A Legal-Historical Review of the Division of Responsibility for the Elimination and Protection of Railroad-Highway Grade Crossings," in Appendix A of this report.

Congressional Questionnaire. In August 1969 an extensive report on Federal Programs for Grade Crossing Safety was forwarded to the House Public Works Committee's Special Subcommittee on the Federal-Aid Highway Program. This report was prepared by the Action Group in response to some 400 questions posed by the staff of the subcommittee on all facets of the railroad-highway grade crossing problem, including associated ongoing programs.

National Conferences

Through participation and encouragement by FHWA and FRA and some sponsorship by the Department of Transportation jointly with other interested organizations, three national conferences have been conducted on railroad-highway grade crossing safety.

A Grade Crossing Safety Symposium was held on December 12-14, 1967, at Texas A&M University, College Station, Texas, jointly sponsored with the Texas Transportation Institute, with an attendance of 160 people representing the major interests in grade crossing problems: Railroad companies; State, county and municipal highway agencies; State regulatory commissions; railroad associations; manufacturing and research organizations; trucking organizations; railroad labor organizations; safety organizations, trade publications; educators; DOT, FHWA, FRA, and NTSB.

A National Conference on Rail-Highway Grade Crossing Safety was held on February 11-13, 1969, at the University of Illinois, Urbana, Illinois, jointly sponsored by the Department of Transportation and the Highway Research Board of the National Research Council, in cooperation with the University. Approximately 300 people were in attendance, again representing the key interests in the grade crossing problem.

The 1970 National Conference on Railroad-Highway Grade Crossing Safety was held on August 25-27, 1970, at the Georgia Institute of Technology, Atlanta, Georgia, under the joint sponsorship of Highway Research Board and National Safety Council. Action Group members participated intensively in the program, as they had at the other two national conferences, and they took a prominent part in the planning and direction of each of the conferences.

The program format of these conferences, with numerous panel discussions, workshops, and periods of audience participation, evoked useful discussion and an airing of divergent points of view, resulting in a better understanding among those participating.

Proceedings of these conferences were given wide distribution to railroads, bus and trucking associations, State highway departments, State public utility commissions, interested Federal agencies and Congressional committees.

Research Projects Related to Grade Crossing Safety

The results of several significant research projects related to railroad-highway grade crossing safety have become available during the past 4 years and several other projects sponsored by the two administrations are in progress.

In 1968, the Highway Research Board issued NCHRP Report 50, Factors Influencing Safety at Highway-Rail Grade Crossings, by Alan M. Voorhees and Associates, sponsored by the American Association of State Highway Officials in cooperation with the Bureau of Public Roads (now FHWA). This comprehensive analysis utilized the then best available statistics to develop a mathematical model for predicting the number of accidents at a grade crossing based upon the number of vehicles and the number of trains using the crossing and the type of device protecting the crossing. The report also includes an analysis of accidents that did not involve trains. It includes some recommendations for experimental signs for use at grade crossings and for a study of train visibility. This latter recommendation was implemented by an FRA sponsored study discussed later.

In October 1969, Alan M. Voorhees and Associates completed A Program Definition Study for Rail-Highway Grade Crossing Improvement, sponsored by FRA. Using the quite limited data available, this study developed a procedure for economic analysis of proposed grade crossing improvements, and indicated the magnitude of an estimated national program of warranted improvements. The report also recommends a 5-year program of further research to improve the effectiveness and the economics of grade crossing improvements, including better data accumulation and methods of policy formulation and administration.

In November 1969, the Office of Research and Development of BPR (now FHWA) issued an Interim Report on An Analysis of Operating Characteristics and Safety of Railroad-Highway Grade Crossings prepared by the Fairbank Highway Research Station of BPR and the Kelly Scientific Corporation. The project involves a systems analysis utilizing a digital computer simulation model of the flow of vehicles and trains through a railroad-highway grade crossing. The objective is to reduce the grade crossing situation to a manageable and understandable form and to take into account variations in

the physical features of the crossing, the dynamic behavior of the driver and his motor vehicle, as well as the train and its control mechanisms. This research procedure is intended to establish a measure of the value of alternative grade crossing protective devices. The improvement of protective devices is believed to be related to a better understanding of the information needed by the driver approaching the crossing.

Under a contract with FRA, the Texas Transportation Institute conducted a comprehensive review of the reporting of railroad-highway accidents, and on July 31, 1970, submitted the final report on Reporting Rail-Highway Grade Crossing Accidents, covering reporting and data collection by public and private agencies, and suggesting methods for improved reporting and data collection.

As a further effort in this same area FRA has retained the Tolis Cain Corporation under a contract on Railroad Accident Information Reporting System to analyze the railroad accident information reporting system in use by the Bureau of Railroad Safety. This analysis will result in recommendations for changes in the present system to provide more useful and timely information on all types of railroad accidents, including those involving motor vehicles at railroad-highway intersections. Tolis Cain is scheduled to present their recommendations in July 1972.

In May 1971, Systems Consultants Incorporated completed a report on The Visibility and Audibility of Trains Approaching Rail-Highway Grade Crossings, sponsored by FRA. As an output from this study it is recommended that for daytime visibility two contrasting colors should be used, each at least 3 1/2 x 5 ft. and that one color should be bright, such as flourescent or bright yellow. Flashing high-output zenon strobe lamps, together with lighted panels, are recommended for night use. The report states that a locomotive horn with enough output to be totally effective would be an unacceptable nuisance.

A June 1971 Technical Report on Technological Innovation in Grade Crossing Protective Systems by Transportation Systems Center, sponsored by FRA, treats two related subjects: (1) Grade Crossing Protective Devices, and (2) Grade Crossing Train Detection Systems. Based upon information available from previous studies and upon laboratory investigation of possible applications of advanced technology to existing and potentially new protective devices, the report presents a summary of the potential spectrum of protective devices and systems. Primarily this TSC research effort is designed to produce some new applications of technology to the grade crossing protection problem, as set forth elsewhere in this report.

FRA and NHTSA have arranged joint funding and during Fiscal Year 1972 will pursue a research project in the human factors area on analysis of driver behavior at railroad-highway grade crossings. This project includes a study of (a) driver vision, surveillance, and monitoring; (b) driver response times and accuracy of complex problems; and (c) driver solutions to the impending conflict problems.

FHWA has a research project getting underway to develop more reliable techniques for assessing the Accident Potential at Railroad-Highway Grade Crossings. It is intended to provide better evaluation of train involved accident potential and to provide much more information on the magnitude of the non-train accident problem at grade crossings.

Crossings on High Speed Rail Lines

The Northeast Corridor

A new dimension was added to the grade crossing safety problem by the introduction of high speed rail passenger service on Penn Central routes in the Northeast Corridor under authority of the high-speed ground transportation research and development act approved September 30, 1965. With trains such as the Metroliner and Turbo-Train running at 100 mph and capable of much higher speeds, the question of a safe environment for the high speed trains was added to the traditional issue of the hazard to motor vehicles at grade crossings.

The Department has given special attention to the grade crossings along the routes between Washington and New York and between New York and Boston. High priority has been given to the Washington-New York route because of its greater volume of railroad traffic and its somewhat higher speeds of operation.

There are no grade crossings in the 123 miles of the Penn Central line from New York to a point south of Wilmington, Delaware. In the remaining 102 miles to Washington, there are only 19 public crossings and two private crossings at grade. Four other grade crossings on the Maryland portion were closed through the combined efforts of the railroad, the State, FHWA, and FRA.

Adequate funds not being then available for their elimination, the remaining public grade crossings, 15 in Maryland and four in Delaware, were equipped with modern automatic gate protection, with activated advance warning signals along the approach roadways, and with improved profiles and added width of crossing surfaces. These improvements were financed by the railroad and by FHWA, FRA and the States in a $330,000 program.

On the New York to Boston line (formerly New Haven, now Penn Central also) there are no grade crossings for the first 89 miles east of New York to a point beyond New Haven, Connecticut. On the remaining 141 miles to Boston there are 30 public grade crossings, 14 in Connecticut, 15 in Rhode Island, and one in Massachusetts. There are also 11 private grade crossings in Connecticut, six in Rhode Island, and one in Massachusetts. Many of the crossings on this line carry very light vehicular traffic, but frequently they provide the only access to seashore properties. Through recent action by local highway authorities and State regulatory agencies, six private crossings have been physically or legally vacated.

Demonstration Projects Authorized by 1970 Acts

Section 205(a) of the Highway Safety Act of 1970 (23 U.S.C. 322) provides in part -

Section 322 Demonstration project - rail crossings

(a) The Secretary shall carry out a demonstration project for the elimination of all public ground level rail-highway crossings along the route of the high-speed ground transportation demonstration projects between Washington, District of Columbia, and Boston, Massachusetts, conducted under authority of the Act entitled "An Act to authorize the Secretary of Commerce to undertake research and development in high-speed ground transportation, and for other purposes," approved September 30, 1965 (49 U.S.C. 1631 et seq.).

(b) The Secretary shall carry out a demonstration project for the elimination or protection of certain public ground-level rail-highway crossings in, or in the vicinity of, Greenwood, South Carolina.

(c) (1) If the highway involved is on any Federal-aid system, the Federal share of the cost of such work shall be 90 per centum and the railroad's share of such cost shall be 10 per centum.

(2) If the highway involved is not on any Federal-aid system, the Federal share of the cost of such work shall be 80 per centum and the railroad's share of such cost shall be 10 per centum and the remaining 10 per centum of such cost shall be paid by the State in which such crossing is located.

(d) Before paying any part of the cost of the demonstration projects authorized by this section, the Secretary shall enter into such agreements with the State and railroads involved to insure all non-Federal costs will be provided as required by this section.

* * * * * * * * *

(f) There is authorized to be appropriated not to exceed $9,000,000 from the Highway Trust Fund to carry out paragraph (1) of subsection (c) of this section. There is authorized to be appropriated out of the general fund not to exceed $22,000,000 to carry out paragraph (2) of subsection (c) of this section.

Of the $31 million authorized for these demonstration projects, $10 million was appropriated for Fiscal Year 1972.

Preliminary planning is underway by the several State highway departments for elimination of the crossings in the Northeast Corridor on the Penn Central between Washington and Boston. This project will consist of a mix of grade separations, crossing closures and frontage road construction to route highway traffic to nearby grade separated crossings.

Although the 1970 Act does not authorize funds for eliminating private crossings along the Northeast Corridor, the railroad, State and local governments and agencies are being encouraged to combine their efforts to this end.

The demonstration project in Greenwood, South Carolina, includes the relocation of lines of the Seaboard Coast Line Railroad and the Southern Railway, the construction of grade separations, protection of crossings, and removal of abandoned trackage. Current plans provide for removal of two lines of railroad from the central business district of the city, enhancing its appearance and cohesiveness. A total of 35 grade crossings and approximately 8 miles of track would be eliminated from the urban area, freeing land for other uses. The improved protection along the rail line would permit increased train speeds, further reducing delay to motor vehicles, as well as to railroad operations. Some preliminary work has been performed on this project and planning is proceeding on the remainder.

V

THE DRIVER

Nearly all grade crossing accidents can be said to be attributable to some degree of "driver error." Thus, any effective program for improving safety at railroad-highway grade crossings should be oriented around the driver and his needs in approaching, traversing and leaving the crossing site as safely and efficiently as possible.

If the driver were not human and subject to errors of judgment, and if he and his vehicle always functioned perfectly, grade crossing accidents would be greatly reduced, as would all highway accidents. Thus, it is essential for those responsible for the grade crossing environment to understand the driver and his problems. To this end, all feasible steps should be taken to assist him in carrying out his task by conveying the proper message and maintaining the proper attitude.

In the area of highway safety in general, a three point approach is traditionally employed: Engineering, Education and Enforcement.

Engineering

To properly engineer the grade crossing environment, it is necessary to examine the decisions the driver must make, his proficiency in making them, his attitudes about various situations he encounters, his informational needs for making proper decisions, his ability to assimilate that information, and his reaction upon receiving certain pieces of information.

In approaching a railroad-highway grade crossing, the first stimulus encountered by the driver is the advance warning of the crossing. This will normally take the form of the standard round advance warning sign which will inform him that he is approaching a grade crossing. There may also be pavement markings present which confirm the presence of the crossing. This information, if properly assimilated, stimulates the first decision the driver must make. His experience either at this particular grade crossing or at grade crossings in general will be reflected in his decision. This decision would be either to decelerate immediately or to take no immediate action but retain the information for later use. It is imperative, of course, that to have positive value, these signs must clearly be visible, well maintained and situated at a sufficient distance from the crossing to accommodate the prevailing highway speed.

The standard advance warning sign provides no other information, such as number of tracks or angle of crossing or whether the protection at the crossing consists of an automatic device or merely a sign. Such information might well serve to assist the driver in determining his actions and responsibilities when he reaches the crossing.

The next stimulus received by the driver as he continues toward the crossing would normally be from the protective devices at the crossing or the crossing itself. Their location, state of repair, and other factors will have a significant bearing on the driver's action at this point.

At crossings which have automatic protection, a completely dark signal indicates that no train is approaching. This, incidentally, is not consistent with the message the driver receives at signalized highway intersections where he receives a positive indication to proceed in the form of a green light or a blinking yellow light. At crossings with automatic protection, most drivers are inclined not to look for an approaching train. Instead, they rely on the protective device.

If the automatic protective device is operating the driver is required to stop at the crossing. The device in operation is intended to signify the imminent approach of a train or the presence of a train on the crossing. Again, from experience, the driver may have encountered signals operating where the train, although visible, was delayed for an unreasonable amount of time or did not reach the crossing. This usually occurs at crossings with a wide range of train speeds or with switching operations but can happen at any location where circuitry design does not fully account for the specific train operations at that point. It is difficult to precisely quantify the reduction in effectiveness of automatic devices due to the lack of credibility or integrity but it is a very real problem, with results ranging from partial to total disregard of the signals by the driver.

This type of activation problem can be avoided by the installation of more sophisticated and expensive equipment which measures train speeds and gives the driver a consistent and reliable message. Such equipment is being used in new signal installations when prolonged signal activation would otherwise create severe problems; however, there is a need for broader use of such devices, not only in new signal installations but also in modernizing existing signals, although the available equipment is quite expensive.

When the driver approaches a crossing protected solely by crossbucks, the only information he receives from this sign is that there is a crossing. The responsibility for discerning the presence or approach of the train rests with him.

The driver's response when encountering a crossbuck protected crossing will be governed by several factors. These can be classified broadly in two areas; his attitude, which is influenced by his experience, and his ability to cope with the actual physical environment at a given crossing. It can readily be agreed that a driver should look for the approach of a train. However, since crossbuck signs are generally used to protect crossings with lower exposure, train traffic usually will be less frequent than at automatically protected crossings. Thus, a driver may use a crossing repeatedly and not see a train. This understandably reduces his vigilance and he becomes more susceptible to a collision when a train is present at the crossing.

If he observes a train approaching the crossing, the driver must decide either to stop before reaching the crossing or proceed through the crossing ahead of the train. Such a decision must be based on his almost instantaneous judgment of several complex factors, including train speed and distance from the crossing. The result may be indecision or a wrong decision.

The foregoing assumes that the driver is afforded sufficient clear sight distance between the highway and the approaching train, as well as sufficient sight distance to the crossing, to take the proper action. The more restrictive of these two unrelated sight distance restrictions should govern the driver's approach speed. This information may be conveyed to him by an advisory speed warning sign. Where the sight distance is restricted, the driver must also assimilate and react to this information as a part of the driving process.

All of the foregoing assumes the driver encounters no other restrictions or distractions within the grade crossing environment. Other possible actions required of him might include a required stop at every crossing because of the type of vehicle he is driving or a stop or speed change because the vehicle preceding him has taken such action.

When the driver approaches a crossing, he needs to know if there is a train (1) on the crossing, (2) approaching the crossing, or (3) not in the vicinity of the crossing. This can be satisfied in part by providing improvements such as (1) more effective and informative passive signing, (2) improved sight distance along the highway, and (3) better visibility of the crossing area and of the train on or approaching the crossing. However, all of these improvements still leave the basic responsibility for determining the hazard with the driver and may require almost simultaneous tasks of him. At a crossing protected with an automatic device, the driver's primary responsibility is to observe and respond to the message conveyed by that device. Thus, automatic devices which give the driver a uniform warning time prior to arrival of the train significantly simplify the driver's task and substantially reduce motor vehicle-train collisions.

Education

Industry Programs

In recent years the railroad industry has been instrumental in organizing groups composed of representatives of railroad management, organized labor, and State and local Government agencies for the purpose of increasing driver awareness of the inherent hazards at railroad-highway grade crossings. Organizations such as the Joint Management-Legislative Grade Crossing Accident Program made up of the Santa Fe, Union Pacific, Western Pacific and Southern Pacific have actively participated in statewide programs to develop cooperative interest in the reduction and prevention of grade crossing accidents. Through the joint effort of railroad management and labor, educational literature has been distributed to the news media, law enforcement agencies, public schools and civic clubs. Much of the educational material published by the National Safety Council (NSC), including pamphlets, radio and television spots, safety posters and stickers, safety quizzes and news releases are distributed through these industry oriented organizations. Several railroad companies, some individually and others through joint effort, have budgeted several thousands of dollars for the production of grade crossing accident prevention films. These film and slide presentations are made available free for public use in schools, driver education programs and civic club activities.

On their own joint initiative and without public financial support, the railroad industry and organized labor have established and continue to maintain sizable programs that are helping to educate the driver on his role and responsibility under law for reducing serious railroad-highway accidents at grade crossings.

The National Safety Council Programs

In 1960 a committee made up of 50 members, representing railroads, trucking and petroleum industries, railroad labor, public agencies, and the general public was formed by the National Safety Council to assist in the reduction and prevention of railroad-highway accidents. The committee is charged with the responsibility to: undertake a continuing educational campaign designed to impress all drivers with the need for greater caution at railroad-highway grade crossings; encourage better enforcement of traffic laws at or near grade crossings; encourage physical improvement of grade crossings; work for uniformity of State laws; and endeavor to upgrade the performance of school bus operation and drivers of vehicles carrying flammables who are required by law to stop at railroad-highway grade crossings.

The "Near Miss" Program. One of the projects developed by this committee is the railroad "near miss" program. In this program, train crews observe and record violations of stop laws at grade crossings, as well as other hazardous vehicle maneuvers which nearly result in

collisions. The railroads then report the violation to the company or school district whose driver was involved in the violation or, in the case of the passenger car driver, contact the driver directly. The main value of this program is that contact is made immediately with the company or school district, a procedure which allows the fleet supervisor to take steps to correct the erring driver as well as remind other drivers of the necessity to obey traffic laws at railroad-highway grade crossings. Near miss reports are compiled by the NSC staff to be used for educational purposes. In this sense the entire program is intended to be educationally oriented and not punitive in nature. In a recent year NSC received 605 reports of near miss incidents. Trucks carrying flammables were involved in 203 instances while school buses were cited in 255 reports.

Other educational programs sponsored by the NSC include: articles in publications such as Traffic Safety and Family Safety which describe railroad-highway grade crossing hazards; safety materials for driver education programs; pamphlets, posters, studio and television spots; and sponsoring of conferences and courses related to railroad-highway safety.

State Driver Manuals

A review of current state driver manuals reveals considerable difference in the emphasis placed upon the railroad-highway grade crossing hazard by the individual states, because laws to be observed at or near these intersections differ from state to state. In general, the driver's manual provides emphasis to the prospective driver on: (1) the need to recognize and respond to the railroad advance warning sign, (2) the crossbuck sign which specifically locates where the tracks cross the roadway, (3) the requirement for buses and trucks transporting hazardous materials and other selected vehicles to stop at all grade crossings. The driver is also cautioned about multiple tracks, staying on tracks or changing gears and not driving between or around lowered crossing gates.

The lack of consistent signing and use of protective devices at or near railroad-highway grade crossings, in addition to non-uniformity of state and local traffic laws and codes, results in a difficult situation for those who are charged with driver education, driver licensing and driver performance. As manuals and codes are revised, consideration must be given to uniformity of driver information systems.

Enforcement

Police administrators, as with other public service administrators, are faced with increasing demands from a growing population without commensurate increases in funding and staffing. One method, employed by

police administrators to improve the effectiveness of law enforcement officers, is called selective enforcement. In implementing selective enforcement, the police administrator attempts to place his available manpower at known problem locations during the most hazardous time of day or night. By observing the violations which are contributing to accidents, the police administrator may use both enforcement and educational measures to reduce the accident experience at hazardous locations.

Coordinated Community Program

Oftentimes, when a major crisis comes upon a community, the citizenry and its elected and appointed representatives band together in a coordinated effort to meet the crisis. It is not uncommon that tragic railroad-highway accidents which take the life of one or more local citizens create an atmosphere of crisis. The San Joaquin County California Accident Reduction Plan adequately serves to illustrate an approach that has been taken by one community to cope with this problem.

The plan, conceived and implemented in early 1970 by the County Sheriff's Department, combines the traditional elements of engineering, enforcement, and education. Copies of the Accident Reduction Plan were mailed to each traffic judge, railroad company, newspaper, radio station, and traffic engineer in the county, with a letter explaining the problem and its proposed solution.

A short time later, law enforcement officers contacted the traffic judges and informed them of the problem of an increased number of train-auto accidents and what was proposed to be done to reduce this experience. The educational and enforcement aspects of the plan were discussed. Judges agreed to raise the bail schedule on the vehicle code sections pertaining to vehicles failing to heed railroad signal lights; and, in some aggravated cases, to require mandatory appearance of the violator. Railroad companies were contacted and asked to report observed crossing violations to the California Highway Patrol.

All traffic officers were informed of the problem and the methods that were proposed for its solution. They were instructed to step up their enforcement action against grade crossing signal violations throughout the entire county and when a motorist was stopped for this violation, to advise him of the hazards involved.

The next step was to inform the driving public by means of a concentrated ongoing educational program involving all of the news media. The major newspapers, and radio and television stations cooperated fully. Another phase of the program involved meetings between law enforcement officers and trucking company representatives. The purpose of this meeting was to develop special projects which related to truck movements over railroad-highway grade crossings.

As the final phase of the plan, engineering was initiated by requesting traffic officers to provide information on hazardous locations where improved engineering design would eliminate or significantly reduce hazards. Although the plan involved only a single county, its designers are quick to point out that all drivers traversing San Joaquin County benefit from the program.

This summary of one local Government program to improve railroad-highway safety is presented in this report as an example of what can be accomplished through a coordinated community involvement program.

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VI

THE WARNING SYSTEM

Standards and Guides

For the purpose of this report, the railroad-highway grade crossing warning system includes all pertinent traffic control devices encountered by the driver in the process of approaching and traversing the grade crossing. The function of the system is to advise and warn the driver of the potential or actual hazard and the responsibilities and the actions required of him. National standards for the devices in this system, like all other highway traffic control devices, are provided in the Manual on Uniform Traffic Control Devices (MUTCD).

The need for uniformity of traffic control devices led to publication of the first manual in 1935. A revised edition issued in October, 1971, replaces one published in 1961. The revised edition was prepared as a cooperative effort of Federal, State and local officials and traffic engineers and approved by the Federal Highway Administrator as the National Standard for all highways open to public travel in accordance with his authority under Federal law. In virtually all States, traffic control devices placed and maintained by State and local officials are required by statute to conform to a State Manual which must be in substantial conformance with the MUTCD.

Both the 1961 edition and the 1971 revision require the standard advance warning sign on each highway approach except in a few special situations where such advance warning is deemed unnecessary or would be ineffective. They also require the standard crossbuck at the crossing on the right-hand side of the roadway on each highway approach to all crossings.

The use of pavement markings in advance of a grade crossing has been modified in the revised edition by recommending such markings on all paved approaches and requiring them on all paved approaches where flashing lights and/or gates are located and at all other paved approaches where the prevailing speed is 40 mph or greater. Stop signs are no longer specifically warranted at railroad-highway grade crossings, but neither are they specifically prohibited; thus permitting, but not encouraging, their use at these crossings.

The new edition has been revised to permit the use of regular traffic control signals at industrial track crossings and other crossings where train movements are very slow. It continues the prohibition against their use at crossings of mainline railroad tracks.

One significant change in the new edition is the deletion of the use of wigwag signals as a protective device at crossings. The types of control, design, location, installation, and operation of protective devices are required to be in accordance with Association of American Railroads Bulletin No. 6. One exception is that the striping on automatic gates has been revised to require alternate red and white striping as opposed to the use of alternate black and white stripes. Another exception is the specific requirement for providing a minimum lateral clearance of 2 feet from the face of curb or from the edge of the usable highway shoulder to the near edge of the device for all automatic protective devices.

The specific requirements for crossing protection devices, as distinguished from advance warning devices, contained in Bulletin No. 6, issued by the Train Operation, Control and Signals Committee of the Association of American Railroads, have generally been adopted or approved for use by the railroads, State agencies having jurisdiction, and the Federal Highway Administration.

Existing Active Systems

The First Steps

Consistent with their legal responsibility to warn highway travelers of the approach of trains, the railroads in their early days provided watchmen at some important highway crossings in addition to the warnings provided at all crossings by locomotive whistles, lights, and bells. At night a watchman would provide warning by swinging a red lantern. Some hand operated crossing gates were made available about 1870. In 1889 the first automatically activated railroad-highway crossing protective device, a bell, was placed in service. This audible warning was more suited to the slow moving horse-drawn vehicles than it is to modern closed vehicles, although bells still in service provide a good warning signal for pedestrians. Today they are installed as adjuncts to modern visual types of warning devices at crossings used by both vehicles and pedestrians.

The "wigwag," an automatic swinging banner, was first used at grade crossings in 1914. The wigwag with a red light symbolized the crossing watchman's swinging red lantern.

Development of Current Devices

A development of the 1920's was the automatic flashing-light signal which simulated the swinging red lantern, utilizing two alternately flashing, horizontally-spaced fixed red lights sufficiently powerful to be visible in daylight. Improved models of flashing light signals constitute the most widely used form of grade crossing

protective device being installed in current programs. Cantilever supports are being used much more frequently to improve visibility of signals at crossings of the more important highways, particularly multi-lane facilities.

In 1936 the short-arm gate was developed as a supplementary device for use with the flashing light signal. The signal-gate combination, usually designated as an automatic gate, is particularly suitable for use at grade crossings of two or more tracks where the gate arm across the highway will restrain highway traffic when a second train is approaching and for use at single track crossings with restricted sight distance and used by high-speed trains. The automatic gate is the other form of protective device being installed generally in current programs.

Protective Device Improvements and Performance Record

It is significant and of some concern that the protective devices now being used in new installations were initially developed some 35 and 45 years ago. Improvements in flashing light signals and automatic gates introduced over these many years include reflective signs, brighter signals with longer range, sophisticated signal control systems to eliminate unnecessary operations, materials and equipment requiring less maintenance and lighter weight signal assemblies and gates to reduce installation costs. These improvements have contributed to increased effectiveness and cost reduction in protective systems.

The performance record of these protective devices has been quite good. Several analytical studies of "before" and "after" records show that accidents and resulting fatalities and injuries have been substantially reduced where automatic flashing light signal installations and automatic gate installations have been made. Elsewhere in this report it is shown that between 1920 and 1970 the grade crossing casualty ratio was reduced 92 percent. Installation of automatic protective devices played an important role in this accomplishment.

The Cost Problem

Under current programs, the installation costs for flashing light signals frequently exceed $15,000 and, in many instances, automatic gates cost more than $20,000 at even the most simplified railroad-highway grade crossing. The annual maintenance costs of these devices are currently in excess of $700 and $1,000, respectively. To some extent these high costs are attributable to the restraints placed upon suppliers and their products through public regulation, legal restraint and market size.

Public Regulation

As indicated at the beginning of this section, grade crossing protective systems must not only meet the requirements of the Manual on Uniform Traffic Control Devices (MUTCD) as well as other similar requirements imposed by State and local law and regulation but also must satisfy the recommended practices for these matters set forth in Bulletin No. 6 of the Association of American Railroads. On one hand, controls of this nature are necessary to achieve a reasonable degree of uniformity in practice nationwide. On the other hand, such controls can act as a deterrent for developing and testing new devices, particularly under circumstances where the controls have the force and effect of law, coupled with the added complication of surmounting the problems stemming from divided jurisdictional authority and responsibility when implementing and approving new devices.

Legal Restraints

Because of the legal implications of nonconformance to "accepted" signs and signals, railroads are generally reluctant to utilize a new type of equipment unless it meets current standards and regulations. Another item tending to restrict innovation is that railroads have found that improved products tend to make older equipment, still in service, subject to legal claims that the protection is not as "good" as it might have been.

New products require a period of testing by both the supplier and the railroad industry. Most difficult to introduce are products which involve new techniques or technologies. Product testing is extended as more complicated apparatus and circuitry is introduced. Product acceptance problems also result from changes in railroad operation. Although higher speed trains cause only minor changes to occur in the system, the mixing of high-speed with slow-speed trains brings about a requirement for an improved system or product to detect this difference in speed in order to provide a uniform warning time for trains approaching grade crossings at varying speeds.

The railroad-highway protective device supply industry reports that the relationship of development costs to sales price for new products of average complexity is such that 3 to 4 years of sales are required to recover these costs with no profit being generated during this period. Even when railroad-highway grade crossing protective systems meet all current regulations and specifications, railroads have frequently been required to pay damages in lawsuits resulting

from crossing accidents. When non-standard equipment is involved, successful defense against accident claims is made more difficult. Under these circumstances railroads continue to be reluctant to voluntarily install new types of protective equipment, even though they represent some improvement.

Market Size

The railroad-highway protective device market is shared by as many as seven or eight individual suppliers. Using data from the most recent 5 years, the annual market for basic protective equipment is approximately $12 million. Based upon current spending programs of Federal, State and local governments and the railroad industry, some 400 automatic gate and 850 flashing light signal installations are completed each year. There are some 47,000 existing installations of automatic protection that require replacement parts and, periodically, total replacement. There are also some 134,000 other grade crossings with no automatic protective devices, some of which are likely prospects for installation of automatic devices. Regardless of how the potential market is viewed, at the current annual rate of expenditures and the number of suppliers in the field, it is not surprising that railroad-highway protective device improvements and innovations are somewhat inhibited. It is conceivable that increased market size could result in some reduction in equipment costs.

Marketing Methods

Although government bodies now exert a strong influence in the market and are currently paying an increasing part of the costs, they do not make the purchase. Since the equipment is actually being purchased, installed, and maintained by the railroads with their forces, it has been their prerogative to select the particular equipment to be used. This practice has probably contributed to the lack of innovation in equipment design and use as much as any other single factor. Even though governmental bodies issue orders for installation of the equipment, the supplier's marketing effort is still directed toward the railroad companies. The size of the market is being established by public bodies. The only choice available to the railroad is the source of equipment.

The Track Circuit Principle

The basic method of detecting the presence of a train has always utilized the rails to accommodate track circuits. For fail-safe operation, the track circuit employs the closed loop principle with electrical energy applied to the rails at one end of the track circuit to activate a protective detection and holding device at the opposite end.

When a train enters the track circuit the energy to the protective device is shorted out through the wheels and axles of the train. This in turn activates the warning device. Other necessary components in this circuit are insulated joints, rail bonds, lightning and surge suppressors, batteries, rectifiers, relays, etc.

New Technology in Active Systems

Current and proposed technological innovations in the present state of the art for railroad-highway grade crossing protection systems include:

(a) An audio frequency tone track overlay which transmits sound into the track has been developed to replace the DC track circuit. The primary advantage of this innovation has been the reduction or elimination of insulated joints, which have a relatively high cost of maintenance, and the flexibility of using this system with existing railroad signal circuits without extensive modification.

(b) To eliminate excessively long activation of flashing lights and gates by slow speed trains operating in high speed territory, speed detectors and restart devices have been developed and placed on the market. The speed detector, although expensive to install and maintain, provides additional benefits by constantly measuring the approaching train's speed and translating this to a uniform warning time for the driver. Not only is credibility of the warning device improved but also motor vehicle delay time, especially where gates are installed, is held at a minimum.

(c) The development of a parabolic reflector lamp and a better focusing roundel (lens) to improve warning light visibility to drivers.

New Technology Under Study

The Transportation Systems Center of the Department of Transportation now has under way a research program applying expertise gained from aerospace research to the field of railroad-highway grade crossing protection systems. Under study currently is:

(a) The application of microwave systems, both telemetry and radar, to the activation of protective devices. One system utilizes a low-cost, highly reliable microwave telemetry link between the train-sensing point required for adequate warning and the protective device at the grade crossing. Power consumption is at a minimum permitting operation from batteries on a yearly replacement schedule and eliminating the need for line-power installation. This system should influence

several items of protection expense, including hardware, installation and maintenance. It is estimated that the system would reduce protection cost at many grade crossings by 20 to 50 percent.1/

This program has advanced to the stage that field tests will begin prior to the end of calendar year 1971. It is planned to include the production of engineering models by commercial organizations to meet FRA specifications for performance, reliability, simplicity, conformance with railroad requirements, climatic conditions and maintainability, together with estimates of cost of manufacturing units in quantity and cost of installation. An extended period of testing is in prospect.

Proposed Train and Vehicle Warning Systems

Among the many ideas frequently proposed for improvement of safety at railroad-highway grade crossings are those involving techniques which require special system elements installed on trains and/or motor vehicles. A general discussion of these concepts follows:

Train to Crossing Systems. The basic concept involves a locomotive-mounted transmitter with a receiver at the crossing. The means of communication can be radio, optical, acoustic, or other. There are several inherent major defects associated with these systems. All locomotives using the crossing must be appropriately equipped, and for most systems the locomotive must precede all other rolling stock. Generally, this will be difficult to ensure, particularly because of locomotive interchange among railroads and the situation where cars are being shoved in switching moves. Further, the equipment must be in operating order, which raises the question of what is to be done in the event of a failure in service. Fail-safe operation is impossible, as the presence of an unequipped train will be indistinguishable from the no-train situation. The probability of human failure must also be considered. Finally, both uniform warning time, difficult to obtain for such a configuration, and proper activation regardless of the orientation of the locomotive or its position in the train, are necessary for system implementation.

Some of the above objections are eliminated if crossing signal activation is accomplished by means of some inherent property of the train, such as vibration, noise, etc., rather than through special apparatus. However, appropriate effectiveness of such means under a variety of environmental conditions for diverse types of rolling stock (with constant warning time) seems to present an extremely challenging task.

1/ See Transportation Systems Center Report entitled Technological Innovation in Grade Crossing Protective Systems (June 1971).

Crossing to Vehicle Systems. A number of concepts have been suggested involving activation of special in-the-vehicle signals by roadside components. Many of these are applicable to grade crossings. Inasmuch as the major part of protection expense is in train detection and signal activation, it is clearly desirable to utilize all possible means of alerting motorists once the basic investment has been made. However, it seems unreasonable to expect installation of the necessary receiving and signal apparatus in all vehicles simply for grade crossing protection, hence it will be necessary to await implementation of such a system for general highway usage before crossing applications are feasible. In addition, since the presence and operability of the vehicle-mounted components cannot be guaranteed, such a warning device must be considered as a secondary system, to enhance the effectiveness of more conventional warning systems.

Train-Vehicle Systems. The idea of direct communication between train and driver has strong appeal, but appears to be a very unpromising approach in spite of numerous ventures into this concept. Essentially, such a method would combine the defects of both cooperative systems discussed above. The one exception to this conclusion is found in the direct observation of the train by the driver, either visually or by auditory means. This topic is fully treated later in this report.

Stalled-Vehicle Indicators. It is a popular notion that a major element of grade crossing safety is prevention of collisions with motor vehicles which have become stalled on tracks. A conclusion frequently drawn is that means must be found to alert the train crew so that the train can be halted. Although 10 to 15 percent of accidents involve motor vehicles stopped on the crossing, the period of time they are on the tracks prior to arrival of the train is unknown.

A very long distrance is required to stop a train. The nature of conventional train braking systems, the limitations imposed by train dynamics, and the predominance of lengthy freight trains combine to make even an emergency brake application a slow and hazardous process, requiring initiation one-half to two miles in advance of the obstacle. Thus, most cases of stalled vehicles are such that there is usually no chance of stopping the train in time to avoid a collision.

Some of the ideas and systems discussed here have little prospect of implementation. On the other hand, others have considerable promise in providing increased railroad-highway safety. The development of new ideas in improved lower cost warning devices for the protection of both drivers and trains at railroad-highway grade crossings is an important element in achieving reductions in accidents at low volume crossings.

Existing Passive Systems

With more than three-fourths of the public grade crossings nationwide not protected with active devices, it is most important for the passive devices to be as effective as possible. Furthermore, at the 70,000 or more crossings in the lowest classification for both highway traffic volume, 500 or less vehicles per day, and railroad traffic volume, less than two trains per day, there is but a remote possibility of finding justification for other than passive protection.

Advance Warning Sign

The existing standard advance warning sign consists of a 36 inch yellow sign with a black "X" and the letters RR. This sign advises that there is a crossing ahead but gives no other information. It has been standard for many years.

Pavement Markings

Pavement markings when required are painted on the highway surface in advance of the crossing and consist of a distinctive "X" and the letters RR.

Crossbuck

The crossbuck device which is used either alone or in combination with other signs or signals at the crossing consists of a set of crossarms with the words "Railroad Crossing" written on the arms. The current standard provides that the crossarms be reflectorized but many older non-reflectorized crossbuck signs are still in use. The crossbuck form of railroad-highway crossing sign has been standard for many years. It has been designed by committees of railroad organizations and has the approval of the American Railway Engineering Association and the Association of American Railroads. It is included in the Manual on Uniform Traffic Control Devices.

In some States the placement of only one crossbuck sign at each crossing is required. However, since the Manual on Uniform Traffic Control Devices requires the installation of a crossbuck sign on the right-hand side of the roadway on each approach to the crossing, which is a minimum of two per crossing, all crossings with a single sign are deficient under the national policy on traffic control devices. To correct this deficiency will require installation of an additional sign at those crossings now having only one, and will require installation of two crossbuck signs at the several thousand public crossings reported as having no signs or signals. Installation of these signs would be made without any prior benefit-cost analysis, on the basis that this is a mandatory minimum requirement for safety.

Other passive devices used at some crossings in conjunction with the crossbuck are (1) illumination and (2) stop signs.

Illumination

Illumination of crossings is a type of passive protection which can be used to improve safety under certain conditions. Illumination is particularly appropriate at crossings with slow moving or standing trains at night, particularly at locations where physical characteristics are such that motor vehicle headlights shine over or under railroad cars on the crossing or where other conditions result in poor nighttime visibility. At crossings with high-speed trains or used only for through operations, illumination may be of questionable value inasmuch as light is concentrated at the crossing and may detract from the view of an approaching train. Appropriate use of illumination has been approved by the American Railway Engineering Association.

Stop Signs

Under the 1961 edition of the MUTCD, stop signs were warranted at grade crossings under conditions where a stop is required by law or by order of the appropriate public authority. Such a warrant is not included in the revised manual. Stop signs are controversial, promoted by some groups, either alone or in combination with "rumble strips" on the highway approach surface, and discouraged by many others.

Limited research indicates that stop signs are generally more effective than crossbucks in reducing the number of vehicle-train collision . Their effect on other accidents at the crossing is unknown although some evidence indicates that stop signs, by increasing the turbulence of traffic flow, increase other accidents, notably the rear-end collision type, particularly where stop signs are used in an area indiscriminantly.

The high operating cost and delay associated with stopping all motor vehicles at a crossing attaches a heavy economic burden to the use of stop signs. Also, studies indicate that stop signs at railroad-highway grade crossings are frequently not obeyed and their use under those circumstances may reduce their effectiveness and credibility in all other situations, including highway intersections.

Other Concepts

Other concepts which have been used at and in advance of crossings include the addition of flashing lights to passive signs. These take the form of both non-train activated (continuously flashing) and train-activated (active) devices.

Non-train activated. These normally take the form of continuously operated, alternately-flashing lights mounted on an advance warning sign or on some modified crossbuck sign at the crossing. The lights on the advance sign are usually yellow; the lights at the crossing either yellow or red. While there are distinct alerting values associated with these devices, they are only advisory and do not indicate actual train approach.

Results with these devices have been mixed, but generally negative. Much of the opinion is very subjective, although at least one State has tested the crossbuck mounted flashing lights and determined that such devices should not be used or adopted as a standard in that State.

The use of continuously flashing lights on advance signs seems to be less controversial, although operating costs and vandalism have been deterrents to any wide-scale use.

Train-activated. Another concept, not really new, but receiving much attention in recent years, is the use of train-activated flashing lights in conjunction with advance warning signs. This method provides to the driver a distinct alerting signal operating only when a train is approaching or is present on the crossing.

At the 19 public grade crossings on the high-speed line between Washington and New York, a combination of flashing amber lights and an advance warning sign has been extended over each roadway approach on cantilever arms. Such application appears appropriate at such special locations.

Potential Improvements to Passive Systems

Because of the importance of the passive signs used in railroad-highway grade crossing warning systems, research and testing is being conducted to develop more effective signs.

Advance Warning

Studies in recent years have resulted in possible new types of advance warning signs which would give the driver more effective information than the existing standard sign. For example, a sign has been developed which might be used in advance of a passively protected crossing to provide an early indication that it differs from an automatically protected crossing. This sign would show by symbol the highway and track crossing and the angle of crossing, thus giving the driver information both on the protection ahead and on where to look for the train. This sign is being used extensively in Canada.

Various signs have been suggested for use in advance of an automatically protected crossing. Most of these incorporate the symbol of the flashing light signal and in this respect would be similar to the "signal ahead" symbol sign used in advance of signalized highway-highway intersections.

These signs might be used to replace the existing standard advance warning sign or to supplement the standard sign, which provides basic warning of a crossing ahead, to give the driver additional information concerning the crossing.

In addition, other designs have been suggested for signs to replace the advance warning sign on the basis that they have more "impact" or "target value." Better backgrounds including black borders have been suggested. Other improvements could take the form of simply larger standard signs.

Protection at the Crossing

Possible improvements to the existing standard crossbuck have been developed for experimentation and testing. Consistent with the human factors research finding that a new system should incorporate some features of the existing system, the proposals being considered retain the crossbuck concept in some form.

A research recommendation in NCHRP 50 would impose the crossbuck symbol on a background shaped like a yield sign. This would provide a message consistent with the driver's responsibility to yield at a railroad-highway grade crossing in the same way as at other yield signs and would provide a better background for the device.

A symbol crossbuck sign is being considered for use in Canada where there is a bilingual need in the use of lettering. The sign being considered is a yellow reflectorized sign, with a black border but without lettering, that can be adapted to the existing standard size crossbuck arms. An experimental installation has been made in Canada. It is considered to have sufficient merit and has been recommended for inclusion in the AAR Signal Manual so that its use will be encouraged on a test basis. This would permit responsible officials to evaluate its effectiveness. It is probable that the yellow crossarms will be more visible against a variety of backgrounds than the standard white crossarms with black lettering.

Several of these new types of passive devices have been and are being installed on an experimental basis and evaluated, demonstrating an active interest in improving grade crossing safety through improved passive systems.

Location of Devices

In recent years it has been well established that a large percentage of the motor vehicles which run off roadways are involved in serious crashes with fixed objects located above the ground along roadsides. Sign supports, trees, lighting standards, and utility poles are some of the objects frequently encountered. In many instances, a roadside area relatively free from obstructions would afford the driver a greater opportunity to recover control of his vehicle and avoid a serious accident. Also, experience has shown that breakaway and yielding supports for signs and other traffic control devices substantially reduce the severity of this type of accident.

Railroad-highway grade crossing protective devices, like other highway signs and traffic control devices, often present roadside hazards to the motor vehicle. The location, mounting and structural design of these devices along the roadside has attained new importance as part of the overall highway safety program during the past several years. However, the problem is viewed very differently by various people in the public agencies responsible for grade crossing safety and by representatives of the railroad industry.

Comprehensive accident statistics are not available to accurately determine the frequency of impact of highway vehicles with grade crossing protection supports. However, railroads have erected protective barriers around the base of a large number of these supports, particularly at complicated intersections.

When automatic protective devices are activated, the flashing lights, lowered gates and ringing bells not only warn the motorist of an approaching train but also specifically locate the device for the motorist. However, during a high percentage of the time the device is not activated. It then, in effect, takes on the characteristics of a roadside sign similar to other passive signs.

The problem of railroad-highway automatic protective device supports as a roadside fixed object hazard has no simple solution; however, it is a problem that is receiving attention by industry and government.

In preliminary exploratory investigation of the impact behavior of railroad-highway protective device supports, the Texas Highway Department, in cooperation with the Department of Transportation and an equipment supplier, conducted full-scale tests of various types of railroad-highway protective device supports. These tests, observed by railroad representatives as well as representatives of the cooperating State and Federal agencies, were conducted on four types of devices and their supports. The results of these tests indicate that accident severity is significantly reduced when supports are mounted on frangible bases.

The following items, among others, represent some of the current methods for minimizing the effect of railroad-highway protective devices as roadside hazards to the driver:

(1) The revised Manual on Uniform Traffic Control Devices, which was discussed earlier in this section, sets forth the current minimum lateral clearances to signs and signals from the edge of the highway shoulder. Signs and signals being placed in accordance with this standard reduce the potential for collisions.

(2) Guardrail protection is being used by some agencies. However, it should be noted that, while guardrail is provided in many instances to protect the driver from collision with the automatic device, attempts to develop a totally acceptable guardrail design have not been successful for several reasons: (a) Proximity of the signal to the tracks complicates the structural design of the guardrail; (b) location of the guardrail often restricts the access of railroad maintenance crews from the highway to the railroad right-of-way; and (c) the most important unanswered question of the effect that guardrail might have on vehicle-train collisions either by blocking an escape route or by diverting the out-of-control vehicle back onto the highway and into the train.

(3) In order to achieve more adequate lateral clearances without compromising the effectiveness of the device, automatic devices are being mounted on cantilever supports in some areas. This permits moving the support beyond even the widest highway shoulders but keeps the signal itself over the traffic lane. It also avoids the problem of a vehicle parked on the shoulder obstructing the signal or, on a highway of four or more lanes, a vehicle in the outer lane obstructing the view of the signal for a driver in the inside lane.

Maintenance

All too often increased safety at railroad-highway grade crossings has only been associated with the installation of new or improved warning devices. In many instances the effectiveness of existing warning devices could be materially improved by adequate maintenance of the devices and their environment. There are a number of contributing factors that influence the degree to which a railroad-highway grade crossing is properly maintained. Maintenance responsibility is divided. The railroad is responsible for installation, maintenance and upkeep of devices located in and adjacent to the tracks, while the governmental agency, either State, municipal or county, is responsible for signs and pavement markings placed on the approaches to the crossing.

One approach to achieving the collective attention of all parties interested in the design, operation and maintenance of the railroad-highway grade crossing and its environment has been the formulation of diagnostic study teams at the State level. These teams, structured to include professional people from highway departments, city traffic departments, law enforcement agencies, railroads, Federal agencies and research organizations, provide a means of focusing the attention of all parties of interest on the problems at specific grade crossings. A summary report of one diagnostic team's effort provides an example of the type of problems encountered by multiple discipline teams in making on-site inspections of grade crossings. To facilitate this study, 36 railroad-highway grade crossings were selected by a random choice technique, within the study State to assure that these crossings would be representative of those throughout the State; the crossings were classified according to (1) their location in either rural or urban areas, (2) whether or not they had experienced accidents within the last 3 years, and (3) the type of crossing protective devices.

From conditions observed by the diagnostic team, at each of the study crossings, 60 percent were considered to be fairly safe, while the remaining 40 percent were rated as unsafe. Table 13 lists the types of and extent of unsafe conditions observed at all study crossings and reported by the team in order of their frequency of mention. From this list it may be seen that pavement markings and driver visibility obstructions were the most frequently mentioned unsafe conditions. Illumination, signing, signalization and fixed object hazards were mentioned with somewhat less frequency, while roadway geometrics, maintenance of railroad devices and traffic conditions on adjacent roadways were the least frequently observed unsafe conditions.

Diagnostic teams may be used to secure recommendations on improved maintenance procedures as well as specific improvement projects. Proper maintenance of the railroad-highway grade crossing environment may contribute significantly to the reduction of accidents without increased expenditures for capital improvements.

TABLE 13

Unsafe Conditions Observed by Diagnostic Team at Study Rail-Highway Grade Crossings

	Conditions Observed	Percent of Crossings at Which Conditions Observed
1.	Pavement markings missing, improperly located or in need of maintenance.	72
2.	Vehicles required by law to stop at all crossings would present a hazard to other vehicles by blocking traffic lanes and obstructing view of protective device.	60
3.	Driver's visibility of railroad approach obstructed by growth of vegetation.	52
4.	Under nighttime conditions lack of illumination presents additional hazards at grade crossing.	44
5.	Conflicts for driver's attention due to traffic conditions and the location of traffic control devices on adjacent roadways.	40
6.	Advanced warning signs missing, improperly located or in need of maintenance.	40
7.	Absence of area immediately adjacent to grade crossing for the driver to take evasive action.	36
8.	Highway signs and fixed objects obstructing driver's view of protective and warning devices.	32
9.	Fixed mount protective devices or barriers presenting fixed object hazard to vehicles.	32
10.	Legally parked vehicle would block driver's view of protective and warning devices.	28
11.	Geometrics of roadway design contribute to unsafe conditions at the crossing.	20
12.	Railroad protective device not properly located or maintained.	12
13.	Traffic conditions on adjacent roadway conducive to vehicles becoming stalled or stopped on railroad tracks.	8

Exempt Crossing Issue

School buses and public buses carrying passengers, and trucks carrying hazardous materials are required to stop at most public railroad-highway grade crossings pursuant to State motor vehicle laws and ICC Regulations. Although the laws of individual States differ, the specific vehicles generally are not required to stop where: (1) tracks are along or in the roadway (similar to street car tracks) in a business or residential district; or (2) traffic is controlled by a traffic officer or traffic signal.

A third classification has been added to the exempt crossing list by the State of California to include crossings of industrial or spur tracks and certain other tracks where there is sparse train service. In order to qualify for exemption from mandatory stops a crossing in the third classification must be approved by the public agency having jurisdiction after study of the environment of the grade crossing. Conditions such as sight distance, train and vehicular speed and neighborhood development, are a few of the factors considered prior to the assignment of exempt status. The grade crossing is then distinctly marked with an approved "exempt" crossing sign.

The purpose of exempt crossings is to attempt to reduce the hazard created by these special motor vehicles when they are required to stop at low train volume crossings. A vehicle stopped at a railroad-highway grade crossing when no train is present or approaching increases the danger for other vehicles using the highway and has resulted in vehicle-vehicle collisions when such vehicles are decelerating to stop, are stopped, and also when such vehicles attempt to re-enter the traffic stream.

Following the lead of the State of California and the transportation industry of the State, a proposed exempt crossing program is under consideration by the National Safety Council and the National Committee on Uniform Traffic Laws and Ordinances.

The program under consideration contemplates that any person or organization may request that a crossing be declared "exempt." To assure that care is taken in the selection of crossings to be declared "exempt" a diagnostic evaluation would be made prior to such declaration. All interested parties, including the highway agency, railroad(s) involved, regulatory commission and any other interested party or organization would be consulted. The diagnostic team, in evaluating a crossing, would consider, but not be limited to, the following factors:

a. Daylight and night visibility

b. Motor vehicle traffic volume and composition

c. Railroad traffic volume and operating procedures

d. Motor vehicle speed

e. Train speed

f. Crossing environment and neighborhood development

g. Suitable placement of "exempt" sign

Provision for public hearings, should the need arise, would be included. Similar provisions should be made for the addition or deletion of crossings from any "exempt crossing register".

As indicated elsewhere in this report, the number of non-train-involved crossing accidents is estimated at about 28,000 annually. This is clearly a problem to which attention should be directed. As also indicated, there is much speculation about the causes and nature of these accidents, but little hard data to support conclusions.

A primary concern is that an action, or program, to alleviate a particular type of crossing-related problem may actually cause a greater problem. For example, would motorists be unduly confused by the fact that some crossings were exempt and some not? Might this confusion manifest itself at other, more critical crossings? This sort of problem, of course, applies to the entire traffic safety field, but it is especially true in the area of grade crossing safety where little human factors or causal relationship work has been done.

It is perhaps because of these uncertainties that Exempt Crossing programs have not been widely adopted. Although the California program appears to be successful, and is certainly acclaimed by all parties involved, it may be some time before results can be measured. In the meantime, work is continuing to gather and analyze accident data which may provide the basis for program efforts regarding non-train-involved accidents.

VII

THE TRAIN

Unlike motor vehicles, trains cannot be quickly stopped nor can an engineer take evasive action to avoid vehicle-train collisions at grade crossings. Brake application may be required two miles in advance to stop a 10,000 ton freight train. This presents a vastly different situation to the driver of a vehicle approaching a railroad-highway grade crossing than is experienced by a driver arriving at a highway intersection.

Highway traffic control devices assign the space at a highway intersection alternately for use by the conflicting streams of motor vehicle traffic. This technique is not adaptable for use at a railroad-highway grade crossing, where the driver must determine whether a train is approaching. The several forms of grade crossing protection are designed to assist him in this endeavor.

Visibility and Audibility of Trains Approaching Railroad-Highway Grade Crossings

A common cause of grade crossing accidents is failure of the driver to see or hear an approaching train. This is of particular importance at crossings with only passive (signs) protection, where direct view and audibility are the only indicators of the presence of a train. A recently completed Federal Railroad Administration study explored the possibility of enhancing the visibility of the train to the driver by appropriate painting or marking on locomotives and by high intensity flashing lights or rotating lamps mounted on them. The study also explored the effectiveness of audible signals as a method of warning a driver of the presence of a train on or approaching the crossing.

Advantages of the use of conspicuous patterns and colors in marking locomotives seem fairly clear. There are approximately 12,000 train involved grade crossing accidents each year in the country. When the data for urban area accidents are analyzed separately, it appears that many of these accidents occur at crossings of city streets protected by signs only. Furthermore, the type of train usually involved in this type of accident is the rather slow moving switch engine with its relatively short string of railroad cars. Recognizing that there could be rather quick pay offs to a study of the relative effectiveness of improved engine mounted audible and visible warning devices, FRA structured the aforementioned technical study to include the following objectives:

1. To define the performance level of devices in general use on trains for attracting the attention of drivers of motor vehicles.

2. To describe desirable performance levels for devices which are used to make a train more visible or more audible to a driver as he and the train approach a crossing.

3. To identify the extent of nuisance which devices with the qualities or performance levels described above would have in rural, urban and suburban areas under differing conditions.

4. To propose devices which will meet desirable performance levels within acceptable nuisance levels.

A brief summary of the study follows:

Visibility of the Train

A good visual warning system functions in several ways. It informs the driver that something is there, helps him identify the object as a locomotive, and gives him cues for estimating the degree of hazard the locomotive represents. The natural illumination of daylight should be used when available, but artificial lighting is needed as a substitute when natural light is absent. Compounding the problem is the immense variety of backgrounds against which trains must be seen, and the range of lighting and atmospheric environments in which they are operated.

A review was made of the literature pertinent to visual alerting qualities, including such factors as hue and brightness for contrast, size of color areas, fluorescent and regular colors, the use of lights during daylight, and the special problems of night alerting, such as cues for estimating distance and movement. Available lighting devices were surveyed, including headlights, swept headlights and roof lights. Visual displays such as lights and flourescent color panels were applied to a locomotive and evaluated in the field.

Audibility of the Train

Air powered horns are almost universally used on locomotives as the basic audible warning device at grade crossings. The prime objectives in the audibility study were to determine the performance characteristics to the ability of horns to warn drivers in real crossing encounters. Other objectives were to identify the nuisance value of different horns to communities, and to suggest lines for future research into improved audible warnings.

Several techniques were used to measure the sound levels produced by various horns. Stationary measurements of new horns were made at measured locations to provide readings at several known distances and angles. Stationary measurements of horns on in-service locomotives were made in railroad yards, at known distances. Wayside recordings and measurements were made at crossings on several railroads at various locations. Nuisance was studied by a review of the literature on noise and nuisance, and by an experiment in which several sounds were presented to subjects as they performed mathematical tasks.

Findings and Conclusions

The findings and conclusions of the study are summarized as follows:

Audible Warning from the Train:

(a) Horns have marginal output as warning devices in high-speed encounters, as with a train moving at 50 mph and a motor vehicle moving at 50 mph.

(b) A locomotive horn with enough output to be totally effective would be an unacceptable nuisance.

Visibility of the Train as a Warning:

(a) Lights must be very bright to add to conspicuity of locomotive in daylight.

(b) Headlight beam is too narrow for drivers to see well at typical angles of encounter.

(c) Freight cars are hard to see at night in shoving switching movements.

(d) Estimating distance and speed of train by a driver is especially difficult at night.

(e) Large areas of bright color have value for visibility, fluorescent colors are useful. No single color offers high contrast with all background.

Beacon-Reflector Warning Device

One of the interesting concepts derived from the aforementioned study and the further FRA sponsored research at the Transportation Systems Center is a possible train approach warning system that would involve beacon equipped locomotives in conjunction with reflectors at the railroad-highway grade crossing.

Although the primary effectiveness of this system would be direct alerting of the driver, through his peripheral vision view of the locomotive beacon, it appears quite possible that nighttime effectiveness could be significantly enhanced by use of properly designed reflectors at the crossing. It should be noted that such reflectors, if properly designed and located, would operate effectively when illuminated by a locomotive headlight, particularly if it is of the oscillating type so that an intermittent light is seen.

It is important that such a program not be considered as a replacement for flashing light signals. The reflector assembly must not give the impression that absence of a reflected signal is a guarantee

of absence of a train. This raises all of the safety and legal problems associated with non-failsafe systems. The reflector might simply be a symbolic crossbuck, or be inscribed with a legend such as LOOK FOR TRAINS or, simply, TRAINS.

As a measure of the feasibility of this approach, an investment of $1,000 per locomotive (approximately $27,000,000) may be thought of as an expenditure of $150 for each passively protected public crossing, and an additional expenditure of several hundred dollars per crossing might be warranted at many selected locations to provide proper reflectors, These numbers, though merely estimates, arise from preliminary examination of the topic, and are probably of the right order of magnitude. A warning system such as this would be applicable also to a large percentage of the some 140,000 private crossings with only the addition of the reflector. Adding these to the passively protected public crossing provides a possible opportunity to improve safety at some 320,000 railroad-highway crossings.

The tentative nature of this concept suggests the desirability of further research and development.

Reflectorization of Railroad Cars

Reflectorization of the rolling stock of railroads is a common public suggestion for grade crossing safety improvement. It is also a very controversial subject, having been debated for many years by various factions. Federal legislation has been introduced at various times over the years. In 1953 the Interstate Commerce Commission and the Department of Commerce recommended against legislation which would have made railroad car reflectorization or illumination mandatory. However, such legislation had qualified support from ICC. The subject was considered formally by ICC during lengthy hearings in Docket Number 33440, decided January 22, 1964, and at that time the suggestion was rejected. See Prevention of Rail-Highway Grade-Crossing Accidents Involving Railway Trains and Motor Vehicles, 322 ICC 1 (1964).

In order to support any wide scale program to reflectorize railroad cars, it is first necessary to consider whether: (1) truly effective reflecting materials or devices are available under the present state of the art, (2) the safety benefit can be sufficiently identified to justify the expense involved, (3) a reflectorizing program should be mandatory by law or on a voluntary basis, and a program should be financed by the public or the railroads, (4) reflectorizing material currently available can improve safety in many highway environments. It must be recognized, however, that the environment to which railroad cars are subjected is unique and severe. Under normal service, freight cars are constantly subjected to conditions of dirt and grime, and weather extremes. In view of the right-of-way conditions and the overall nature of railroad operations, reflectorizing benefits would seem to be seriously diminished unless the cars receive special maintenance treatment not common in current railroad operating programs. The problem would be compounded for cars used continually in such service as iron, ore, coal, and similar products.

Although it is not an overriding consideration, it is difficult to ignore the serious liability question which arises if reflectorization is made mandatory. In cases involving grade crossing accident claims, the condition of any required reflectorizing material would probably be an issue. Railroads, which are subject to many claims arising from grade crossing accidents, might be held liable for not maintaining the material in its original condition, regardless of whether the reflectors were a contributing factor.

Assuming maintenance practices or procedures which could keep the reflective devices relatively clean, it appears that available products would be sufficiently effective. The fact that many railroads now use reflective markings for advertising and other purposes on their cars, adds to the recognition of the degree of this effectiveness.

Regardless of condition, the presence of reflectorizing material on a railroad car should not be presumed automatically to be a major deterrent to crossing accidents. The extremely diversified range of crossing characteristics provides a variety of problems which make questionable the actual effectiveness of reflectorization. High motor vehicle speeds, restricted sight distance, diverse type of rail movements, widely varying number and layout of tracks, and other unique physical problems, make very questionable the actual amount of improvement to be expected.

Consideration must also be given to the potential for accident reduction, based simply on the number of accidents in which effective reflectorization might have been of help; i.e., the motor vehicle hits-train-in-dark type of accident. Bureau of Railroad Safety statistics for 1970 show a total of 614 such accidents, about half of which involved striking a leading locomotive (the possible improvement of which has been discussed earlier in this section) and about one-fourth of which were at crossings with active protective devices. Although these two sets of data cannot be correlated under present reporting formats, it is estimated that slightly less than half the 614 accidents occurred under circumstances where effective reflectorization might have had some beneficial effect. Applying this same ratio to those accidents which occur but are not reported to BRS, it then appears that approximately 800 accidents are involved annually. Data is not available to determine the types of road systems on which they occur nor is severity data such as to allow a supportable finding as to the benefits which might be derived. It is, at best, a very subjective issue which almost defies quantification until much better information on all aspects of the subject is available.

As indicated, the railroad industry and private car owners are currently bearing the full expense of whatever reflectorization is being done. Whether or not this allocation should remain, in the event of any full-scale program, would be dependent on the severity of the requirements and the time allowed to implement the program. Estimates

of the cost of total reflectorization range from $18 million to $180 million. These estimates are based on a total fleet of nearly 1,800,000 cars, with reflectorization costs ranging from a minimum of $10 to a high of $100 per car. The costs of maintenance and replacement would also be a most important consideration in an economic analysis of a program.

It does not appear that even massive reflectorization of railroad cars can substitute for the far greater results to be obtained by a full program of reflectorization to signs, signals and other markings, with particular attention to advance warning techniques. In this same regard, inasmuch as the purpose of car reflectorization would be to assist in showing the presence of a car on a crossing, it should not be overlooked that overhead lighting or illumination at the crossing serves essentially this same purpose and that in the long run could well be a more effective and more economic choice.

Impact Attenuation on Trains

In the proceedings of the first National Grade Crossing Safety Symposium, a member of the staff of the National Transportation Safety Board (NTSB) put forth the following proposal:

> "Consider the possibility of cushioning the automobile by placing a structure on the front of the train that will cushion the shock and deflect the auto off to the side of the track."

It was further explained in the discussion of this proposal that the technical problem associated with the survival of people riding in cars is not the acceleration or shock of impact, but is related to the crushing of the structure of the car by the structure of the front of the train. Since the structual members on the front of the train are heavy steel while the structure of automobiles is very light steel (fiber glass in some instances) the problem is magnified.

While there may be some opportunity for improvement in this area, a great deal of work must be done before the feasibility of such a concept can be established. It presently appears that neither impact attenuation or deflection will be useful at other than very low speeds. The Federal Railroad Administration has included in its current program a research project that will continue to investigate the feasibility of the NTSB proposal. The preliminary testing of the impact of vehicle train collisions will be conducted at the DOT Pueblo test track.

VIII

PEDESTRIAN PROTECTION

Definitions

Prior to a discussion of pedestrian safety along railroad rights-of-way, it may be helpful to define terms that are used throughout this section of the report.

Densely Populated Area

For purposes of this report a densely populated area has been defined as any municipality which has a population in excess of 500 persons per square mile or which is contained within a Standard Metropolitan Statistical Area (SMSA) of population density greater than 500 persons per square mile. In the United States, there are 110 SMSA's which have population in excess of 250,000. Of these 110, there are forty with population density in excess of 500 persons per square mile and, therefore, were considered to be high-density areas. These high-density areas include Boston, Chicago, Cleveland, Detroit, Jersey City, Los Angeles, New York City, Newark, Philadelphia, Providence, San Francisco, Trenton, St. Louis, and Washington, D.C. among others.

Pedestrians Along Railroad Rights-of-Way

Pedestrians along railroad rights-of-way has been defined as any person other than a motor vehicle occupant or passenger on a train who is on railroad property for reasons other than working for a railroad or in a railroad-related occupation. Pedestrians include commuters and other railroad passengers during the time that they are on railroad property but not on trains. They also include all persons trespassing on railroad property such as children, vandals and commuters crossing tracks other than at authorized places. Not included as pedestrians are persons involved in motor vehicle grade crossing accidents as well as accidents involving passengers on trains. The definition excludes consideration of the protection of railroad employees or employees of railroad contractors who are working, coming to or going from work.

Persons injured in stations or not on railroad property but as a result of train accidents or objects thrown up by or broken off of passing trains are considered to be pedestrians.

Trespasser

A trespasser has been defined as any person on railroad property for unauthorized reasons or at other than authorized places (stations, grade crossings). A pedestrian has also been defined as a trespasser when crossing tracks at a grade crossing by going under or around activated crossing gates. The definition of a trespasser at a grade crossing is not a legal distinction, but was used to conform with the convention of the study's principal data source.

Statistical Procedures

The only definitive body of data available on pedestrian accidents at this time is the accident reporting system of the Bureau of Railroad Safety. The quantitative data in this study was derived from the BRS accident reports. Consequently, the data only reflects accidents as reported by common carriers by rail. It does not include any information about pedestrian accidents on rapid transit systems such as the New York City Transit Authority, the Chicago Transit Authority, or the Massachusetts Bay Transportation Authority in Boston. On the other hand, it does contain accident data on the commuter operation of such railroads as the Penn Central, Illinois Central, Southern Pacific, Burlington Northern and the Chicago & Northwestern. Therefore, the body of data provides a good cross section of the nature of pedestrian accidents but may understate the total number of accidents to some degree.

The interstate carriers report to the Bureau of Railroad Safety all accidents which involve fatalities or injuries to nonemployees "if the injury is sufficient to incapacitate the injured person from following his customary vocation or mode of life for more than 24 hours in the aggregate during the ten days (240 hours) immediately following the accident." This distinction of an injury probably excludes some minor accidents from being reported, particularly those in stations, but overall the definition appears to be sufficient to assure a level of reporting of pedestrian accidents which is consistent with the reporting of highway and other transportation accidents. An analysis of the accident reports showed that some reports were being filed for accidents not involving trains when the only injuries were abrasions and minor contusions. It is apparent that few if any accidents which involved pedestrians being struck by trains would be excluded from reporting by these criteria.

Scope of the Problem

There are about 1,350 pedestrian right-of-way casualties reported annually by the interstate carriers, 840 in densely populated areas, and 510 in other areas. In contrast, the interstate carriers in 1969 reported 25,650 casualties of all kinds, including 17,450 employee casualties (68%),

870 passenger and commuter on-train casualties (3.4 percent), 4,920 motor vehicle grade crossing accident casualties (19 percent), and 1,350 pedestrian right-of-way casualties (5.3 percent). The figures above indicate that the pedestrian right-of-way accident is a small part of the total railroad safety problem. On the other hand, the 650 total annual pedestrian right-of-way fatalities comprise 28 percent of the total 2,300 reported railroad accident fatalities from all causes.

Accidents in High Density Areas

Table 14 shows the average annual number of fatalities and injuries to pedestrians in densely-populated areas as defined in this study and estimated from the sample data. However, Table 14 does not include injuries to nontrespassers in stations or in areas other than the right-of-way where trains were not involved. This class of accident involves commuters and other passengers and is primarily a matter of slipping or falling.

The table indicates there were 838 pedestrian injuries and fatalities per year along railroad rights-of-way during the period 1968-1970. These accidents resulted in 353 fatalities and 485 injuries, a very high fatality-injury ratio for transportation accidents. About 80 percent of the casualties (injuries and fatalities) were trespassers, persons on railroad property in unauthorized areas. The remaining 20 percent were pedestrians at grade crossings with flashing lights or nonactuated warning devices such as crossbuck signs (10 percent), and pedestrians hit by derailed cars or objects thrown up by passing trains such as bolts and rocks (10 percent).

Most of the train-involved accidents which resulted in injuries or fatalities to pedestrians were caused by:

(1) Persons being struck by trains while crossing, standing on, sitting on, or lying on tracks and persons hurt by jumping out of the way of trains, primarily from bridges or trestles.

(2) Persons falling off freight cars, being run over or caught between freight cars while riding freight trains, attempting to cross under or through them.

The first class of accident is by far the most prevalent and accounts for 66 percent of all pedestrian right-of-way accidents. It includes all reported cases of persons being struck while crossing tracks. It also includes a considerable number of reports of hoboes and drifters lying on tracks, apparently asleep, and a number of apparent suicides by standing on tracks or running into approaching trains. No attempt has been made to provide a classification of the details of these accidents because sufficient information for this type of analysis is not available.

The second class of accident comprises 22 percent of all pedestrian right-of-way accidents. Whereas the first class of accident is primarily a case of a train striking a person, the second class is the case where a person was injured while being on or under a train. This classification includes (1) falls from trains whether or not the casualty was subsequently run over, (2) accidents where persons were run over while passing under trains or where limbs were caught in couplers while persons were passing between cars, and (3) accidents involving "train hitchhikers" while they are riding on trains.

The remaining 12 percent of pedestrian right-of-way accidents do not involve trains. These are mostly case of persons slipping or falling on railroad property.

There were 19 fatalities and 32 injuries listed as trespasser accidents at grade crossings. These casualties were reported as trespassers because they had walked around or under activated pedestrian gates at crossings before contacting a train. Casualties at grade crossings protected by flashing lights or nonactivated devices are considered to be nontrespassers, and there were 32 fatalities and 50 injuries of this type. The data indicated that 63 persons annually are nontrespasser right-of-way casualties injured at places other than crossings. The great majority of these accidents involves persons in stations or off the right-of-way (not on railroad property) who were struck by derailed equipment, struck by debris thrown up by or broken off of trains, or otherwise injured as a result of derailments.

TABLE 14

ANNUAL PEDESTRIAN INJURIES AND FATALITIES IN
DENSELY POPULATED AREAS ALONG RAILROAD RIGHTS-OF-WAY

LOCATION	TRESPASSERS Killed	TRESPASSERS Injured	NONTRESPASSERS Killed	NONTRESPASSERS Injured	TOTAL Killed	TOTAL Injured	TOTAL
At Grade Crossings	19	13	32	50	51	63	114
In Yard Limits	6	107	---	25	6	132	138
Outside Yard Limits	271	164	---	13	271	177	448
Unknown	25	88	---	25	25	113	138
TOTAL	321	372	32	113	353	485	
Total Killed and Injured		693		145		838	

Source: Bureau of Railroad Safety Accident Reports 1968-1970 (5.3% Sample)

Accidents Involving Juveniles

About 700 of the 840 pedestrians killed or injured in right-of-way accidents in densely populated areas are trespassers. About 300 of these 700 trespassers are juveniles. Thus, about 35 percent of all right-of-way pedestrian accidents involve juvenile trespassers and about 19 percent involve juveniles under the age of 14. Some of these juveniles are on unfenced rights-of-way solely for the purpose of crossing. Others are using fenced or unfenced rights-of-way as playgrounds and may be involved in vandalism.

Right-of-Way Trespasser Casualties

	Number		
Age	Killed	Injured	Total
Under 14	50	107	157
14-20	63	76	139
Over 21	208	189	397
Total	321	372	693

Important Accident Subclasses

Bridges and Trestles. Railroad bridges seem to be especially attractive to juveniles even though they are extremely dangerous. The sample indicated there are about 40 juveniles killed or injured annually as a result of being hit by a train while on a bridge or trestle or jumping or falling from a bridge while attempting to avoid being struck by a train. Also, the severity of this type of accident appears to be even greater than that of train-involved pedestrian accidents in general.

Catenaries. Catenaries are the overhead wiring systems used to carry energy to electric locomotives. Catenary accidents may or may not involve trains. All of the catenary accidents in the sample data involved juveniles and all resulted in serious injury or death. Minor catenary accidents are rare because all of them result in severe electric shock, and there is a strong probability that a fall from the top of a boxcar will follow. While there may be a general awareness of danger associated with catenary systems as with power lines, few people outside the railroad industry are aware that the electrical potential is so great that shocks can result without actual contacting of the wire.

Multiple Track Grade Crossings

A unique type of pedestrian accident is the case where a pedestrian at a double or multiple track grade crossing is struck while standing on a near track waiting for a train to clear the crossing on a far track. The pedestrian is usually watching the train on the far track and does not hear a second train approaching on the track he is occupying because of the general level of noise or confusion. The horn and bell on the second train often cannot be heard by the pedestrian or are mistakenly determined to be coming from the first train.

It was not possible to determine how many of the pedestrian accidents at grade crossings were of the two-train type described above. Neither was it possible to develop at this time the effectiveness of various types of pedestrian protective devices at grade crossings.

Accidents in Low Density Areas

The data indicated that in addition to the 840 pedestrian right-of-way casualties in densely populated areas, there were 517 casualties in low density areas. Thus, about 62 percent of all pedestrian right-of-way accidents occur in densely populated areas. Of the 517 casualties in low density areas, 296 were fatalities and 221 were injuries. Thus, the fatality-injury ratio is 1.34 in low density areas but only 0.73 in densely populated areas.

The higher severity of pedestrian accidents in low density areas is caused by higher train speeds and other significant differences in the rail environment. There is less switching and more through movement in low density areas so there are relatively fewer persons injured getting on and off trains and relatively more struck by moving trains.

Statistical Trends

Prior to the preparation of this report there were no statistics on the incidence of pedestrian-railroad accidents in densely populated areas. The data in the study were developed from the reports of the Bureau of Railroad Safety which is the only comprehensive information system covering this type of accident. Individual accident reports in this system are only retained for a 3-year period. There are summary statistics covering the last 10 years, but the information is not stratified by population density nor any other major parameters of this study.

Table 15 shows the number of casualties classed as trespassers in all types of railroad accidents during the period 1961-1970. The

accidents differ in some important respects[1] from the group of accidents with which this study is concerned but there are no strong reasons why the trends evident in this data should differ significantly from those which could be derived from the target data if it were available.

Preventative Measures

The data outlined above indicate that there are an estimated 850 pedestrian injuries and fatalities annually in densely-populated areas.

Trespassing on rights-of-way at places other than grade crossings was the cause of 79% of all pedestrian right-of-way accidents in densely-populated areas. An understanding of the factors which motivate pedestrians to enter railroad rights-of-way is essential for the determination of effective preventative measures. Three important factors motivating persons to enter railroad rights-of-way are the following:

Track Crossings: A regrettable side-effect of the pattern of our urban development is that railroad rights-of-way often act as physical dividers between important, interrelated elements of communities, particularly in densely-populated areas. Some of these inter-related elements are homes and schools, homes and jobs, home and the commuter stations by which jobs are reached, homes and shopping areas, and homes and play areas.

Juvenile "Play Areas": Whether or not railroad rights-of-way are located between homes and schools or playgrounds, they have always attracted and fascinated juveniles as "play areas" in their own right. The potential of rights-of-way as "play areas" has increased as population growth and urban development moved out from city centers.

Train Hitch-hiking: The practice of "hopping" freight trains is extremely hazardous, especially to juveniles and hoboes or drifters who may be suffering from illness, malnutrition or intoxication.

The following is a discussion of the types of preventative measures which are and can be employed to reduce the incidence of pedestrian accidents. The measures discussed are full right-of-way fencing, selective fencing, separated crossings, raised platforms, warning signs, education, surveillance and alternative measures for protection of pedestrian at-grade.

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[1] The accidents occurred in both urban and rural areas and involved trespassers only.

TABLE 15

ANNUAL TRESPASSER INJURIES AND FATALITIES IN URBAN AND RURAL AREAS, 1971-1970

	Walking Along Tracks	Crossing Tracks At Public Highway Crossing	Crossing Tracks At Other Places	On or Getting On or Off of Trains	Miscellaneous	Total
1961	151	124	135	284	608	1.302
1962	165	127	92	255	656	1,295
1963	171	124	124	259	551	1,229
1964	188	134	117	289	602	1,330
1965	157	158	118	232	637	1,302
1966	236	179	134	285	546	1,380
1967	197	145	120	265	615	1,342
1968	194	124	137	204	632	1,291
1969	206	226	96	196	577	1,301
1970	195	207	106	187	544	1,239

Source: Bureau of Railroad Safety Accident Bulletins

Fencing

Because the deterrence of pedestrian access to railroad rights-of-way is such an obvious answer to the problem, a commonly proposed solution is fencing. Proponents of fencing cite its effectiveness and its precedents. They reference the common law decisions regarding "attractive nuisances" which have required that all potentially hazardous industrial installations must be physically separated from public areas by fencing or other means. On the other hand, opponents of fencing cite its cost, maintenance problems, inapplicability to the railroad environment and susceptibility to vandalism.

There are two types of fencing which can be effective with respect to the prevention of two different forms of the pedestrian problem. Enclosed right-of-way fencing is used to restrict access to the right-of-way by juveniles and potential train hitchhikers. It commonly consists of 6-8 foot high chain link fencing and is sometimes topped with three strands of barbed wire. It is usually placed on both sides of the right-of-way, but in some circumstances can be just as effective if it were placed on only one side (i.e., where a residential area was on one side and a field or industrial area was on the other). Enclosed right-of-way fencing on one or both sides of the right-of-way has the side benefit of preventing track crossings.

Some problems associated with enclosed right-of-way fencing are that it is expensive to construct and maintain, is vulnerable to vandalism and is much less effective when not fully maintained. It also has the shortcoming of being discontinuous at grade crossings.

The cost of constructing full right-of-way fencing is approximately $90,000 per route mile.[1] Of the estimated 30,000 railroad route miles in densely-populated areas, it is assumed that two-thirds of the mileage is not presently fenced. Therefore, full fencing route miles in densely-populated areas not now fenced could cost as much as $1.8 billion.

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[1] Testimony of the staff of the New York Public Service Commission in Case 25610: proceeding on motion of the Commission as to the protection provided by Penn Central Transportation Company on its Hell Gate line in the Borough of the Bronx, City of New York.

Alternatively, a single waist-high fence parallel to the track and across a pedestrian crossing route can be an effective deterrent to track crossing. This type of fence can be made of wood, chain link, plain or barbed wire, wrought iron or pipe and is usually placed between two tracks on multiple-track rights-of-way. It is commonly observed at commuter stations. Protection of this type is less expensive than full right-of-way fencing because the fence is lower and only one length need be used.

Separated Crossings and Raised Platforms

In order for fencing to be effective, pedestrian crossings over or under the right-of-way should be provided at reasonable intervals along the tracks. The absence of such crossings is a strong inducement for persons to cut through or knock down the fencing.

Raised platforms at commuter stations in conjunction with separated crossings will increase the effectiveness of inter-track fencing, but they are very costly and are generally warranted only where there is high commuter volumes and train frequencies.

Improved Signing

The quantitative data indicated that certain areas or aspects of railroad rights-of-way are more hazardous than others. Two of these features are bridges and catenary structures.

With or without other preventative measures, it is believed that the placement of effective warning signs at the ends of bridges and along electrified segments of the rights-of-way can reduce accidents involving juveniles. These signs should provide both symbolic representation and the warning legend.

The warning legend and symbols should be indicative of the potential hazard. For example, a catenary warning could depict a stick figure on top of a boxcar below the catenary with a lightning bolt between the wire and the child. A bridge warning could depict a figure on a bridge as a train approached, and the caption could read "no time to run."

Education

Safety education, particularly of actual and potential juvenile trespassers but also of adults, can reduce the incidence of right-of-way accidents. Safety education should be effective either as a substitute for or a complement to fencing and other preventive measures. Individual railroads as well as the Association of American Railroads for many years have conducted active railroad safety programs through

the schools. Several railroads have safety officials or railroad police lecture at schools, often in conjunction with the movies. The Southern Pacific has started a unique program in the Los Angeles area by hiring a young man who lost a leg in a railroad trespassing accident to give lectures at certain schools along the SP lines.

Surveillance and Enforcement

No form of protection for pedestrians on railroad rights-of-way can be effective without some level of surveillance and enforcement.

Railroad rights-of-way are usually patrolled by railroad police. Local law enforcement agencies are also active in major problem areas. However, in many cases budgetary pressures on the railroads and local governments have forced lower levels of surveillance and enforcement.

In order for patrolling of the right-of-way by either force to be an effective deterrent to pedestrians, it is also necessary that there be efficient, effective punitive measures. Trespassing on railroad property is generally considered to be only a misdemeanor. Consequently, law enforcement officials are often indisposed to prosecute these types of cases.

One railroad has proposed that a more effective procedure for some forms of railroad trespassing would be to treat it like jaywalking, issuing a citation with automatic imposition of a fine if a hearing was waived. This procedure would impose some burden on the trespasser who might otherwise only be reprimanded. It may also aid in shifting the burden of keeping juveniles off the right-of-way from the police to parents.

Grade Crossing

Pedestrian accidents at grade crossings in densely populated areas result in 51 fatalities and 63 injuries annually. Of these 114 casualties, 32 occur at crossings protected by actuated pedestrian gates. Because there are so many more crossings that are not protected by pedestrian gates and because pedestrian gates almost always have the same lights and bells as other actuated warning installations, the fact that 28% of all pedestrian accidents at grade crossings occur because pedestrians go under or around actuated gates indicates that these devices are not fully effective.

Summary

It is clear from the varied nature of accidents involving pedestrians, the widely dispersed locations of those accidents and the variety of existing preventive measures that programs to reduce pedestrian accidents must be designed for the particular problems affecting

specific local areas. Programs could include one or more of the types of preventative measures outlined above. Because of the variety of factors which may contribute to pedestrian hazards in different local situations, detailed studies are necessary to determine the most effective measures warranted. These studies could be conducted by groups similar to the grade crossing diagnostic teams discussed elsewhere in this report.

Special Issues

High Speed Rail Service

The danger to pedestrians on railroad rights-of-way increases with higher train speeds because both the pedestrians and the enginemen have less warning time of the others presence. Also, the severity of an accident involving a high-speed train can be expected to be greater. At the same time, the danger to trains and their occupants from vandalism increases with train speed. Therefore, there is the dual consideration in high speed rail territory of providing a safe environment for the train service and reducing hazards to pedestrians.

Vandalism

The railroad industry has been affected considerably by increasing vandalism and other crime in recent years. Juveniles (and some adults) break into freight cars to steal merchandise, throw rocks at the windows of commuter and passenger trains, uncouple trains in motion and attempt to derail trains by placing objects on the tracks or misaligning switches. Enginemen have been blinded and have suffered severe mental damage as a result of their windows having been shattered by bricks suspended by ropes from overhead structures. Recently, a Metroliner was derailed by a refrigerator loaded with truck tires which had been placed on the tracks. Sections of the main passenger rail line between New York City and Boston are virtual siege areas where passenger trains, including the Turbo-Train, are regularly attacked by bands of rock-throwing youths. Engine crews on slow-moving freight trains lie on the floor because of the hazards. These types of incidents are evident in almost all major urban areas.

Therefore, not only pedestrians, but also railroad passengers and employees could benefit from those measures which reduce access to railroad property of unauthorized persons.

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APPENDIX A

A LEGAL-HISTORICAL REVIEW OF THE DIVISION OF RESPONSIBILITY FOR THE ELIMINATION AND PROTECTION OF RAILROAD-HIGHWAY GRADE CROSSINGS

C O N T E N T S

Foreword . . . . . A 3

The First Sixty Years . . . . . A 3

"Senior-Junior" Principle of Responsibility. . . . . A 5

States and Courts Place Major Responsibility Upon Railroads. . . . . A 5

Motor Vehicles Change Safety Problem . . . . . A 7

Federal Aid for Grade Crossing Projects. . . . . A 8

Railroads Plead Financial Inability. . . . . A 8

Private Crossings. . . . . A 9

Public Responsibility is Recognized and Implemented. . . . . A 11

Landmark Court Decision on Responsibility. . . . . A 12

Some States Change Their Criteria. . . . . A 14

Federal Regulation of Grade Crossings Opposed. . . . . A 15

An Era of Safety Progress. . . . . A 15

More Responsibility Assumed by Federal Government. . . . . A 16

Federal Criteria for Responsibility Established. . . . . A 17

Several States Revert to Prior Criteria. . . . . A 18

"Economic Benefits" Basis for Responsibility . . . . . A 19

State Grade Crossing Elimination and Protection Funds. . . . . A 20

Federal-Aid Highway Funds. . . . . A 21

Federal Aid Highway Acts Codified. . . . . A 22

ICC Findings on Responsibility and Jurisdiction. . . . . A 22

State Support for Public Responsibility. . . . . A 24

Landmark Federal Legislation in 1970 . . . . . A 28

Summary and Conclusions. . . . . A 30

Reference Sources. . . . . A 32

Foreword

The safety problem at railroad-highway grade crossings is more than a century old but remains a matter of great public interest and importance today. Over the years grade crossings have been the scenes of many spectacular and tragic accidents, and currently the number of fatalities and injuries resulting from such accidents is alarming. Higher casualty figures are expected in the future unless something is done soon to reduce the number of accidents at grade crossings.

An issue, which is as old as the grade crossing safety problem itself, is that of responsibility. Who should provide and pay for the protection or other improvements needed at grade crossings? Financing of the now-existing protection and the allocation of costs between the railroads and Federal, State and local authorities over the years has been a complex task, and future solutions to the grade crossing safety problem will require larger expenditures of money to keep pace with advancing transportation technology.

In order to establish a reasonable and equitable policy and guidelines for the future in the matter of division of responsibility and financial participation, careful consideration must be given to the legal and economic factors involved. It is important to look at the history of the railroad-highway grade crossing safety problem, the changes and developments which have occurred, and the criteria which have been followed for the division of responsibility under past and existing Federal and State laws, State commission regulations and orders, Federal and State court decisions, and private agreements.

The First Sixty Years

Prior to 1830 there were no railroad-highway grade crossings in the United States, because there were no railroads--and only a few highways or streets. The Nation's population was centered in those States east of the Allegheny Mountains, and most of the country to the west was largely wilderness, unsettled and undeveloped. A reliable, economical and rapid method of transportation was needed to open up the West, to stimulate commerce, and to unite the country. The timely birth of the railroad industry in 1830 in the United States provided the means. By the end of that year some 23 miles of railroad were built in the Atlantic Seaboard States, and by 1840 the total trackage had increased to 2,818 miles. Every community of any importance wanted a railroad, and certain concessions were made to obtain one. As a primary concession the railroads were allowed under contracts or ordinances to build their tracks across existing streets and roads at grade, primarily to avoid the high capital costs of grade separations which could have discouraged building of the railroads. Some of the communities objected to making any changes

in the grades of existing highways and streets. Few people, if any at that time, envisaged the safety problem which would result from such crossings at grade.

During the years from 1850 to 1870 the Federal Government and certain States encouraged the westward expansion of the railroads and financially supported them by land grants and loans. There were few highways and streets west of the Alleghenies, so grade crossings were originally few in number. However, a tremendous growth in population followed the railroads west. Consequently, there was a need for new highways and streets, practically all of which crossed the railroads at grade, again for economic reasons. As the population increased in certain areas some of these grade crossings which were originally thought to be safe were no longer considered so. In most cases the responsibility and financial burden of protecting these crossings automatically fell upon the railroads. This responsibility was based primarily upon the old legal maxim that "he who creates and maintains upon his premises a condition dangerous and inimical to others is under a legal obligation to guard and protect it so that injury to third persons may not result therefrom." At the beginning, this burden of responsibility was not arduous and the expense to the railroads was not great. Trains were few in number and slow, as were the highway travelers who were mostly on foot, horseback, horse-drawn vehicles, or cycles. Occasionally, there were accidents at grade crossings, but they were not usually as serious as those occurring today.

One of these early accidents, involving the collision of a train and wagon at Lima, Indiana, resulted in a court suit which eventually reached the U.S. Supreme Court in 1877. In Continental Improvement Co. v. Stead, 95 U.S. 1 (1877), the Court had to determine who was liable for the damages incurred. In its decision the Court said that the duties, rights and obligations of a railroad company and those of a traveler on the highway at the public grade crossing were "mutual and reciprocal." It also said that a train had preference and the right-of-way over grade crossings because of its "character", "momentum", and "the requirements of public travel by means thereof," but that the railroad was bound to give due, reasonable and timely warning of the train's approach. The Court further stated that "those who are crossing a railroad track are bound to exercise ordinary care and diligence to ascertain whether a train is approaching." In this particular instance the driver lost his case, because he did not exercise such caution. However, the dicta by the Supreme Court in this early decision clearly indicated for the future that there was a responsibility upon the railroads to warn travelers on the highways of approaching trains and a responsibility upon such travelers to look, listen and stop for approaching trains. These responsibilities continued to be mutual as an increasing number of highway users became exposed to more hazards and inconveniences at an increasing number of grade crossings.

By 1890 there were 163,605 miles of railroads in this country, and a corresponding increase in the number of grade crossings. The number of accidents at grade crossings also had increased. The various communities being affected thereby were becoming more alarmed about such accidents

and also the delays being incurred at crossings by highway traffic. Many States, cities, and towns began demanding that the railroads take immediate action to eliminate the hazardous grade crossings and to provide better protection at others to minimize the accidents. Numerous laws, ordinances, and regulations were enacted or adopted to enforce these demands. There was no uniform pattern with regard to the delegation of enforcement authority, the division of responsibility, or the allocation of costs for the safety projects ordered.

There were requirements for railroads to build fences and cattle guards along their entire rights of way; train speeds to be reduced; locomotive engineers to be examined and licensed; bells, whistles, lookouts, and warning devices to be installed on locomotives; gates, lighting, signaling, and other warning devices to be erected at crossings; and various other safety precautions. In 1888 the State of Massachusetts, by legislative action, appointed three civil engineers to study the possibility of gradually eliminating all of the railroad-highway grade crossings in that State. The engineers made their investigation in a short time and reported that it would cost almost $40.8 million dollars just to eliminate that State's 2,247 grade crossings, which was more than $18,000 per crossing. The plan was dropped soon thereafter, because it was considered to be economically impracticable.

"Senior-Junior" Principle of Responsibility

In 1893 the U.S. Supreme Court in New York & N.E. Ry. v. Town of Bristol, 151 U.S. 556, upheld the constitutionality of a Connecticut statute which required the railroads to pay three-fourths of the costs for the alteration or elimination of grade crossings in that State where the highway was in existence before the railroad was constructed, and one-half of such costs where the highway was constructed after the railroad. This so-called "Senior-Junior" principle was followed by the commissions and courts in several State jurisdictions to determine the railroads' division of responsibility or liability for the construction, alteration or elimination of grade crossings. See Trustees of New York N.H. & H.R.R. v. City of New Bedford, 315 Mass. 154, 52 N.E. 2d 324 (1943); Prosser v. Seaboard Air Line Ry., 216 S.C. 33, 56 S.E. 2d 591, cert. denied, 339 U.S. 911 (1949); and 44 Am. Jur. Railroads §297 (1942). The principle later appeared as one of the guidelines (Class IV on page A-17 herein) being used by the U.S. Bureau of Public Roads (now Federal Highway Administration) in determining the division of responsibility for grade crossing projects on Federal-aid highway systems.

States and Courts Place Major Responsibility Upon Railroads

The 1889 Connecticut statute mentioned in the Bristol case required a railroad, if financially able to do so, to eliminate one grade crossing in the State each year, at its own expense, for every 60 miles of track located in that State. If the railroad did not select the crossing, the State Railway Commission had the authority to do so. The Commission selected one and found that the railroad was financially able to pay for the grade crossing project, that the particular crossing selected was

dangerous, and that public safety required its removal and relocation at a different place. The Supreme Court of Connecticut upheld the Commission's findings, and in its opinion affirming that court, the U.S. Supreme Court in the Bristol case, supra, said:

> "The conclusions of this court have been repeatedly announced to the effect that though railway corporations are private corporations . . . their uses are public . . . that therefore they are subject to legislative control in all respects necessary to protect the public against danger, injustice and oppression; that the state has power to exercise this control through boards of commissioners; that there is no unjust discrimination and no denial of the equal protection of the laws in regulations applicable to all railway corporations alike; nor is there necessarily such denial nor an infringement of the obligation of contracts in the imposition upon them in particular instances of the entire expense of the performance of acts required in the public interest, in the exercise of the legislative discretion; nor are they thereby deprived of property without due process of law, by statutes under which the result is ascertained in a mode suited to the nature of the case and not merely arbitrary and capricious; and that the adjudication of the highest court of a state, that in such particulars a law enacted in the exercise of the police power of the state is valid, will not be reversed by this court on the ground of an infraction of the Constitution of the United States."

The U.S. Supreme Court in Chicago, B&O Ry. v. Chicago, 166 U.S. 226, (1896), also upheld the validity of an 1880 ordinance which authorized the City of Chicago by condemnation procedures to extend or widen its streets over railway tracks or rights of way, which action resulted in the railroad being required to provide protection gates and a control tower at the crossing at its own expense. Justice Harlan, in writing the opinion for the Court, said:

> "The expenses that will be incurred by the railroad company in erecting gates, planking the crossing, and maintaining flagmen, in order that its road may be safely operated . . . necessarily result from the maintenance of a public highway under legislative sanction and must be deemed to have been taken into account when it accepted the privileges and franchises granted by the state. Such expenses must be regarded as incidental to the exercise of police powers of the state."
>
> * * *
>
> "The items of expense for which appellant claims compensation are such as are involved in its compliance with a police regulation of the state. It is well settled that neither a natural person nor a corporation can claim damages on

account of being compelled to render obedience to a police regulation designed to secure the common welfare . . . . Uncompensated obedience to a regulation enacted for the public safety under the police power of the state is not a taking or damaging without just compensation of private property or private property affected with a public interest!"

From 1896 to 1935 the U.S. Supreme Court adhered to the oposition that by the exercise of its police powers a State could allocate to the railroads all or a portion of the expense or cost for the construction, maintenance, alteration, elimination or protection of public railroad-highway grade crossings to meet local transportation needs and to further public safety and convenience made necessary to the growth in population. See Chicago, G&O R. R. v. Nebraska, 170 U.S. 57 (1898); Detroit Ft. W & B.I.R.R. v. Osborn, 189 U.S. 383 (1903); Chicago, B&O R.R. v. ex rel. Grimwood, 200 U.S. 561 (1905); Northern Pac. Ry. v. Minnesota, 208 U.S. 583 (1907); Cincinnati I&W R.R. v. Connersville, 218 U.S. 336 (1910); Chicago, M&St. P.R.R. v. Minneapolis, 232 U.S. 430 (1914); Denver & R.G. R.R. v. City & County of Denver, 250 U.S. 241 (1919); Nashville, C. & St. L. Ry. v. Walters, 294 U.S. 405 (1935). These cases also established the doctrine that the exercise of police powers by the States in the interest of public health and safety was to be maintained unhampered by any contracts of private interests. The railroads had argued unsuccessfully in a few instances that the grade crossings had been established pursuant to contracts with and ordinances of the various municipalities, and that the Federal or State governments and courts should not interfere with such private contracts.

Motor Vehicles Change Safety Problem

The grade crossing safety problem was changed greatly by the appearance of motor vehicles on the Nation's highways and streets in 1893. By 1900 there were more than 8,000 motor vehicles registered, and more highways and streets were being built to accommodate them. At that time all road or highway construction programs, and the financing therefor, were exclusively a function of the local governments. As the motor vehicle population increased and their use became more general, the demand for new and better roads exceeded the ability of the local governments to finance highway construction. New sources of revenues and funds had to be found. The imposition of motor vehicle taxes and the creation of State-aid funds resulted. Motor vehicle registration and license fees were first levied in New York in 1901. The first gasoline tax was enacted in 1919 in Oregon. By 1929 every State was collecting such a tax, and three years later the Federal Government started collecting a gasoline tax.

New Jersey in 1891 was the first to appropriate State funds for highway construction, and by 1917 all of the States were providing some kind of highway aid. As the number of motor vehicles, highway mileage, and railroad trackage increased in the early 1900's, so did the number of grade crossings and grade crossing accidents. The demands for elimination of grade crossings grew stronger nationwide. Because of the dominance and financial status of the railroad industry during this period, the public,

State legislative and regulatory bodies, and most of the courts did not hesitate to place the major or entire responsibility for grade crossing separations and protection upon the railroads. Only a few State courts held to the contrary. With reference to them, the U.S. Supreme Court in Missouri Pac. Ry. v. Omaha, 235 U.S. 121 (1914) said:

> "In placing the expense entirely upon the railroad company, whose locomotives and trains are principally responsible for the resulting danger to the public, we do not find such abuse of the recognized authority of the state as has justified the courts in some cases in enjoining the enforcement of state and municipal legislation."

By 1915 the railroads were beginning to feel the impact of the grade crossing safety problem, and established a national committee to study and cope with the problem. During the period from 1915 to 1924, this committee and the National Safety Council; which was organized in 1913, engaged in numerous safety activities to reduce the number of accidents at grade crossings.

Federal Aid for Grade Crossing Projects

The first authorization of Federal-aid funds for highway construction occurred in 1912, when Congress responded to public demands for better highways by allocating $500,000 for an experimental rural post road program. In July 1916, Congress passed the Federal-aid Road Act which provided Federal funds to be used by the States for the construction of "rural post roads." The primary limiting factor was that the States had to match these funds on a 50-50 basis. Of considerable importance was the fact that some of these funds, as expended through the regular Federal-aid highway program, could be and were used for projects to eliminate hazards at railroad-highway grade crossings. This was the first time that Federal funds had been used for such projects. On many of these projects, however, the railroads were required under State laws to pay as much as the States' 50 percent share, and on certain occasions paid more. The 1916 Act was followed by the Federal Highway Act of 1921, which restricted the expenditure of Federal funds on a 50-50 basis to a limited connected system of principal roads, now called the Federal-aid primary highway system. Other Federal-aid highway acts followed in later years. The Federal Highway Administration administers the Federal-aid highway program established under these acts.

Railroads Plead Financial Inability

By 1920 the railroads were feeling the economic impact and drain of funds caused by the ever increasing demands for grade crossing separations and improvements. Some railroads argued that such projects would eventually force them into bankruptcy, and others pleaded financial inability. The Erie Railroad Company made such an argument before the U.S. Supreme Court in Erie R.R. v. Board of Public Utility Commissioners, 254 U.S. 394 (1920). The railroad had been ordered by the State commission

to alter or remove 15 grade crossings in the City of Paterson, New Jersey, at its own expense. Justice Holmes, in the Court's decision, said:

> ". . . the authority of the railroads to project their moving masses across throughfares must be taken to be subject to the implied limitation that it may be cut down whenever and so far as the safety of the public requires. It is said that if the same requirement were made for the other grade crossings of the road it would soon be bankrupt. That the states might be so foolish as to kill a goose that lays golden eggs for them has no bearing on their Constitutional rights. If it reasonably can be said that safety requires the change it is for them to say whether they will insist upon it, and neither prospective bankruptcy nor engagement in interstate commerce can take away this fundamental right of the sovereign of the soil . . .
>
> To engage in interstate commerce the railroad must get on to the land and to get on it must comply with the conditions imposed by the states for the safety of its citizens. Contracts made by the road are made subject to the possible exercise of the sovereign right."

There was no doubt after this decision that the railroads could be held primarily responsible, legally and financially, for grade crossing separations or protection. It also was apparent that there were no limitations of the State's powers in such matters where public safety was involved. Realizing this, the railroads in 1922 began an extensive public education program to reduce the number of accidents at grade crossings, and hopefully thereby reduce the demands for elimination of grade crossings. The program was directed by the American Railway Association (which eventually became the Association of American Railroads). Prior to 1920 the demands for grade crossing eliminations and improvements had been based almost entirely upon consideration of public safety, but gradually the States began to lean towards consideration of public convenience, which was related to the increase in highway construction. The railroads then began attacking not only the costs apportioned to them for grade crossing safety projects, but the fairness or reasonableness of such projects ordered by the States. However, they were unsuccessful with such arguments during the 1920's. See Missouri v. Public Service Commission, 273, U.S. 126 (1927) and Lehigh Valley R.R. v. Board of Public Utility Commissioners, 278 U.S. 24 (1928).

Private Crossings

The term "private crossing" has received various and, in some instances, contradictory definitions. One court has stated that a private crossing is one neither required nor used for any public purpose. Wabash R.R. v. Williamson, 104 Ind. 154, 3 N.E. 814 (1885). Such a

definition, of course, leaves unanswered the question of what kind of factual pattern is sufficient to constitute a "public purpose." This labelling must be done on a case by case basis.

In many instances, judicial construction of the term "private crossing" has occurred in the context of interpretation of a statute requiring a railroad to give warning of its approach at "public crossings." In such cases two basic theories have been advanced. According to one theory, the distinction between public and private crossing turns on the frequency of the general use of the crossing by the public. See Louisville & Nashville R.R. v. Wallace, 302 S.W. 2d 561 (Ky. Ct. App. 1957). On the other hand, some courts have stated that the distinction lies in the nature or character of the crossing rather than in the frequency with which it is used. See Model City Lumber Co. v. Southern Ry., 33 Ala. App. 425, 34 So. 2d 862 (1948); Pieckowicz v. Oliver Iron & Steel Co., 351 Pa. 209, 42 A. 2d 416 (1944); Recco v. Chesapeake & O. Ry. 127 W. Va. 321, 32 S.E. 2d 449 (1944).

Some statutes refer only to "farm crossings." This term has been defined as "the simplest, or 'lowest' form of railroad crossing. It is private in character, access to the same being through or upon private lands, and its purpose is only to accommodate the occupants of such lands." Weiss v. Chicago, N.S. & M., 9 Wis. 2d 581, 101 N.W. 2d 688 (1960).

The number of private, industrial and farm crossings in the United States is considerable, but unknown. Current estimates indicate that there are about 140,000.

Despite this number, very few states have any laws or regulations applicable to the use and protection of such crossings. The power of the various regulatory commissions over private crossings depends upon the applicable statutory provisions. In some states the regulatory commissions have no jurisdiction over private crossings. In other states, the legislature has given the commission authority to establish private crossings and make orders for the continued maintenance, location or arrangement of existing crossings. See Bolger v. Boston & M. R.R., 82 N.H. 372, 134 A. 524 (1926).

In one recent case, City of Bayonne v. Board of Public Utility Commissioners, 30 N.J. Super. 520, 105 A. 2d 417 (1954), the court ruled that the Board did possess the authority to barricade railroad property in order to protect the safety of the public and persons using the trains. In this case the court agreed with the Board's finding that the crossing was so dangerous that it was a public nuisance. The court left answered the broader question of whether the New Jersey statute at issue gave the Board general power over private as well as public grade crossings.

In exercising its statutory jurisdiction, if any, over private crossings, a regulatory commission must, of course, keep in mind the requirements of the Fourteenth Amendment. In all cases the enforcement of the rights of individual property owners, as well as the railroad is for the courts. An attempt was made by the Nebraska Railway Commission in

1924 to require a railroad, at its own expense, to eliminate a private grade crossing between two adjacent farm areas, and to construct an underpass for the owner of the property. Justice Stone, speaking for the U.S. Supreme Court in Chicago, St. P.M. & O. Ry. Co. v. Holmberg, 282 U.S. 162 (1930), said:

> "The Nebraska Statute has delegated to the State Railway Commission authority to order farm crossings underground because either inadequate or dangerous, if circumstances warrant. But, there is nothing in this record to suggest that the order of the Commission was either asked or granted as a safety measure. The Commission did not find that the crossing was dangerous either to the public, the litigants or their property. Neither did it find that this crossing was in anywise different from the usual farm crossing at grade.
>
> * * *
>
> It is plain that the Commission proceeded upon the assumption that the statute authorized it to compel plaintiff (railroad) to establish an underground pass for the convenience and benefit of defendant in the use of his own property, and that that alone was the ground and purpose of the order. The application thus given to the statute deprives plaintiff or property for the private use and benefit of defendant and is a taking of property without due process of law, forbidden by the Fourteenth Amendment." Id. at 167.

In most cases private crossings are constructed, maintained and protected under private agreements between the landowners and railroads, and the division of responsibility for costs involved is stated therein. Whenever public safety is involved, such crossings should be protected in some manner or be closed. However, the question of public safety being involved is sometimes difficult to establish or determine, as illustrated by the above-mentioned decision. In Sanborn v. Detroit B.C. & A.R.R., 91 Mich. 538, 52 N.W. 153 (1892), the Supreme Court of Michigan held that general signal statutes were not even applicable to private crossings. (See also 16 L.R.A. 119, 120.)

Public Responsibility is Recognized and Implemented

The depression era of the 1930's brought about some abrupt and varying changes in the respective volumes of rail and highway traffic over grade crossings, which contributed to some new ideas with regard to whose responsibility it was for grade crossing separations and protection. For example, in 1933 the Public Utilities Commission of the State of California discarded its 50-50 percentage basis for the allocation of costs for such projects and adopted an "economic benefits" basis. Other States were also making changes for legal or economic reasons, as they recognized the

railroads' financial straits and limited abilities in dealing with the grade crossing safety problem. Various State courts were beginning to find a joint public and railroad responsibility for such safety projects.

This new idea of public responsibility was enhanced by Congress in its passage of the National Industrial Recovery Act of 1933, Act of June 16, 1933, Ch. 90, 48 Stat. 195. This Act was passed primarily to provide employment throughout the Nation and to promote safety. President Roosevelt was authorized under the Act to make grants totaling $300 million to the States to be used in paying any or all of the costs for eliminating the hazards of railroad-highway grade crossings. The Act also provided that the States did not have to provide matching funds and that the grade crossing improvements were not limited to Federal-aid highway systems.

The Hayden-Cartwright Act of 1934, Act of June 18, 1934, Ch. 586, 48 Stat. 993, carried forward the concept of public responsibility and additional funds were authorized for the construction of railroad-highway grade separations and the installation of grade crossing protection devices. Although the Federal government assumed all initial construction costs, no provision was made in either act to authorize funds for the maintenance of these facilities This responsibility was left entirely with other agencies, generally the railroads and State and local governments. Also, there was no Federal participation in right-of-way costs, and this hampered many of the grade crossing safety projects.

Landmark Court Decision on Responsibility

The expanded Federal highway construction programs in the early 1930's, which extended Federal-aid highways into and through municipalities thereby creating numerous new grade crossings, and the Federal Government's new policy of public responsibility for the financing of grade separations and grade crossing protection apparently had a great deal of influence upon the U.S. Supreme Court's landmark decision in Nashville, C. & St. L. Ry. v. Walters, 294 U.S. 405 (1935). In that case the railroad was ordered by the Tennessee State Highway Commission to construct and pay one-half of the costs for an underpass where a proposed new State highway would cross its main line. The Tennessee statute required a flat percentage basis and did not permit the Commission to consider any other facts. The railroad argued that because of changed conditions, the State statute was unconstitutional by requiring it to pay one-half of the costs for a project which was primarily motivated for the commercial convenience of motor vehicle traffic rather than for public safety. Justice Brandeis, writing for the majority of the Court said:

> "The railroad has ceased to be the prime instrument of danger and the main cause of accidents. It is the railroad which now requires protection from dangers incident to motor transportation. Prior to the establishment of the Federal-aid system, Tennessee highways were built under the direction of the county courts, and paid for out of funds raised locally by taxation or otherwise. They served in the main, local traffic. The long-distance traffic was served almost

> wholly by the railroads and the water lines. Under those conditions the occasion for separation of grades was mainly the danger incident to rail operations; and the promotion of safety was then the main purpose of grade separation. Then, it was reasonable to impose upon the railroad a large part of the cost of eliminating grade crossings; and the imposition was rarely a hardship. For the need for eliminating existing crossings, and the need for new highways free from grade crossings, arose usually from the growth of the community in which the grade separation was made; this growth was mainly the result of transportation facilities offered through the railroads; the separation of grade crossings was a normal incident of the growth of rail operations; and as the highways were then feeders of rail traffic, the communities growth and every improvement of highway facilities benefited the railroad The effect upon the railroad of constructing Federal-a. ighways, like that here in question, is entirely different. They are not feeders of rail traffic. They deplete the existing rail traffic and the revenues of the railroads. Separation of grades serves to intensify the motor competition and to further deplete rail traffic. The avoidance thereby made possible of traffic interruptions incident to crossing at grade is now of far greater importance to the highway users than it is to the railroad crossed. For the rail operations are few; those of the motor vehicles very numerous."

The Court further stated:

> "The promotion of public convenience will not justify requiring of a railroad, any more than of others, the expenditure of money, unless it can be shown that a duty to provide the particular convenience rests upon it. Missouri Pacific Ry. v. Nebraska, 217 U.S. 196 and Great Northern v. Minnesota, 238 U.S. 340."
>
> "While money raised by general taxation may constitutionally be applied to purposes from which the individual taxed may receive no benefit, and indeed, suffer serious detriment; St. Louis & Southwestern Ry. v. Nattin, 277 U.S. 157, 159; Memphis & Charleston Ry. v. Pace, 282 U.S. 241, 246; so called assessments for public improvements laid upon particular property owners are ordinarily constitutional only if based upon benefits received from them. Myles Salt Co. v. Iberia Drainage District, 239 U.S. 478; Gast Realty Co. v. Schneider Granite Co., 240 U.S. 55; Kansas City So. Ry. v. Road Imp. Dist. No. 6, 256 U.S. 658."

This decision, in effect, placed a criteria of equity, reasonableness, and beneficial interest as possible limitations upon the exercise of police powers by the States in their apportionment of the responsibility and costs for grade separations and grade crossing protection.

Some States Change Their Criteria

In light of the Walters decision, some State Legislatures, commissions and courts took another look at their division of responsibility criteria, and the resulting allocation of costs, relating to grade crossing safety projects. Several States, such as Colorado, Massachusetts, Missouri, and South Dakota, authorized their public utility commissions to investigate these matters in a more extensive manner and to determine the allocation of costs from the facts developed. Other States such as Alabama, Indiana, New York, Pennsylvania and Tennessee eventually reduced the railroads' percentage portion of the costs for such projects.

The effect of the Walters decision was also seen in State court decisions, such as State ex rel. Wabash Ry. v. Public Service Commission, 340 Mo. 225, 100 S.W. 2d 522 (1936), wherein the Supreme Court of Missouri upheld an assessment by the PSC of 60 percent of the costs for a grade crossing elimination project against the City of St. Louis and only 40 percent against the railroads. The City argued that the entire costs should be paid by the railroads involved, but the court said:

> "Under the facts, as disclosed by the record in this case, it would have been grossly unjust to have assessed the entire cost against the railroad.
>
> * * *
>
> It was entirely proper in this case for the Commission to consider the evidence of the amount of traffic upon the highway and the railroad to ascertain the degree of danger which existed at the crossing and also the inconvenience that was eliminated by the separation of the crossing. Benefits which the various parties derived as the result of the project were of special importance in this case."

The Superior Court of Pennsylvania took similar action in Lehigh & N.E.R. v. Public Service Commission, 126 Pa. 565, 191 A. 380 (Super. Ct. 1937). It upheld an apportionment of costs by the PSC of 40 percent against the railroad, 40 percent by the State and 20 percent by the county, for the reconstruction and relocation of a railroad bridge and underpass. The court said, "the order of the commission was within its power and supported by the evidence and is reasonable and in conformity with the law." A New York court in In Re Existing Highway-Railroad Crossings At Grade, 295 N.Y.S. 831 (Sup. Ct. 1937), reversed an order of the New York PSC which would have required the railroads to eliminate 43 grade crossings in that State at a cost of millions of dollars. The Court said that such an order "should rest upon something other than the mere wish of the city, and upon something more than a mere rough calculation of the resulting costs." The entire matter was remitted to the PSC for further investigation and reconsideration.

Federal Regulation of Grade Crossings Opposed

A legislative attempt was made in 1937 to have grade crossing protective devices regulated by the Interstate Commerce Commission, along with other safety appliances, under provisions of Section 25 (45 U.S.C. 26) of the Interstate Commerce Act. A bill, S. 29, 75th Cong., 1st Sess. (1937), which contained a provision to accomplish this, was introduced. While being considered by Congress, the bill was referred to the ICC for its comments on this specific provision. Honorable Joseph B. Eastman, then Chairman of the Commission, on February 19, 1937, replied, in part as follows:

> "There is no doubt that highway grade-crossing protective devices do in a measure increase safety of railroad operation; nevertheless, devices of this character are installed primarily to safeguard highway traffic. The inclusion of devices of this character in a Federal law would at once raise a question as to the authority of the states, counties, cities and other political divisions, to continue to exercise their present powers in requiring the protection of dangerous highway crossings. * * * it is questionable whether it would be good public policy to include highway grade-crossing protective devices in an act of this character."

Following the Commission's recommendation Congress excluded grade crossing protective devices from the safety appliance bill passed and enacted on August 26, 1937. Since then, no further efforts have been made to seek special Federal legislation pertaining to grade crossings or grade crossing protective devices.

An Era of Safety Progress

Following the public responsibility policy established in the National Industrial Recovery Act of 1933 and the supplementary authorization of the Hayden-Cartwright Act of 1934, and during the period from fiscal year 1935 through fiscal 1942, there were numerous and extensive programs, initiated by the States and financed primarily with Federal funds, to eliminate and protect railroad-highway grade crossings. During that period there were 3,844 grade crossings eliminated, 655 reconstructed, and 4,652 protected. More of such projects were completed during the fiscal years of 1937 and 1940 than in any other years. The Federal funds for these projects were provided, along with other Federal-aid highway funds, in the Emergency Relief Appropriation Act of 1935, Act of April 8, 1935, Ch. 48, 49 Stat. 115, the Authorization and Amendment Act of 1936, Act of June 16, 1936, Ch. 582, 49 Stat. 1519, the Federal-aid Highway Act of 1938, Act of June 8, 1938, Ch. 328, § 14, 52 Stat. 633 and the Federal Highway Act of 1940, Act of September 5, 1940, Ch. 715, 54 Stat. 867. Never before had such a coordinated and concentrated attack been made over such a long period of time on the grade crossing safety problem by Federal, State, and railroad interests. Yet, in spite of such efforts, the number of grade crossings increased almost as fast as they could be

eliminated. This was caused primarily by numerous highway construction projects being completed during the same period. During World War II, both the highway construction and grade crossing improvement programs were halted.

More Responsibility Assumed by Federal Government

Towards the close of World War II the railroads and the National Safety Council launched a nationwide safety program, called the "Signs of Life" program, to reduce accidents at grade crossings. This program was an effort to educate the motoring public to observe grade crossing signs and signals. At the same time Congress again saw a need for employment opportunities and a continuation of the highway construction programs halted by the war, and the Federal-aid Highway Act of 1944 was enacted on December 20, 1944, Ch. 626, §3(b), 58 Stat. 839. When this legislation was originally introduced, it did not contain any provision which would have required any payments from the railroads for grade crossing improvements. However, while the bill was under consideration that omission was noted and it met strenuous opposition from Southern and Western Senators. There was even a strong move to impose a requirement for the railroads to pay 25 percent of such costs. The railroads objected vehemently to this, so when the bill was finally passed by Congress it provided a 10 percent maximum participation by the railroads.

The 1944 Act authorized the expenditure of Federal funds for Federal-aid highways in urban areas, and provided for the designation of a Federal-aid secondary highway system and a National System of Interstate Highways. Federal funds for the primary, secondary and urban highway systems were apportioned to the States for expenditure on a 50-50 matching basis. However, section 5 of the Act provided that the entire cost for the elimination of rail-highway grade crossing hazards on the Federal-aid highway system could be paid from Federal funds, except that not more than 50 percent of the right-of-way and property damage costs could be paid from such funds. This section also provided that not more than 10 percent of the total funds apportioned to each State in any year could be used for grade crossing projects on a reimbursable basis up to 100 percent. Federal funds could be paid as reimbursement to the States as the work progresses; final payment being made when the project is completed.

Subsection (b) of section 5 provided that any railroad involved in any project for the elimination of hazards at grade crossings, paid for entirely or in part with Federal funds, would be liable to the United States for "a sum bearing the same ratio to the net benefits received by such railway from such project that the Federal funds expended on such project would bear to the total cost of such project." This subsection also provided that the net benefits received by a railway should not "be deemed to have a reasonable value in excess of ten percent of the cost of any such project." The Commissioner of Public Roads was authorized to determine the amount of railroad benefits, or liability, on the basis of recommendations made to him by the State highway departments, and from

such other information or facts disclosed in any investigation which he deemed necessary.

Federal Criteria for Responsibility Established

Between 1944 and 1948 many difficulties were encountered by the Commissioner of Public Roads in determining how to measure precisely the benefits a railroad would receive from an individual grade crossing improvement project on the Federal-aid highway system in order to affix its liability under the Act for a portion of the costs. During this period, many grade crossing safety projects were delayed, or never started, because of prolonged negotiations, arguments and litigation on this single issue. The various parties involved met on numerous occasions and discussed ways or means to administer these particular provisions of the 1944 Act. A compromise was eventually reached whereby each of the grade crossing improvement projects would be classified as being in one of five general classes. Depending upon the classification assigned to an individual project, the railroads would be considered as receiving benefits therefrom and would be liable for the full 10 percent of the costs, or there would be no cognizable benefits and their liability would be nil. The five general classes are briefly described as follows:

Class I is for grade crossing eliminations. The determinant is that there is a benefit to the railroad when the existing principal crossing or crossings at grade will be closed after the project is completed. The railroad liability is therefore 10 percent of the cost of the project. However, if the crossing is not closed, there is no railroad liability.

Class II is for reconstruction of existing railway-highway grade separation structures. The determinant is that there is no ascertainable benefit to the railroad and hence no railroad liability.

Class III is for grade crossing protection at existing crossings. The determinant is that any protective device installation is of benefit to the railroad, therefore its liability is 10 percent.

Class IV is for an existing railroad crossed by a new highway, or an existing highway crossed by a new railroad. The determinant is that the moving party is the predominate beneficiary, and thus should bear all costs for the construction or protection. Therefore, the railroad liability is nil where a new highway crosses an existing railroad.

Class V is for a railroad-highway grade crossing elimination physically required in connection with the elimination of an adjacent at-grade highway intersection. The determinant is that if it is an at-grade railroad-highway crossing at which an automatic signal device has been installed.

or to which a watchman has been assigned, or there is an order in force requiring a protective device to be installed, or watchman assigned, or the crossing to be eliminated, there is a benefit to the railroad resulting from the elimination. The railroad liability is 10 percent of certain defined additional costs of the project.

The railroad's participation in the costs under any of the above classes could be made in the form of cash, work or services performed, or by property or materials furnished and used on such projects. The first four of these general classes for the assignment of railroad responsibility were initially published in General Administrative Memorandum No. 325, dated August 26, 1948. These four, plus the fifth classification, were later incorporated in the Department of Commerce, Bureau of Public Road's Policy and Procedure Memorandum 21-10, dated October 3, 1958. These allocations of costs to the railroads and the various public authorities involved were considered to be fair and equitable. Under such guidelines total investments in grade crossing projects both on and off the Federal-aid highway system increased substantially after 1948. Also, during the 10-year period from 1948-1958 the financial share of the costs borne by the railroads on Federal-aid highway projects actually averaged less than 5 percent, but ranged between 50 to 100 percent on non-Federal-aid highway projects. Following is a summary of grade crossing elimination and protection projects financed in whole, or in part, with Federal funds during fiscal years 1934-1970 inclusive:

TYPE OF PROJECT	NUMBER	TOTAL COSTS**	FEDERAL FUNDS**
Crossings eliminated*	10,603	$2,825,892,936	$2,321,988,051
Structures reconstructed	1,572	292,885,701	247,435,082
Crossings protected	12,873	95,019,433	82,027,400
TOTALS	25,048	$3,213,798,070	$2,651,450,533

Source: Federal Highway Administration (unpublished statistical summary).
*Both existing and potential grade crossings.
**Costs for preliminary engineering and rights-of-way are not included.

Several States Revert to Prior Criteria

As time passed, the effect of the Walters decision began to disappear, or did not exist, as far as some States were concerned on non-Federal-aid projects. Some of the State legislatures, commissions, and courts either maintained or reverted to their prior positions that the elimination of grade crossing hazards was the railroads' primary responsibility, and that they should bear a major portion of all of the costs involved. See Illinois Cent. R.R. v. Franklin County, 387 Ill. 301, 56 N.E. 2d 775 (1944); Illinois Cent. R.R. v. Louisiana Public Service Commission, 224 La. 279, 69 So. 2d 43 (1953). In October 1949 the California Public Utilities Commission reverted from the "economic benefits" basis established in 1933, to its previous 50-50 percentage basis for

the apportionment of costs for grade separations. This change in policy was also predicated upon the long-established principle of a continuing and inherent responsibility of the railroads to participate financially in such projects.

"Economic Benefits" Basis for Responsibility

To combat the tide of change, the California railroads in 1952 employed the services of the Stanford Research Institute for a general study of the aged question: "Whose responsibility is it for the elimination and protection of rail-highway grade crossings?" Primary emphasis and research was placed upon the economic benefits derived from such projects. The study, which was in part predicated upon the dicta on this subject in the Walters decision, arrived at the following conclusions:

> (1) that grade crossing projects can be measured for economic justification only on a case-by-case approach; (2) that the costs of grade-crossing improvements are joint costs; (3) that these costs should be distributed in accordance with the relative values of benefits received by the several beneficiary groups; and (4) that a fixed percentage distribution of such costs is not economically sound.

The results of this study and the "economic benefits" argument were used by the railroads in Atchison, T. & SF. R.R. v. Public Utilities Commission, 346 U.S. 346 (1953). The California Public Utilities Commission had allocated costs to the railroads on the 50-50 basis for several grade separation projects ordered. The railroads argued that the costs should be distributed only upon the basis of benefits which would accrue to their property. The U.S. Supreme Court considered this argument at length, and with special attention thereto said:

> "Their principal contention is that as to them the cost of the improvements may be distributed only on the basis of benefits which will accrue to their property. In this contention, we think the appellants are in error. These were not improvements whose purpose and end result is to enhance the value of the property involved by reason of the added facilities, such as stree, sewer or drainage projects, where the costs assessed must bear some relationship to the benefits received."

The Court then distinguished the Walters case, supra, by stating:

> "In our cases, not only are the facts distinguishable in many material particulars but unlike the Supreme Court of Tennessee which refused to consider the facts to determine whether the statute's allocation of 50% was arbitrary or unreasonable, the California Commission considered all the evidence offered, including that going to the benefits

received, and properly applied the rule of allocation sanctioned by this Court . . . ."

The theory of "economic benefit," however, continues to be an important factor in determining responsibility as indicated by the Fifth Circuit's decision in City of Gainesville v. Southern Ry. 423 F. 2d 588 (5th Cir. 1970).

State Grade Crossing Elimination and Protection Funds

In 1953 the State of California took the first step towards establishment of a State grade crossing protection fund. The Public Utilities Commission was authorized by legislation to expend or allocate funds from the State Highway User Fund, or any other fund, to assist the cities and counties in paying their allocated portion of the costs for the installation of automatic protective devices (flashing light signals and automatic gates) on non-Federal-aid highways and streets. The State Highway User Fund obtained its revenues from gasoline tax receipts and motor vehicle license fees. Although this fund contributed nothing towards relieving the railroads of their financial burden, it was a State recognition of a public responsibility for grade crossing protection. The grade crossing protection fund could be used to pay only one-half of the local public authority's share of the costs for such projects. Ordinarily, the public authority's share was one-half of the total costs, so the net result on a particular project would be that the public authority would pay 25 percent of such costs, the State funds would pay 25 percent, and the railroads would pay 50 percent. Since the funding method was established, a total of $8,200,000 has been expended on authorized State grade crossing improvement projects. The appropriation for the fiscal year 1971-72 was $1,000,000. In 1957 the State of California established a grade separation fund, with an appropriation of $5,000,000 per year. The purpose of this fund was to eliminate grade crossings by the construction of new separation structures, or by improving, widening or heightening existing separation structures. The PUC was required to compile a priority list each year for such projects. The State Highway Commission actually makes the expenditures from this fund for projects in the order of the priority standings established by the PUC. Approximately 107 separation projects have been financed from this fund since its inauguration. The allocation of costs between the public authorities and the railroads was based upon criteria of responsibility similar to that found in the five general classifications followed by the U.S. Bureau of Public Roads, (now Federal Highway Administration) as discussed previously herein.

For many years the California PUC assessed the costs of railroad grade crossing protective device installation to both the railroad and the public agencies involved, but the total cost of maintenance was always assessed to the railroad. In 1965 the California legislature passed a bill which required the Commission to apportion maintenance costs in the same manner in which the construction costs were assessed. Thus, if the construction costs are assessed 50 percent for the city, and 50 percent for the railroad, then the maintenance costs for the

protection are distributed in the same proportion. The legislature also established a fund which in effect pays the entire share for the city or county. The budget allocation for 1971-72 is $700,000 for the grade Crossing Maintenance Fund.

Since 1953, grade crossing protection funds have been established in 11 additional States, and similar funds are under consideration in others. The 12 states which have established such funds are California, Colorado, Illinois, Iowa, Minnesota, Nebraska, North Dakota, Oklahoma, Texas, Washington, Wisconsin, and Wyoming. In 1955 the State of Illinois established a grade crossing protection fund which could be used by the State Department of Public Works and Buildings, Division of Highways, upon orders of the Illinois Commerce Commission to pay that part of the costs apportioned by the Commission against the State to cover the installation of grade crossing protective devices on the highways, roads and streets on the county highway systems, township or district road systems, and/or the municipal street systems. The fund cannot be used for grade crossing protection or improvement projects which are financed with Federal funds on Federal-aid or State highways. Revenues for this fund are derived from State motor fuel tax receipts. When started, the fund was provided with $25,000 per month. Later amendments to the law changed the amount to $100,000 per month, or $1,200,000 per year.

Bills which would provide for increasing the amount of allocation to $400,000 or $500,000 per month are under consideration by the Illinois legislature. This proposed legislation provides that allocations could be made to projects for constructing grade separations, as well as installing crossing protection, present use being limited to the latter. Since 1955 the Fund has been credited with a total of $11,300,000 in Motor Fuel Tax receipts, and to date approximately 1,000 crossing protective installations involving some payment from the Fund have been ordered. The orders of the Illinois Commerce Commission direct that a definite percentage (most commonly 70 percent) of the actual cost be paid from the Fund with the remaining portion of the cost borne by the railroad and the local highway agency in the proportions prescribed by the Commission. The Illinois Program requires all railroads to bear the costs for maintenance and operation of protective installations after they have been placed in service. The Illinois fund has been considered to be one of the most successful, and has been followed as a guide in other States.

Federal-Aid Highway Funds

The Federal-Aid Highway Act of 1956, Act of June 29, 1956, Ch. 462, Title I, §§102, 108-110, 70 Stat. 374, and the companion Highway Revenue Act of 1956, Act of June 29, 1956, Ch. 462, title II, §§ 202-210, 70 Stat. 387, of the Interstate Highway System, and provided funds for its completion. Originally, projects on the Interstate System were financed on a 50-50 Federal-State matching basis. In 1954 this was changed to a 60-40 Federal-State matching basis. The

1956 Act changed the matching basis for these project to a 90-10 ratio, and provided for the apportionment to be made on the basis of the estimated cost of completion in each State. Also, prior to 1956, revenues received from all Federal excise taxes on motor fuel, motor vehicles, and related products were placed in the General Fund of the U. S. Treasury. However, the Highway Revenue Act of 1956 changed this by earmarking some of these revenues to go into a newly created Highway Trust Fund which would be the sole source of monies for Federal-aid highway programs authorized during the years 1957-1972. These funds for primary, secondary, and urban highway projects are apportioned to the States in accordance with statutory formulas that give weight to population, area, and mileage. In using the Federal-aid funds for highway construction the States determine the systems to be improved, the projects to be built, and the design and construction standards to be used subject to Federal approval. They make the surveys and plans, negotiate and execute the necessary contracts, and supervise the construction. The roads or highways remain under the administrative control of the States who are responsible for their operation and maintenance.

Federal-Aid Highway Acts Codified

On August 27, 1958, the Federal-aid Road Act of 1916, and subsequent amendments or Acts related thereto, were codified, without substantive changes, into Title 23 of the U. S. Code, Sections 101-136, Pub. L. No. 85-767, § 1, 72 Stat. 885. The pertinent provisions concerning rail-highway grade crossings are contained in Section 101 (definitions), 109 (e), 120 (d) and 130. Under Subsection (b) of Section 130 the classification of grade crossing projects for determining the division of responsibility is authorized, but the allocation of costs against the railroads cannot exceed 10 percent.

ICC Findings on Responsibility and Jurisdiction

By a petition filed on May 11, 1960, with the Interstate Commerce Commission, several railroad labor organizations sought the institution of a general investigation to determine what action should be taken by the Commission to prevent collisions at grade crossings between trains and highway motor vehicles transporting certain kinds of commodities, including flammable, explosive and dangerous articles. The petition was denied on August 15, 1960, and a petition for reconsideration was filed on September 20, 1960. By an order entered on February 6, 1961, the Commission on its own motion instituted an investigation proceeding under Docket No. 33440, to dtudy the causes of accidents involving all highway motor vehicles at grade crossings. All State regulatory commissions and State, county, and municipal authorities having jurisdiction over railroad and motor vehicle operations at grade crossings were invited to participate in the proceeding. The investigation was completed on June 21, 1952, and recommeded report was served on May 21, 1963. The Commission's report was served on February 10, 1964, and is cited as 322 ICC 1. One of the primary subject considered and discussed at length by the Commission in its report, at pages 81-84, was "the cost of upgrading crosssings and the installation of additional grade

crossing protection, and upon whom the cost burden should fall." With regard thereto the Commission said:

> "For practical reasons this cost should be borne by public funds as users of the crossing plus the fact that it is the increasing highway traffic that is the controlling element in accident exposure at these crossings. There is ample precedent for such a conclusion. Already the Federal Government, with State matching funds, is paying a good share of crossing elimination on Federal-aid highways. This appears to be a satisfactory solution as well as the only solution to offer any practicality for meeting the increasing problem on all crossings. Many of the States share in the costs of improvements at grade crossing under a pro rata arrangement between the railroads and the public, dependent upon the benefits received by each. This arrangement has been successful where used. Insofar as this record is concerned, the consensus support a conclusion that the major costs of grade separation and protection at rail-highway grade crossing should be borne by the public since the public is the principal recipient of the benefits derived from grade crossing protection.
>
> These contentions deserve serious consideration particularly in view of the changes that have taken place since the early day of railroading. In the past it was the railroad's responsibility for protection of the public at grade crossings. This responsibility has now shifted. Now it is the highway, not the railroad, and the motor vehicle, not the train which creates the hazard and must be primarily responsible for its removal. Railroads were in operation before the problem presented itself and if the increasing seriousness is a result of the increasing development of highways for public use, why should not the cost of grade crossing protection be assessed to the public. This is the contention of many of the witnesses testifying at the hearings in this proceeding." ID at 81-82

One of the official witnesses heard was Senator Hubert H. Humphrey, who in a statement submitted on June 27, 1962, said as follows:

> "In considering this matter of rail-highway grade crossing accidents, a major consideration must be the rapid growth of our nation's interstate superhighway systems. Many years ago Congress recognized the public responsibility for the cost of grade crossing separation structures. Under now established policy no railroad may be required to pay anymore than the benefits it received from the erection of such a structure over its tracks on any federal-aid road and in no case may its benefits be calculated at more than 10 percent of the cost. I am sure that this policy of public responsibility has not only expedited the construction of fine federal-aid road but also has saved many lives " (Tr. 2928-29.)

The Interstate Commerce Commission concluded its discussion on this particular subject by stating:

> "Since the Congress has the authority to promulgate any necessary legislation along this line it is recommended that it give serious study and consideration to enactment of legislation with a view to having the public including the principal users, assume the entire cost of rail-highway grade crossing improvements or allocating the costs equitably between those benefited by the improvements."

The Commission after an extensive investigation of the grade crossing safety problem also found that it had no jurisdiction over railroad operations at grade crossings, or the protective devices at such crossings, under provisions of Section 25 (45 U.S.C. 26) of the Interstate Commerce Act. This finding was appealed to the courts by motor carrier interests. A three-judge U. S. District Court in American Trucking Association v. United States, 242 F. Supp. 597 (D.D.C. 1965), which was later affirmed by the Supreme Court in a per curiam decision in 382 U. S. 373, held that the Commission was correct in its finding of no jurisdiction. The Court said:

> "In view of the legislative history, it is clear to us that Congress by the 1937 amendments to Section 25, did not intend to encroach upon the rights of the States to exercise their police power with respect to rail-highway grade crossing safety matters . . .
>
> * * *
>
> We conclude therefore that jurisdiction to establish safety regulations with respect to rail-highway grade crossing matter resides exclusively in the states."

State Support for Public Responsibility

The idea of public responsibility for the elimination of hazards at grade crossings did not originate with the National Industrial Recovery Act or the U. S. Supreme Court's decision in the Walters case supra. As early as January 1924, Governor Alfred E. Smith of New York had recognized the increased use of public highways by automobiles, and recommended to the State legislature a plan whereby the State and municipalities would participate in the costs of eliminating grade crossings. An amendment to that State's Constitution was approved in November 1925, which provided that 25 percent of the costs of grade crossing elimination projects would be borne by the State, 25 percent by the municipality or municipalities, and 50 percent by the railroad or railroads. The municipalities objected strongly to their percentage apportionment and under subsequent amendments their share or responsibility was reduced from 25 percent to 10 percent, and eventually to 1 percent. Accordingly, the State's share was increased from

25 percent to 40 percent to 49 percent. In 1926 the State of New York by a referendum vote approved a $3 million bond issue for the elimination of grade crossings. Substantial progress was made under the new apportionment arrangements and with proceeds from the bond issue. With the coming of the depression years, the railroad then began to complain about their percentage share of the costs for such projects. However, nothing was done with regard to their complaints until a later date.

In 1931 the State of Michigan took an additional step towards public responsibility by providing a portion of the maintenance costs for protective devices installed at grade crossings. The highway authorities in the State were directed by statute to pay $10.00 per month towards the railroads' cost of maintaining double-faced flashing signals at each crossing so protected after passage of the Act. The statute also required the highway authorities to pay 50 percent of the costs for new installations of these protective devices. Other States, namely California, Florida, Kentucky, North Carolina, Texas, and Virginia, later started participating to some degree in the maintenance costs of grade crossing protection. The Federal Government does not provide any for the maintenance of Federal-aid highway or grade crossing projects. This policy has been followed since the Federal-aid programs began. In most States the railroads are required to bear the entire maintenance costs for grade separation structures and protective devices. In some States a fixed percentage is allocated to the railroads, or it is a matter of negotiation. As the number of crossings protected increase, the maintenance costs therefore will become progressively higher in future years. Therefore, the cost of maintenance of grade crossing protection is a significant factor as far as the railroads are concerned. In fact, some railroads have agreed on occasions to bear the entire initial cost of installation, if the States would relieve them of the maintenance costs. In some States the highway authorities have maintained overpass structures and the railroads the underpass structures. Maintenance of underpasses is sometimes allocated so that the railroads maintain the track structure only, including ballast, and the highway authority maintains the bridge, paving, lighting and all other facilities. By statute in Kentucky, the governmental unit constructing or installing the grade crossing protection, in whole or in part with State funds, must bear the full cost of maintenance. The State of California in 1965 established a fund with an appropriation of $1,000,000 annually to pay the cities and counties allocated share of the costs for maintenance of automatic grade crossing protective devices. The specific amount, which is normally half, is determined by the State highway commission after consultation with the public utility commission. A few States allocate maintenance costs on the same basis as the cost for installation. In North Carolina and Virginia there are agreements between the State highway authorities and the railroads to share on a 50-50 basis the annual maintenance costs of protective devices at crossings in certain areas. The State of Texas also fixes the maintenance cost by agreement with the railroads.

In 1933, former, Governor Smith of New York, as a member of the National Transportation Committee, stated in a supplemental report to the committee dated February 13, 1933, his opinion that the railroads' share of the costs of grade crossing elimination projects should be reduced. He said:

> "In many states the railroads' share is as high as 50 percent. This is unduly burdensome and unfair to the railroads, and it has naturally resulted in bitter opposition orders and the general slowing up of the crossing elimination problem. This reduction cannot, however, be accomplished by federal legislation or fiat. It must be brought about by persuasion in the several states."

With such support the railroads were successful in 1938 in obtaining another amendment to the Constitution of the State of New York providing that the State would advance the cost of grade crossing elimination projects, but at the conclusion of the work, pursuant to an accounting by the Public Service Commission, the railroads would pay 100 percent of the costs of all railroad improvements not an essential part of the elimination project, and for net benefits received not exceeding 15 percent of the costs for elimination of the grade crossing. The State was required to bear the remaining 85 percent of the costs. Several other States later adopted a similar flat percentage apportionment basis. In 1956 the State of New York elected to pay 50 percent of the costs for the installation of grade crossing protective devices, such as flashing lights and automatic gates. In 1958 the railroads' 50 percent share of the cost of reconstructing existing grade separation structures was reduced to 15 percent by that State. In its Preliminary Report for 1960 the Public Service Commission of New York said:

> "Historically, the railroads were required to pay the entire cost of whatever protection installations the Commission, the State agency responsible for directing such work, might order. In 1956, however, in recognition of the growing public responsibility for the hazards which exist because of greater highway use and in consideration of the economic plight of the financially hard-pressed railroads, the State assumed half the costs of such installations."

Prior to this, in 1958, the State of Ohio in a report entitled, Grade Crossings in Ohio, made the following statement:

> "In providing better protection for an existing crossing a substantial benefit is derived by the general public as well as the railroad. The railroads, if an extensive program of upgrading protective devices is employed, would be required to make heavy capital investments. To the extent that these heavy costs are caused by other than railroad needs and do not save railroad expense, a portion this burden possibly

should be shifted from railroad users to the motoring public. Past experience has shown that a fairly precise measurement of benefits is virtually impossible to derive but must rest on rough and in part arbitrary determinations. The question of what share of the costs should be borne by the State or its subdivisions again is limited by the amount of additional taxes and fees which the motoring public is willing to assume. The cost to the State or its subdivisions of such a program would depend upon the present needs of the State. Given an inventory of existing crossings, the cost of the State can then be determined, if the railroad is to be freed of some portion of the installation expense. This determination, of course would depend upon the nature of the program undertaken and the percentage of cost assumed."

Other interests also have endorsed or supported the idea of public responsibility. The president of the American Association of State Highway Officials in 1944, in a public statement, said:

"If all installations and separations which might be justified by the explosive growth of motor vehicle traffic were actually carried out the railroads would be bankrupt if they were required to pay all or even a very substantial part of the cost. The only way to get the speed in grade crossing elimination adn automatic protection, which may be demanded, is for the public to assume the cost."

On September 28, 1961, the National Association of Railroad and Utilities Commissioners in convention at Atlantic City, New dersey, passed a resolution which recognized the deteriorating financial status of the railroads and the changed conditions with regard to motor vehicle operations over grade crossings. The resolution provided:

"That the National Association of Railroad and Utilities Commissioners go on record as favoring the review by the appropriate state bodies of the equities of the present cost allocations of railroad-highway separation and crossing protection projects in the light of the change in conditions which today make such projects of primary benefit to highway users instead of to the railroads and the need for revision of present cost allocation procedures to reflect such changed conditions."

Then, the Interstate Commerce Commission in its report on February 10, 1964, made the following finding:

"(13) That highway users are the principal recipients of the benefits following from rail-highway grade separations and from special protection at rail-highway grade crossings.

For this reason the cost of installing and maintaining such separations and protective devices is a public responsibility and should be financed with public funds the same as highway traffic devices." 322 ICC 1, 87 (1964) (Emphasis added).

The United States Conference of Mayors at its annual conference of June 21, 1967, adopted a resolution in support of public responsibility for the elimination and protection of grade crossings which read, in part, as follows:

> "Whereas, the federal government has an obligation to share in the solution of the traffic problem because a steadily growing protion of the traffic on city streets is composed of vehicles flowing into and through the cities on thoroughfares whose construction was promoted and financed by the Federal Government.
>
> Now therefore be it resolved that the U. S. Conference of Mayors urges: . . . (5) Provision by Congress of Federal aid for the construction and maintenance of highway-railway grade crossing separation structures and protective devices for city streets and local roads comparable to that now provided for Federal-aid highways . . ."

Then, the National League of Cities on July 22, 1967, urged that:

> "Railroad crossing safety laws should be strictly enforced. Through Federal and State action, a program should be established to aid the construction and maintenance of highway-railroad grade crossing separation structures and protective devices for city streets and local roads."

The League in 1964 had urged Congress and the legislatures of the several States to make available "materially increased funds" to be used for the protection of motor vehicle traffic at railroad-highway grade crossings.

Federal Legislation in 1970

During the latter part of 1969 and the early month of 1970, Congress considered legislation which, in part, was designed to define the scope of the railroad-highway grade crossing problem as a preliminary step toward eventual elimination or protection of grade crossings. Of the legislation which emerged from these deliberations, three Acts contained specific provisions concerning railroad-highway grade crossings. Collectively, the Federal-Aid Highway Act of 1970, Pub. L. No. 91-605, 84 Stat. 1713, the Highway Safety Act of 1970, included as Title II, §§ 201-205, Pub. L. No. 91-605, 84 Stat. 1742, and the Federal Railroad Safety Act of 1970, Pub. L. No. 91-458,

84 Stat. 971, made significant strides forward in expanding Federal involvement in grade crossing safety. The legislative history of these Acts makes clear the fact that the problem is both a multi-modal problem and a Federal-State problem. The Acts recognized in effect, that railroad-highway grade crossing safety could not be achieved without a coordinated program at both the State and Federal levels utilizing both the authority available to regulate railroads and the authority to utilize Federal funds toward the single goal of providing adequate protection or elimination of grade crossings.

As evidenced by these Acts, Congressional interest was focused on three specific aspects of the railroad-highway grade crossing problem. First, the Highway Safety Act authorized two demonstration projects for the elimination and protection of grade crossings, some of which are located off the Federal-aid highway system. One of these projects provides for the elimination of all public ground level railroad-highway grade crossings along the Northeast Corridor high-speed route from Washington to Boston. The second project provides for the elimination or protection of grade crossings in, and in the vicinity of, Greenwood, South Carolina. These eliminations will be accomplished through railroad relocation.

The Highway Safety Act authorized for appropriation from the General Fund $22,000,000 to meet the Federal Government's statutory share of 80 percent of the costs incurred on non Federal-aid system grade crossing projects. An additional $9,000,000 from the Highway Trust Fund is earmarked to satisfy the Federal obligation of 90 percent of the costs on Federal-aid system grade crossing projects.

The grade crossing issue as it relates to high speed ground transportation projects was discussed in the recently released report entitled Recommendations for Northeast Corridor Transportation (DOT 1971).

Another item in the 1970 legislation which has a significant relationship to the grade crossing problem was the establishment of a Federal-aid urban highway system, which will expand the Federal-aid system of highways in urbanized areas and potentially make Federal-aid funding available for some grade crossings currently ineligible. For the new system, an appropriation of $100,000,000 is authorized for each of fiscal years 1972 and 1973. The Act also carries an authorization for traffic operations projects in the amount of $100,000,000 for each of fiscal years 1972 and 1973. The authorizations for traffic operations projects had been $200,000,000 annually during the two previous fiscal years.

The third aspect of the grade crossing problem which received Congressional attention was the need for definite information concerning railroad-highway grade crossings. The Highway Safety Act of 1970 and the Federal Railroad Safety Act of 1970 require the initiation and completion of comprehensive investigations of grade crossings. The Secretary of Transportation was instructed to prepare, for submission to Congress, within one year after the passage of the Railroad Safety Act, a detailed study of the problem of eliminating and protecting railroad grade crossings, including a study of measure to protect pedestrians in densely populated areas along railroad rights-of-way.

A similar provision in the Highway Safety Act of 1970 required the Secretary of Transportation to conduct a comprehensive investigation of the problem of providing increased highway safety at public and private ground-level railroad-highway grade crossings on a nationwide basis. The Secretary is required to submit a report of his findings, including an estimate of the cost of such a program, not later than July 1, 1972.

Summary and Conclusions

The grade crossing safety problem today, as has been shown, is not exclusively a railroad problem, but is part of a national traffic safety problem. It is of primary concern to railroad employees and highway motorists, most of whom are exposed to grade crossing hazards where they exist. Accordingly, the original concept that railroads have the primary or sole responsibility, financial or otherwise, for the elimination or protection of grade crossings has gradually changed, particularly in situations where Federal participation or Federal funds are involved. On the Federal-aid highway system the railroads are required to pay a maximum of only 10 percent of the cost of installing grade crossing protection, but in a number of States on non-Federal-aid highways and streets, the railroads are required to pay as much as the total cost of such protection. While the present Federal-aid program is a monumental undertaking, only a small percentage, approximately 25 percent, of the total highways and graded crossings in this country are eligible for coverage.

At the State level there also have been very significant changes in the old concept of railroad responsibility. The present trend in many States is towards assuming a substantial degree of public responsibility for the protection of grade crossings. Some states have already taken action, legislatively or otherwise, to provide State assistance to local authorities for crossing improvement projects, and thus to relieve the railroads of the major financial responsibility for such projects. Twelve States have established grade crossing protection funds to assist in the costs for grade crossing protection, because they have recognized that the availability of funds is the controlling factor as to the number of crossings which will be eliminated or protected. Several States also are participating in the maintenance costs for grade crossing protection.

Most States have recognized that the demand and need for grade crossing protection have been caused primarily by the development, growth and public acceptance of motor vehicles and highways; that the separation structures and protective devices are more significantly a part of the highway system rather than the railroad system; and that such safety projects benefit the highway users more than the railroads. Consideration also may have been given to the fact that while railroads are private corporations, they are affected with a certain public interest, and are operated for public purposes. Railroad companies are for certain purposes quasi-public corporations or agencies engaged in the performance of public dutues, intrusted to private hands, but regulated by the public to serve the public convenience. (See 44 Am. Jur. Railroads Section 9 (1942).

Notwithstanding the gradual change in policy, the States could legally and constitutionally require the railroads to bear the entire responsibility, as they did many years ago when the problem arose. This is exactly what happened recently in Florida E.C. Ry. v. Martin County, 171 So. 2d 873, cert. denied, 382 U.S. 834 (1965). A county in Florida condemned an easement for a public road at grade across a railroad track, and the railroad was ordered to pay the entire cost of constructing and maintaining the grade crossing and the automatic crossing protective devices needed to safeguard persons and property using the crossing. The railroad argued and relied upon the U.S. Supreme Court's decision in the Walters case, supra, and the findings and conclusions of the Interstate Commerce Commission in 322 ICC 1 (1964) with regard to the changed conditions and "public responsibility." The county relied upon the U.S. Supreme Court's decision in the 1953 Santa Fe case, supra, and the statement contained therein that "this court has consistently held that in the exercise of the police powers, the costs of such improvements may be allocated all to the railroads." The county argued that the U.S. Supreme Court had discussed the Walters case, supra, in the Santa Fe case, supra, and found both to be in harmony with former decisions rendered by that court on the same subject. The Supreme Court of Florida relied upon the U.S. Supreme Court's decision in the 1897 Burlington case, supra, and the Santa Fe case, supra, in placing the entire responsibility upon the railroad. In light of such decisions it is not realistic to expect the States or their subdivisions to voluntarily assume the entire responsibility for grade crossing improvements or protection. Also, their lack of funds would prohibit this as it has been their principal deterrent to greater progress in the past.

However, in spite of the Martin County decision, supra, which returned to the earlier practice of placing the entire responsibility upon the railroad, the State of Florida has budgeted $1,000,000 annually, starting July 1, 1970, to aid in the installation of grade crossing protective devices.

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