Chapter V

RAILROAD SAFETY PICTURE

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This chapter presents an analysis of railroad accident data and the findings of such analyses as they relate to railroad safety. The data used in this study are based on accident information reported to the Federal Railroad Administration and include data collected between 1966-74. * A discussion of the reporting requirements, the uses of the data, and associated data problems are presented in appendix B.

The safety of the railroad industry as shown by available accident data may be viewed from two perspectives: the safety of people and the safety of property. The safety of people is measured by the number of casualties (injuries and fatalities) and the cost of resulting claims. The safety of property is measured by the loss of and damage to railroad equipment, track, and roadbed (estimated) and the lading (actual).

SAFETY OF PEOPLE

An analysis of the overall casualty data during 1966-74 shows that **95.6** percent of all injuries and fatalities resulted from train service and nontrain accidents.** As shown in table 18, injuries and fatalities resulting from all railroad accidents generally declined during this period, with the exception of a slight rise in injuries and an increase in fatalities resulting from nontrain accidents in 1974.

Total fatalities during the period have decreased by **28.9** percent. In absolute terms, fatalities declined from a high of **2,684** in 1966 to a low of 1,908 in 1974, exhibiting a continuous decline throughout the 9-year period. Injuries in the same 9-year period declined by 18.5 percent. In absolute terms, there were **25,552** injuries in 1966. Injuries then decreased through 1972 to a low in that year of 17,930. Total injuries then increased during 1973 to 20,818 in 1974.

The FRA has established five major classes of persons in reporting casualties. These include employees on duty, employees not on duty, passengers, nontrespassers, and trespassers. For this analysis the employees, both on duty and not on duty, were combined into one class. Also, the nontrespassers were designated as "other" for this analysis and included all persons not included as employees, passengers, or trespassers. This group was made up primarily of casualties resulting from grade-crossing accidents. Of the total casualties in the railroad environment for the 9-year period **(19,829** fatalities **and 195,331 injuries), as** shown in table 19, injuries to employees constituted the largest percentage of total injuries (74.3 percent) while fatalities to persons in the "other" category constituted the largest percentage of total fatalities **(64.9** percent).

*Public Law 94-348 requested accident data for the 10 years preceding July 1976. The data for 1975 have not been used in this report for purposes of comparison with the data of preceding years because of substantial changes in the FRA reporting requirements in 1975, which make direct comparison impractical.

* *Through calendar year 1974, the FRA divides railroad accidents into three major types: Train accident, Train service accident, and Nontrain accident. Train Service and Nontrain accidents will be mainly discussed as they relate to the safety of people (and are defined below) while Train accidents will be discussed in the next section as they relate to the safety of property.

Train Service Accident—an accident arising out of the movement or operation of trains *and resulting* in a reportable death or injury but less than $750 damage to equipment, track, or roadbed.

Nontrain Accident—an accident resulting in a reportable casualty (injury or fatality) but not caused directly by the operation or movement of trains.

Table 18.—Casualties by Type of Railroad Accident

Year	Train accidents			Train service accidents			Nontrain accidents			Total railroad accidents		
	Fatalities	Injuries	Accidents	Fatalities	Injuries	Accidents	Fatalities	Injuries	Accidents	Fatalities	Injuries	Accidents
1966	**214**	**900**	**6,793**	2,387	16,489	16,839	83	8,163	8,152	2,664	25,552	31,764
1967	170	754	7,294	2,238	15,868	16,240	75	7,881	7,846	2,483	24,523	31,380
1966	142	1,293	8,028	2,141	15,500	15,934		7,815	7,765	2,359	24,608	31,727
1969	203	1,173	8,543	2,011	14,986	15,388		7,197	7,170	2,299	23,356	31,101
1970	210	627	8,095	1,936	13,878	14,419	79	6,822	6,812	2,225	21,327	29,326
1971	171	694	7,304	1,792	12,171	12,562	47	6,107	6,068	2,010	18,972	25,934
1972	171	777	7,532	1,704	11,507	11,825		5,646	5,632	1,945	17,930	24,989
1973	149	758	9,698	1,704	11,946	12,384	1:	5,541	5,538	1,916	18,245	27,620
1974	139	911	10,694	1,692	12,878	13,185	77	7,029	7,017	1,908	20,818	30,896
Total	**1,569**	**7,887**	**73,981**	**17,605**	**125,243**	**128,776**	**655**	**62,201**	**62,000**	**19,829**	**195,331**	**264,757**

SOURCE: Compiled by OTA from Federal Railroad Administration data.

Table 19.—Casualties Resulting From Class I and Class II Railroad Accidents

	Employees		Passengers		Trespassers		Other*		Total	
	Fatalities	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities	Injuries
1966	**168**	18,651	**23**	1,244	678	702	**1,815**	**4,955**	2,684	**25,552**
1967	**176**	18,055	**12**	1,054	646	696	**1,649**	**4,718**	2,438	**24,523**
1968	**150**	18,116	**11**	1,329	628	663	**1,570**	**4,500**	2,359	**24,608**
1969	**190**	17,255	**6**	862	627	674	**1,476**	**4,565**	2,299	**23,356**
1970	**172**	16,285	**8**	489	593	646	**1,452**	**3,907**	2,225	**21,327**
1971	**123**	14,191	**16**	536	551	607	**1,320**	**3,638**	2,010	**18,972**
1972	**133**	12,973	**47**	660	537		**1,228**	**3,691**	1,945	**17,930**
1973	**161**	13,511	**6**	503	578	R	**1,171**	**3,577**	1,916	**18,245**
1974	**144**	16.002	**7**	574	565	674	**1,192**	**3,566**	1,908	**20,818**
Total	**1,417**	**145,079**	**136**	7,271	5,403	**5,862**	**12,873**	**37,119**	19,829	**195,331**
Percent total	**7.1**	**74.3**	*0.7*	3.7	27.3	**3.0**	**64.9**	**19.0**	100.0	**100.0**

● Other includes all persons not included as employees, passengers or trespassers. (This group was made up primarily of casualties resulting from grade-crossing accidents.)

SOURCE: Compiled by OTA from Federal Railroad Administration data.

With respect to fatalities, trespassers were the second highest in number with **5,403 (27.3** percent); employees ranked third overall with 1,417 (7.1 percent); and passengers had the least amount of fatalities with 136 (0.7 percent). Of the total injuries, the "other" category registered the second highest number with 37,119 (19.o percent); passengers ranked third with 7,271 (3.7 percent); and trespassers had the fewest injuries with 5,862 (3.0 percent).

Trends toward a general decline in fatalities among trespassers and "other" were evidenced over the 9 years. Trespasser fatalities declined by **16.7** percent from 1966 to 1974 and except for a rise in 1973 showed a continuous decline. "Other" fatalities declined by 34.3 percent from **1966** to 1974 and continuously decreased to a low point in 1973 before exhibiting a slight rise in 1974. Although the absolute number of fatalities decreased from **1966** to 1974 for both employees and passengers, fluctuations were evident during this time.

Injuries declined for all four categories during 1966-74, but in no case were there continuous decreases registered during this period. Employee injuries declined by **14.2** percent from **1966-74** and generally decreased to a low point in **1972** before showing an increase through 1973-74, Although the absolute number of injuries decreased from **1966** to 1974 for passengers, trespassers, and "other," fluctuations were noted during this time.

EMPLOYEE ACCIDENT ANALYSIS

During 1966-74, 146,496 employee casualties resulting from all railroad accidents were reported, with **145,079** of those being employee injuries and 1,417 employee fatalities. Also during this time, the total hours worked by employees decreased from **1,346** million man-hours in **1966 to 1,099** million man-hours in 1974 (– 18.4 percent). To properly analyze the employee casualties, they must be adjusted for the changes in hours worked. When the numbers of employee fatalities and injuries are normalized for these changes in the hours worked, the following resulted:

Employee Fatalities Million Man-Hours

1966	1974
0.125	0.131

Employee Injuries Million Man-Hours

1966	1974
13.86	14,56

Thus, after normalizing, there was no identifiable change in employee fatalities while employee injuries slightly increased.

Employee casualties were further analyzed by cause of accident to determine why various injuries and fatalities were occurring to employees. This analysis generally combined the cause codes of both train service and nontrain accidents to identify those activities which were resulting in a major portion of the injuries and fatalities to employees. The results of this analysis of employee injuries during 1966-74 are shown below:

Employee Injuries (By major cause of accident)

Mujor cause	Percent of tottii *employee injuries*
Getting on or off trains.	16.6
Construct ion and maintenance of cars and locomotives	12.2
Construction and maintenance of track, ties, and rail . . .	8.9
Stumbling, slipping, and tailing (not on train)	7.9
Coupling and uncoupling. ., ...	.5. b
Flying or falling objects, burns, etc. .	4.8

The single major cause, "getting on or off trains," exhibited the highest percentage of all employee injuries with **16.6** percent. This major cause includes 44 subcauses, all associated with getting on or off cars or locomotives. Most of these subcauses relate to equipment component defects, slipping or falling for various reasons, and other miscellaneous reasons. However, most of these injuries were related to slipping and falling and miscellaneous reasons. The second leading contributor to employee injuries was "construction and maintenance of cars and Locomotives," with **12.2** percent. This cause code was made up of two nontrain accident causes ("construction and maintenance of cars" and "construction and maintenance of locomotives") and is largely comprised of those man-machine interface activities conducted while servicing and maintaining equipment. The major cause "construction and maintenance of track, ties, and rail," resulting in **8.9** percent of the total employee injuries, includes similar man-machine interface activities that relate to servicing and maintaining track and roadbed.

When the major causes of employee fatalities are analyzed for 1966-74, the results are:

Employee Fatalities
(By major cause of accident}

Major cause	*Percent of total employee fatalities*
Struck or runover at places other than public rail-highway crossing.	20.7
Various causes of collisions, derailments, and other train accidents	17. Q
Coupling and uncoupling. . . .	7.0
Stumbling, slipping, and falling (while on train).	5.8
Getting on or off trains.	5.2
Construction and maintenance of cars	3.7

The largest single major cause of employee fatalities was "struck or runover at places other than public rail-highway crossings," with **26.7** percent. This major cause includes those sub-

causes relating to employees killed while walking or working along the track. The next major cause resulting in 17.9 percent of all employee fatalities was due to "various causes of coHisions, derailments, and other train accidents." A total of **254** employee deaths (17.9 percent of all employee fatalities) resulted from this cause over the 9-year period. A breakdown by number of employee deaths shows that 166 employees died in collisions, **65** died in derailments, and the remaining **23** died in other train accidents. The third major cause of employee fatalities, "coupling and uncoupling," with **7.0** percent of the total employee fatalities, was comprised of various man-machine activities involved in coupling and/or uncoupling locomotives and cars as well as coupling and/or uncoupling air hoses, steam hoses, and safety chains. Three major causes exhibited themselves with respect to both the employee fatalities and employee injuries listings. These included:

- "Getting on or off trains,"
- "Construction and maintenance of cars," and
- "Coupling and uncoupling."

The major cause "stumbling, slipping, and falling" also was seen in both listings. However, the employee injuries listing included "stumbling, slipping, and falling" in conducting activities not on the train, while the employee fatalities listing included "stumbling, slipping, and falling" in conducting activities while on the train.

An analysis of the employee problem by job classification was conducted by the Association of American Railroads to determine if any casualties were occurring to employees within specific job categories. This analysis resulted in the employee category "transportation (train and engine)" accounting for over 55 percent of the employee injuries and over 54 percent of the employee fatalities. The safety problem of injuries and fatalities occurring to the transportation group (train and engine) compared with other job categories, is shown below:

Total **Employee Injuries**

lob categories	Percent of total *employee injuries*
Executives, officials, and staff assistants	0.1
Professional, clerical, and general	3.4
Maintenance of way and structures	14.0
Maintenance of equipment and stores	15.4
Transportation (other than train, engine, and yard)	5.5
Transportation (yardmasters, switchtenders, and hustlers)	6.5
Transportation (train and engine)	55.1
	100.0

Total Employee Fatalities

Job categories	*Percent of total employee injuries*
Executives, officials, and staff assistants	1.1
Professional, clerical, and general	2.0
Maintenance of way and structures	23.2
Maintenance of equipment and stores	**15.9**
Transportation (other than train, engine, and yard)	2.6
Transportation (yardmasters, switchtenders, and hustlers)	0.8
Transportation (train and engine)	54.4
	100.0

A ranking procedure was then used to investigate the safety problem of the individual job classifications within each job category. This procedure was based on a combination of accident frequency (measured by the number of accidents per year) and the severity (measured by the median days disabled per accident). When this procedure was used to rank the individual job classifications during the 9 years from 1966 through 1974, yard brakemen and yard helpers were ranked first by far in every year. Section "men" ranked second in 8 of the 9 years. Because of analyses of this type, yard brakemen have been selected for further study by the AAR to determine the reasons why these employees are involved in over 50 percent of the total employee injuies and fatalities.

'A. E. Shulman, Analysis of Nine Years of Railroad Per**sonnel Casualty Data** 1966-1974, Association of American **Railroads, November** 1976.

TRAIN SERVICE AND NONTRAIN ACCIDENTS

As previously stated, over 95 percent of all injuries and fatalities from 1966-74 resulted from train service and nontrain accidents, The next two sections examine these two types of railroad accidents which contribute to virtually all of the injuries and fatalities,

Train Service Accidents

During the period 1966-74, the absolute number of train service accidents decreased from 16,839 to 13,185 (–21.7 percent). However, during this time train service accidents resulted in 64.1 percent of all injuries and 88.8 percent of all fatalities resulting from railroad accidents. A substantial number of these train service accidents were rail-highway grade-crossing accidents and are fully discussed in chapter X. When the injuries resulting from rail-highway grade-crossing accidents are excluded from the injuries resulting from total train service accidents, almost **90** percent of the remaining injuries occurred to railroad employees. During the 9-year period, train service employee fatalities accounted for **4.6** percent of total train service fatalities, while train service employee injuries accounted for **67.1** percent of total train service iniuries. Of the total employee injuries (145,079) and fatalities (1,417), 57.9 percent of the employee injuries and 57.5 percent of the employee fatalities resulted from train service accidents (table **20).**

During the 9-year period, employee injuries resulting from train service accidents decreased from 10,814 in 1966 to 8,870 in 1974 (– 18.0 percent). This decrease was not continuous and exhibited a low of 7,426 in 1972. During the same period, employee fatalities resulting from train service accidents decreased from 98 in 1966 to 81 in 1974 (– 17.3 percent). However, as shown in table **20, fluctuations** occurred throughout these 9 years. Figure 1 shows the rate when employee injuries resulting from train service accidents are normalized by changes in employment hours worked.

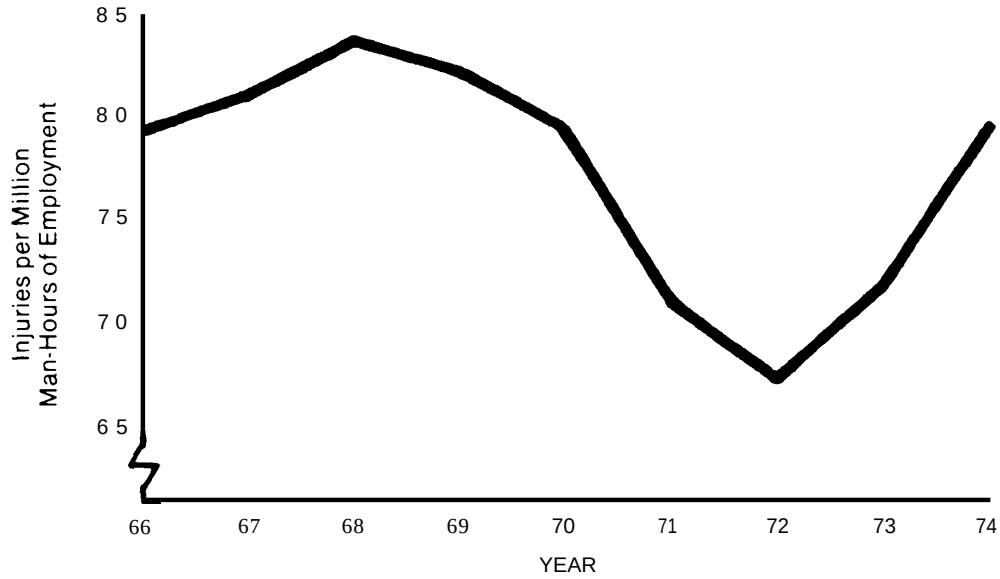
Normalizing the train service emploYee injuries over the 9 years had the effect of changing them from an 18-percent decrease to a slight increase of approximately O.5 percent.

Table 20.—Train Service Accidents

	Train service accidents	Train service injuries	Train service fatalities	Train service employee injuries	Train service employee fatalities
1966	16,839	16,489	2,387	10,814	**98**
1967	16,240	15,888	2,236	10,467	**117**
1968	15,934	15,500	2,141	10,580	100
1969	15,388	14,986	2,011	10,186	**98**
1970	14,419	13,878	1,936	9,633	**84**
1971	12,562	12,171	1,792	8,104	**71**
1972	11,825	11,507	1,704	7,426	
1973	12,384	11,946	1,704	7,968	**: :**
1974	13,185	12,878	1,692	8,870	**81**
Total	128,776	125,243	17,605	84,048	815

SOURCE: Compflied by OTA from Federal Railroad Adminstration data.

Figure 1.—Train Service Employee Injuries Normalized by Million Man-Hours of Employment, 1966-74



Source A E Shulman C E Taylor Analysts o(Nine *Years of Fta//road Ace/dent Data 19667974,* Associat[on of American Ra{l roads, April 1976

The severity of the employee injuries (measured by the frequency of accidents and median days disabled) resulting from train service accidents was analyzed by the AAR.[2] The results indicated that the increase in employee injuries from **1972-74** was not the result of an increase in more severe injuries, but an increase of less severe injuries.

Employee casualties resulting from train service accidents were further analyzed by cause to determine the reasons why various injuries and fatalities were occurring to them. The results of this analysis for employee injuries during the period 1966-74 are as follows:

Employee Injuries in Train Service Accidents (By major cause category)

Major cause	Percent *of* total *train service employee injuries*
Getting on or off trains.	27.0
Stumbling, slipping, and falling (not on train)	13.3
Coupling and uncoupling.	9.5
Flying or falling objects, burns, etc. .	8.1
Operating switches	6.6
Operating hand brakes.	5.3

Analyses conducted by the AAR[3] further considered the various cause categories of train service accidents and ranked them (based on frequency and severity) for the 9 years. "Getting

2A. E. Shulman, C. E. Taylor, Analysis of Nine Years of Railroad Accident Data, 1966-1974, Association of American Railroads, April 1976.

[3]A. E. Shulman, C.E. Taylor, Analysis of Nine Years of Railroad Accident Data, 1966-1974, Association of American Railroads, April 1976.

on and off trains" ranked first in every year while "stumbling, slipping, and falling" (not on cars or locomotives) ranked high in all 9 years. Other causes to rank high were "struck at places other than public rail highway crossings, operating hand brakes, and operating switches. "

When employee fatalities resulting from train service accidents were analyzed by major cause for the period **1966-74,** the results were as follows:

Employee Fatalities in Train Service Accidents
(By major **cause category)**

Major cause	**Per-cent** of *total train service employee fatalities*
Struck or runover in places other than public rail-highway crossings	33.6
Coupling and uncoupling. . .	8.8
Stumbling, slipping, and falling (while on train), ...	7,3
Getting on or off trains.	6.5
Contacting fixed structures while on train	5.4

Appendix C presents the trends of each major subclass of train service accidents for all Class I railroads during 1966-74. As seen from these graphs, all the subclasses of train service accidents showed decreases during 1966-74, except those related to coupling and uncoupling and operating switches. Although one subclass of train service accidents (rail-highway grade-crossing accidents) also decreased during these 9 years, as discussed in chapter X, they continue to be a serious safety matter.

Nontrain Accidents

During the period 1966-74, the number of nontrain accidents decreased from 8,152 to 7,o17 (– 13.9 percent). These numbers decreased continuously to 5,538 in 1973 and then sharply increased in 1974. Nontrain accidents resulted in 31.8 percent of all railroad accident injuries and 3.3 percent of all railroad accident fatalities. During the 9-year period, nontrain employee fatalities accounted for 51.9 percent of the total nontrain fatalities, while nontrain employee injuries accounted for 91.9 percent of the total nontrain injuries. Of the total employee injuries (145,079) and fatalities (1,417), 39.4 percent of the employee injuries and 24.0 percent of the employee fatalities resulted from nontrain accidents (table 21).

During the 9-year period, employee injuries resulting from nontrain accidents decreased from 7,412 in **1966** to **6,625** in **1974 (– 10.6** percent). There was a continuous decrease to a low point of 5,156 in 1973 and then and increase to 6,625 in 1974. During the same 9 years, employee fatalities resulting from nontrain accidents decreased from 49 in **1966** to 37 in **1974 (– 24.5** percent). However, fluctuations oc-

Table 21 .— Non train Accidents

	Non train accidents	**Non train** injuries	**Non train** fatalities	**Non train employee** injuries	**Non train** employee fatalities
1966.	8,152	8,163	83	7,412	49
1967.	7,846	7,881		7,130	37
1968.	7,765	7,815	; :	7,100	42
1969.	7,170	7,197	85	6,574	47
1970.	6,812	6,822	79	6,289	42
1971	6,086	6,107	47	5,700	21
1972.	5,632	5,646	70	5,199	40
1973.	5,538	5,541	63	5,156	25
1974.	7,017	7,029	77	6,625	37
Total	62,000	62,201	655	57,185	340

SOURCE: Compiled by OTA from Federal Railroad Administration data.

curred throughout the 9 years. When the employee injuries resulting from nontrain accidents are normalized by changes in employment hours worked, the rate of employee injuries is as shown in figure 2.

Normalizing the nontrain employee injuries over the 9 years has the effect of changing them from a 10.6 percent decrease to a 9.4 percent increase. The severity of the employee injuries (measured by the frequency of accidents and median days disabled) resulting from nontrain accidents was analyzed by the AAR.[4] The results indicated that the increase in the number and rate of nontrain employee injuries during 1973 and 1974 was the result of an increase in less severe injuries and not as a result of more severe injuries.

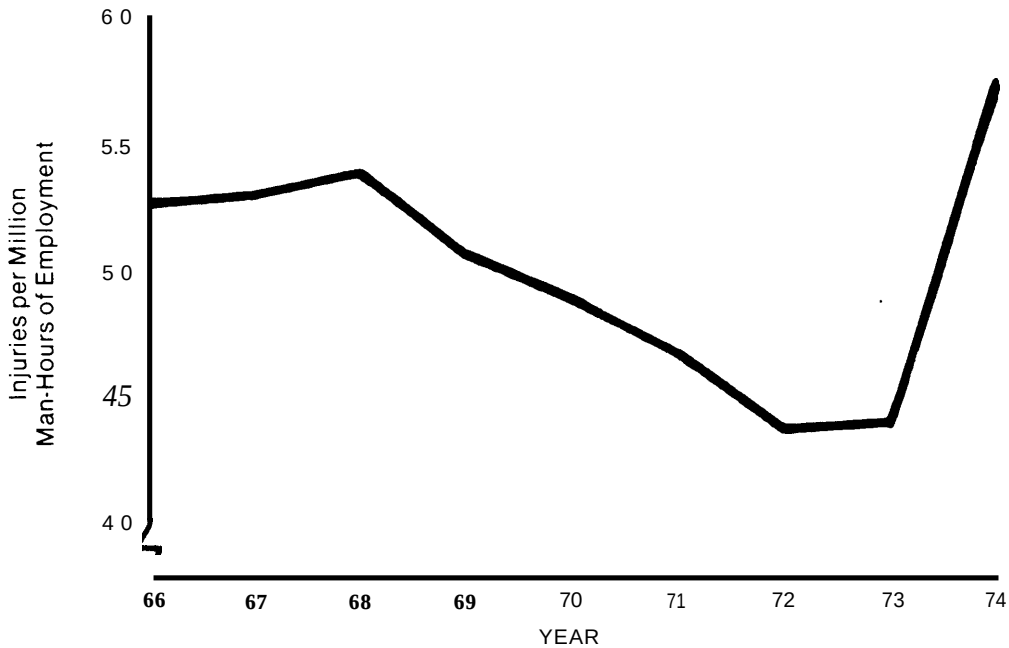
Employee injuries resulting from nontrain accidents were then analyzed by cause to determine the major reasons why various injuries and fatalities were occurring to them. The results of this analysis for the 9-year period are shown below:

Employee Injuries in Nontrain Accidents (By major cause category)

Major cause	*Percent of total nontrain employee injuries*
Construction and maintenance of cars	22.7
Construction and maintenance of locomotives	9,2
Construction and maintenance of track, ties, and rail	23.2
Miscellaneous nontrain causes	24.1

[4] A. E. Shulman, Analysis of Nine Years of Railroad Personnel Casualty Data, 1966-1974, Association of American Railroads, November 1976.

Figure 2.— Nontrain Employee Injuries Normalized by Million Man-Hours of Employment, 1966-74



Source A E Shulman, *Analysis of Nine Years of* Railroad *Personnel Casualty Data 19661974* Associaction of American Railroads, April 1976

A similar analysis of employee fatalities resulting from nontrain accidents by cause for 1966-74 resulted in the following:

Employee Fatalities in Nontrain Accidents (By major cause category)

Major cause	*Percent of total non train employee fatalities*
Construction and maintenance of cars	17.9
Operation and maintenance of track motor cars	11.8
Miscellaneous nontrain causes	11.8
Operation of miscellaneous vehicles on public highways.	11.1
Construction and maintenance of bridges, tunnels, and culverts .	**8.1**

The two major causes, "construction and maintenance of cars" and "miscellaneous nontrain causes, " accounted for **29.7** percent of nontrain employee fatalities and **46.8** percent of nontrain employee injuries.

Appendix C presents the trends of each major subclass of cause of nontrain accidents for all Class I railroads during 1966-74. Again, these graphs show the significant contribution of nontrain accidents by the two causes "construction and maintenance of cars" and "miscellaneous nontrain causes. " When the major causes of nontrain accidents were normalized by changes in employment hours, the two largest contributors to nontrain employee injuries were again "construction and maintenance of cars" and "miscellaneous nontrain causes. " Although many of these subclass causes exhibited fluctuations throughout the 9-year period, those related to track improvement (construction, servicing, and maintenance of ties, tie plates, and fasters; CS&M of rail; and CS&M of motor cars and roadway machines) increased 20, 65, and 61 percent, respectively.

The analysis of nontrain accidents indicated that many of the specific causes identified within the major cause categories did not offer adequate reasons why certain accidents were occurring which resulted in death and injury to employees. Many of these accidents seem to result from a breakdown in the interaction between man and machine. However, more study seems warranted to determine the reasons behind and causes for these accidents. Special or in-depth analyses are needed to develop means for better understanding and alleviating these safety problems.

SAFETY OF PROPERTY

As previously stated, the safety of property is measured by the loss of and damage to railroad equipment, track, and roadbed (estimated) and the lading (actual). This loss and damage occurs primarily in collisions, derailments, and other train accidents. This section examines the types of railroad accidents which contribute to virtually all of the property and lading damage* but only to a small portion of the injuries and fatalities.

Train Accidents

During the period 1966-74, the absolute number of train accidents** increased from 6,793 in 1966 to 10,694 in 1974 (+ 57.4 percent). These train accidents resulted in 4.0 percent of all injuries and 7.9 percent of all fatalities resulting from railroad accidents. Moreover, they resulted in virtually all the loss and damage

*There is some lading damage that occurs which results from other than train accidents (i.e., spoilage, improper handling, etc.) This lading damage was not considered in this study.

* *Train Accident—an accident arising out of the movement or operation of trains and resulting In more than $750 damage to equipment, track, or roadbed whether or not a reportable death or injury occurred.

to track, roadbed, equipment, and lading (see table 22).

Table 22.—Train Accidents and Associated Costs

Year	Train accidents	Loss and damage to track, roadbed, equipment, and lading [million-current$]
1966.....	6,793	117.6
1967.....	7,294	118.0
1968.....	8,028	140.3
1969.....	8,543	161.7
1970..,..	8,095	158.4
1971.....	7,304	144.8
1972.....	7,532	140.3
1973.....	9,698	188.4
1974.....	10,694	243.2

SOURCE: Compiled by OTA from Federal Railroad Administration and Association of American Railroads data.

As previously noted, train accidents are defined as those arising out of the movement or operation of trains and resulting in more than **$750 damage** to equipment, track, or roadbed, whether or not a reportable death or injury occurs. This monetary threshold of $750 established in 1956 was not revised to take inflation into consideration until 1974. At this time, the reporting threshold was increased to $1,750 and subsequent increases were established for the years 1957-74. Since the monetary threshold had remained constant during this time and did not increase with inflation, there was an overreporting of train accidents. Therefore, adjustments to the total number of reportable train accidents were required, which reduced these total numbers. Figure 3 presents the results of adjusting train accidents for inflation. This adjustment resulted in reducing the number of train accidents from 6,793 to 5,604 in 1966 and 10,694 to 7,491 in 1974.

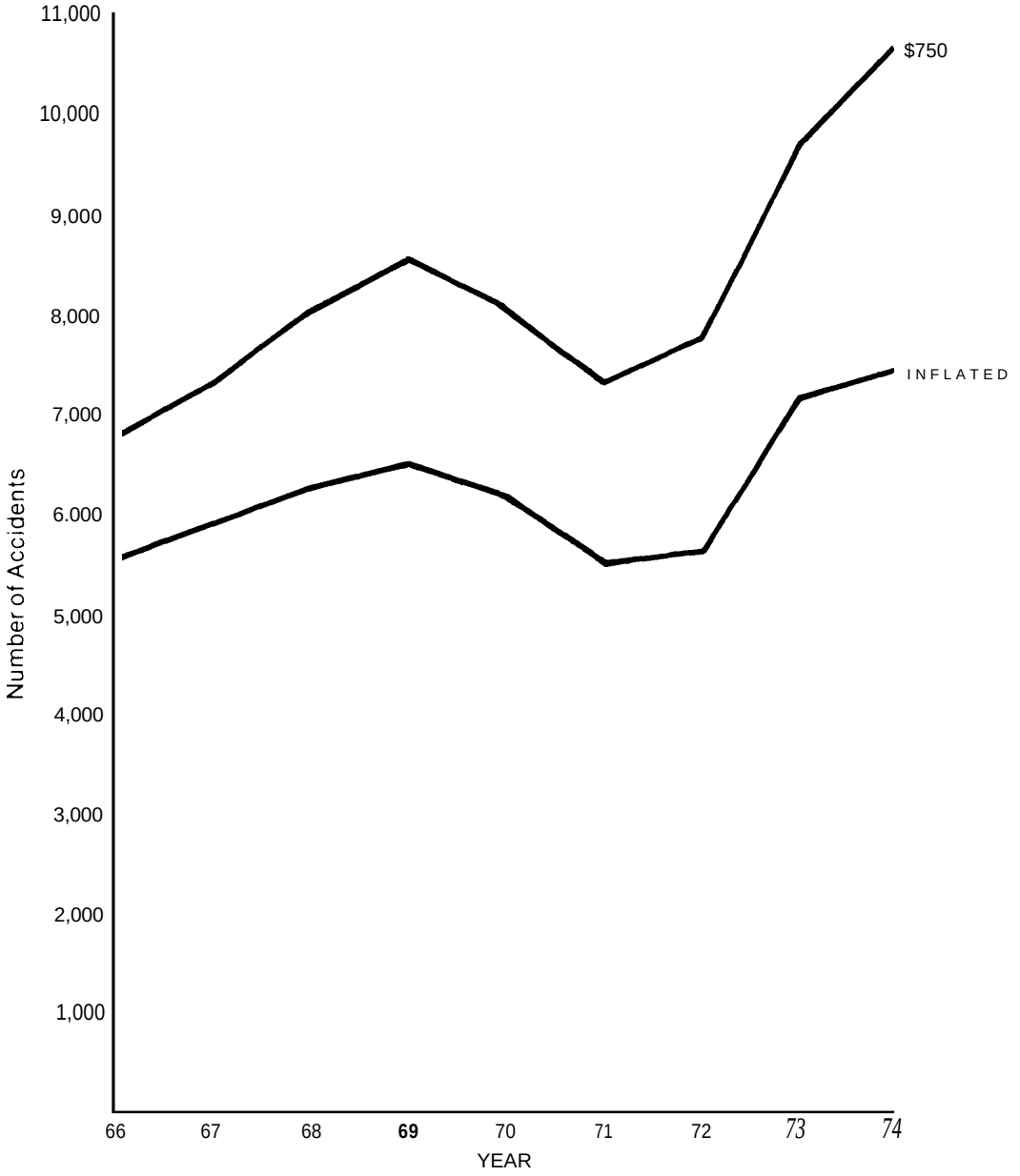
Although inflation had an impact on the number of train accidents reported, the changing operating practices over the 9-year period also impacted the change in the number of train accidents. There has been much discussion as to what is an accurate measure of the railroads' operating practices. Several have been identified: ton-miles, train-miles, and car-miles. From the standpoint of freight movement, ton-miles seems to be the best indicator. With respect to the crew and passenger movement, train-miles or car-miles may be more appropriate. Since the major business conducted by the railroads is the transportation of goods, ton-miles was the measurement used in this study for analysis of changing operating practices with respect to train accidents. When the train accidents as shown in table 22 were adjusted for the monetary threshold and changes in operating practices, the increase in train accidents over the 9-year period was 15.9 percent.

Table 22 also shows that the loss and damage to track, railroad, equipment, and lading in-

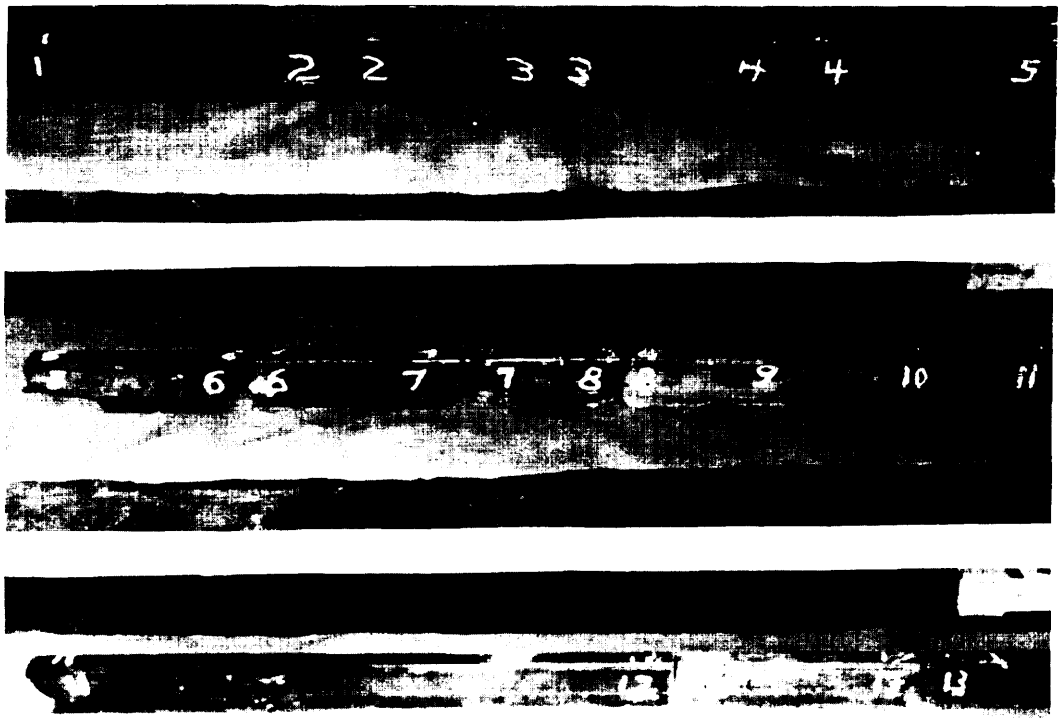
Photo: Courtesy of Federal Railroad Administration

Transverse fissure resulting in broken rail; cause of the Harve, Mont. derailment, November 26, 1976.

Figure 3.— Number of Train Accidents at Thresholds of $750, Inflated, 1966-74



Source A E Shulman C E Taylor, Arra/y.s/s o/ A/me Years of R8(/road Acc/derrf Data 1966-1974, Association of American Ral I roads, April 1976



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creased in current dollars from $117.6 million in **1966** to $243.2 million in 1974. When those dollars are adjusted to constant 1975 dollars, using the consumer price index, the increase over the 9 years is 25 percent.

During the 9-year period, train accident employee fatalities accounted for 16,2 percent of total train accident fatalities, while train accident employee injuries accounted for 47.5 percent of total train accident injuries. Of the total employee injuries **(145,079)** and fatalities (1,417), only 2.6 percent of the employee injuries and 17.9 percent of the employee fatalities resulted from train accidents (see table 23).

The FRA has established four major contributing cause categories to train accidents. These include: human factors, equipment failures; defects in way or structures; and miscellaneous. Table 24 shows that in absolute numbers, human factors-caused train accidents increased by 12. o percent, equipment-caused train accidents increased by 18.0 percent, defects in way and structures-caused train accidents increased by **198.6** percent, and miscellaneous-caused train accidents increased by 32.4 percent.

When these train accidents are adjusted for the monetary threshold and normalized by changes in ton-mileage, the increase in track-caused accidents is seen to be 106 percent from 1966-74, whereas there is no change in miscellaneous-caused accidents and approximately a 15-percent decrease in both equipment and human factors-caused accidents.

Of the four major contributing-cause categories, track-caused accidents nearly doubled as a percentage of total train accidents during the 9 years, increasing from 21.0 percent of the total in 1966 to 39.9 percent of the total in 1974. Figure 4 shows the percentage of the four cause categories within these 9 years and is based on the number of train accidents at the inflated thresholds. While the remaining three contributing causes declined as a percentage of total train accidents, the track cause as a percentage of total train accidents increased by 83.5 percent.

An analysis of train accidents by contributing cause was conducted by the AAR. This analysis applied a ranking index (based on the frequency of train accidents and the median dollar damage) to each major contributing-cause category in the train accident data over the 9-year period.[5] With respect to track-related train accidents, the two most common causes were mainline rails (broken railend, split head, split web) and mainline line and surface (improper superelevation, improper alinement, improper

[5] A. E. Shulman, C.E. Taylor, Analysis of Nine Years of Railroad Accident Date, 1966 1974, Association of American Railroads, April 1976.

Table 23.—Train Accidents

Year	Train accidents	Train injuries	Train fatalities	Train employee injuries	Train employee fatal i ties
1966	6,793	900	214	417	21
1967	7,294	754	170	446	22
1968	8,028	1,293	142	427	8
1969	8,543	1,173	203	482	45
1970	8,095	627	210	354	
1971	7,304	694	171	372	31
1972	7,532	777	171	336	16
1973	9,698	758	149	419	42
1974	10,694	911	139	493	25
Total	73,981	7,887	1,569	3,746	254

SOURCE. Compiled by OTA from Federal Rail road Administration data.

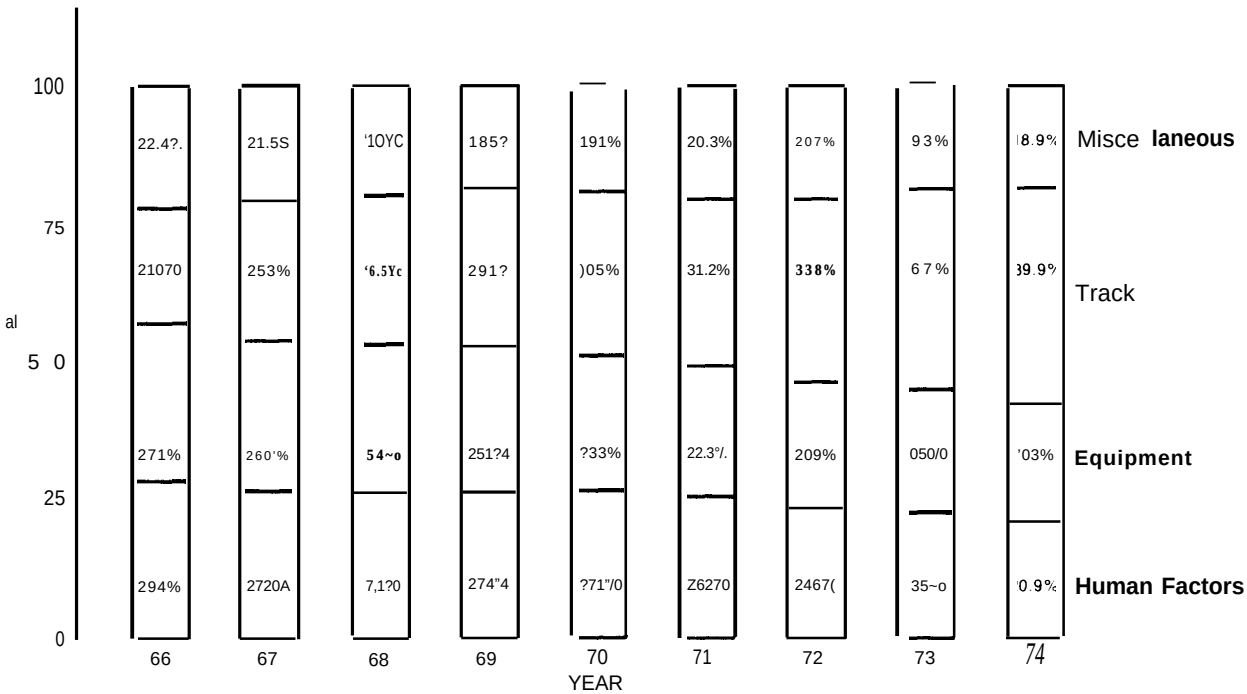
Table 24.—Train Accidents by Contributing Cause

Year	Human factors	Equipment	Track"	Miscellaneous	Total
1966.	1,999	1,843	1,428	1,523	6,793
1967.	1,987	1,897	1,844	1,566	7,294
1968.	2,174	2,042	2,128	1,684	8,028
1969.	2,339	2,142	2,483	1,579	8,543
1970.	2,191	1,890	2,470	1,544	8,095
1971.	1,912	1,630	2,276	1,486	7,304
1972.	1,853	1,577	2,544	1,558	7,532
1973.	2,282	1,992	3,556	1,868	9,698
1974.	2,238	2,175	4,264	2,017	10,694

'The track column is the same as Defects in way and structures.

SOURCE: Federal Rail rOad Administration.

Figure4.— Percentageof Human Factors, Equipment, Track,and MiscellaneousTrainAccidents, inflated Thresholds, 1966-74



SOURCE. Complied by OTA from Association of American Railroads data

surface of track, soft track). These causes ranked first and second throughout the 9-year period, indicating the seriousness of these types of problems.

With regard to equipment-caused accidents, the analysis showed that the two most common causes were axles (journals broken, overheating, cold) and trucks (side bearing missing or defective, improper clearance), Throughout the analysis period, the axle-caused equipment accidents had the highest frequency except for 2 years. However, based on the frequency/severity (severity being measured in median dollar damage) index, it ranked far ahead of the other equipment causes for 7 out of the 9 years. A recent study has identified car dynamics as a major cause of train accidents (specifically derailments) and has passed journal bearing defects as the major equipment cause. [b] Car dynamics (components related to ride stability other than wheels, couplers, and draft gear have shown a steadily upward trend in both the number of equipment-caused derailments and the dollar damage caused by these derailments (figure 5).

With regard to human factors-caused train accidents, the leading causes varied from year to year, but the most common were "failure to secure hand brakes," "absence of man on or at leading car being pushed," and "excessive speed." The cause code "failure to secure by hand brake" ranked first in 6 years and second in the remaining 3 years. Although it is difficult to determine why this cause code ranked so high throughout the 9 years, operating practices, ineffective training, personal problems, or employee apathy may be contributing factors to these types of human factors train accidents. This may indicate that more effort in the area of human factors research and development should be undertaken. A handbrake study by AAR is presently underway which includes human factors analyses.

Within the miscellaneous cause codes, nine different causes were ranked in the top five categories within the 9-year period. In 7 of the 9 years, the number of accidents in the category "accident investigated —other ascertained cause" exceeded the number of accidents in any other cause code within the miscellaneous category. With no discrete cause codes available, the investigation of these types of accidents in determining countermeasures becomes exceedingly difficult. The number of cause codes within the miscellaneous causes was reduced in the 1975 reporting requirements. However, because of the problems that still exist with the data, it is too early to determine the degree of success.

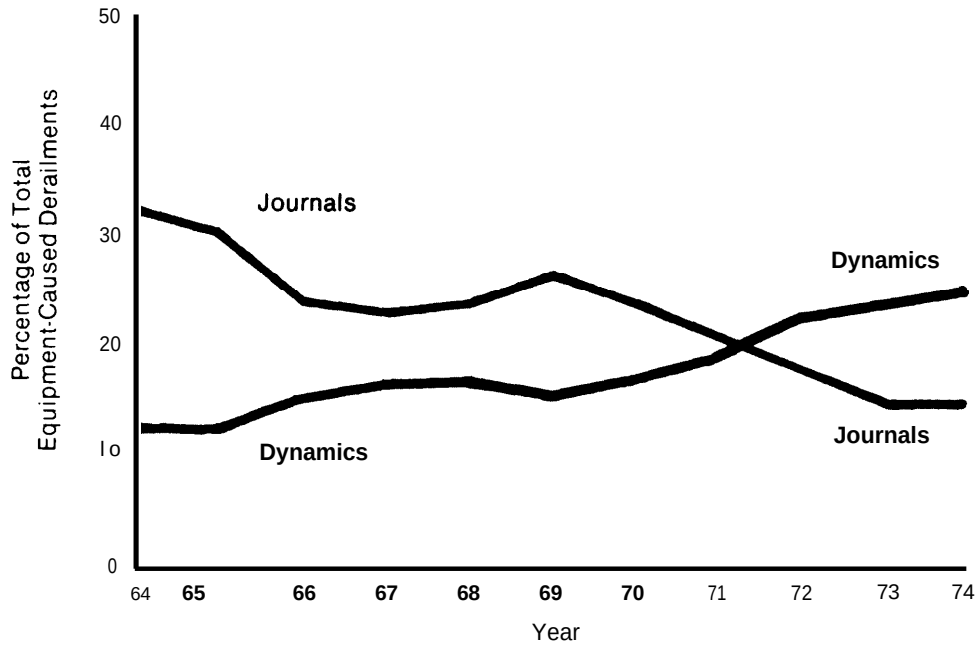
A further investigation by the AAR of the damages resulting from train accidents due to the four contributing causes revealed that track-caused accidents accounted for the largest percentage of dollar damage per million gross-ton miles (MGTM).[7] Since there had been an increase in track-caused accidents over the 9-year period, further investigation of track-caused accidents on mainline, branchlike, and yard track was conducted. The results of this analysis are shown in figure **6.** As the monetary threshold is increased from **$750** to $10,000, the percentage of yard-track accidents greatly decreased while those on the mainline track increased by 87.4 percent. The percentage of track-caused branchlike accidents remained fairly constant. This indicates that a large portion of the yard-track accidents resulted in low-cost accidents, while the mainline track accidents resulted in the higher cost accidents.

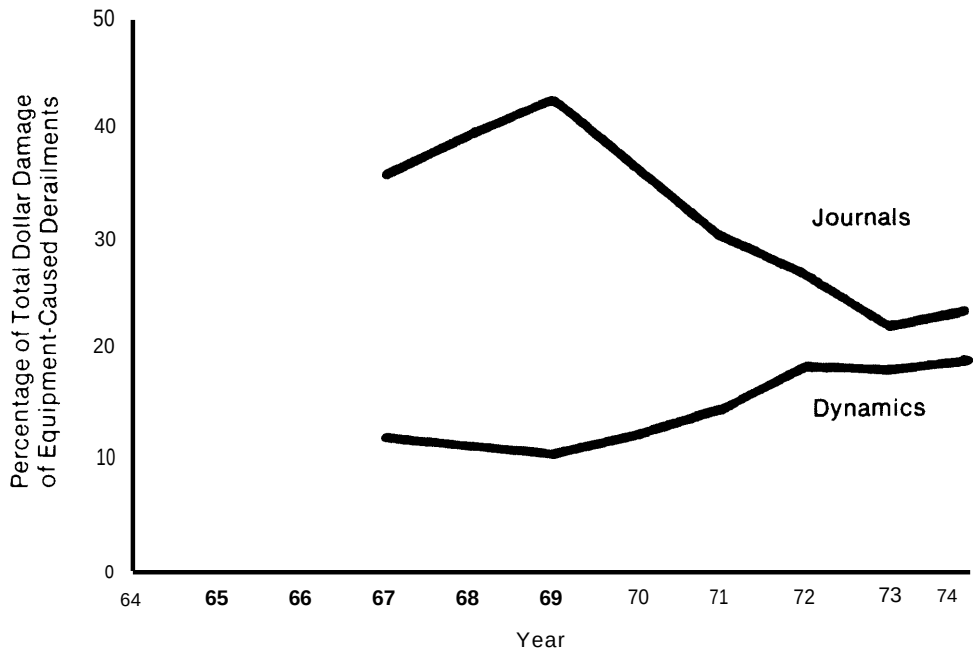
Much has been discussed concerning the reasons behind the increase in track-related train accidents exhibited over the past years. One of these reasons for this increase maybe the financial capability of the railroads themselves. For example, a railroad on the verge of financial collapse may be inclined to divert some of planned maintenance funds from certain areas to reduce losses. Furthermore, the poor financial health of a railroad may have an impact on

'Report No. FRA/FORD'77/18, Wayside Derailment Inspection Requirements Study; J.L. Frarey, R.L. Smith, and A.I. Krauter.

[7] A. E. Shulman, C.E. Taylor, Analysis of Nine Years of Railroad Accident Data, 1966-1974, Association of American Railroads, April 1976.

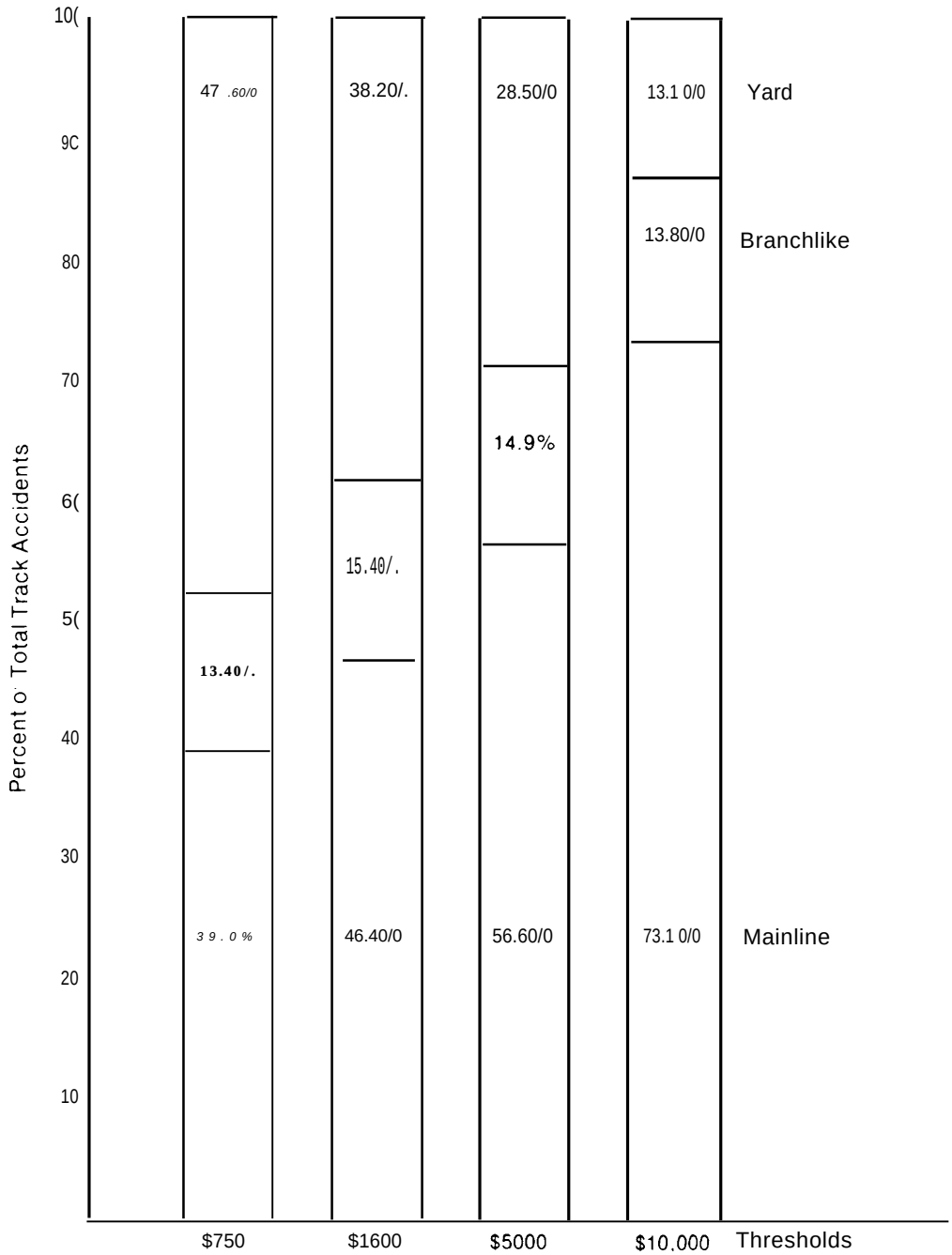
Figure 5.— How Increase in Use of Detection Systems and Incidence of Roller.Type Bearings Has Dropped Journals Below Car Dynamics Group (Bolsters, Side-Bearings, Sills, etc.) as Major Source of Derailments





Source Progressive *Railroading,* November 1977 p 71

Figure 6.— Percent of Mainline, Branchlike, and Yard Track Accidents at Various Thresholds, 1973 Data



Source A E Shulman C E Taylor Ana/vsls of Nine *'fears O(Ra//road Acc/den(Dala* f966 1974 Assoclaf (on of Amer(can Rail roads April 1976

the morale of the employees. With regard to track-caused accidents, there may be a tendency to reduce the amount of effort expended in the yard track programs and, if possible, place these efforts elsewhere, since most yard track accidents have been shown to result in lower cost accidents as measured by equipment, track, and roadbed loss and damage. This point is strengthened by a statement presented in the **1975** FRA Annual Report:8

> As the country's economic woes have increased, the financial condition of many of the Nation's rail carriers has steadily worsened. The rail industry continues to be victimized by spiraling operating costs and sharp declines in traffic which have produced steep revenue losses and financial deficits. In an interim attempt to stem these ever-increasing operating deficits, many of the Nation's railroads have resorted to deferring some of their planned maintenance programs, thereby diverting these funds to reduce the shortfall in revenues. The practice of deferring maintenance has resulted in a steady deterioration of the rail industry's physical plant, reflected in recent years by an alarming increase in the number of track and equipment-related accidents. A substantial improvement in rail safety is therefore largely dependent on the rail industry's financial ability to maintain their physical plants.

A recent study estimated that approximately $6.6 billion of maintenance had been deferred by the railroad industry through 1970s.[9] The practice of deferring maintenance will logically have a negative impact on safety at existing or increasing levels of track usage and roadbed.

With respect to determining what impact the financial standing of a railroad has on its safety picture, the AAR conducted an analysis of track-caused train accidents for bankrupt and nonbankrupt roads during the period **1966-74. 10** The results showed that the absolute number of track-caused accidents was lower for the bankrupt roads than for the nonbankrupt. However, when normalized by MGTM, the track-related train accidents for the bankrupt roads were much higher than those of the nonbankrupt roads (figure 7). This analysis indicates that there appears to be a positive relation between the financial health of the railroads resulting in various levels of deferred maintenance and track-caused train accidents.

Another possible reason behind the increase in track-related accidents may be the usage of heavier cars, which result in higher axle loadings and a damaging effect on track. Over the period 1966-74, the average freight car capacity increased from 61,4 to 71.6 tons. 11 "Moreover, revenue ton-miles increased from 738.4 billion in **1966** to 851.0 billion in 1974 (+ 15.2 percent), while the freight car miles increased from **30.4** billion in **1966** to **30.7** billion in 1974 (+ 1.1 percent). Using this information to determine the increase in revenue tons/freight car, this value increased from 24.3 tons in 1966 to **27.7** tons in 1974. According to the *Yearbook of Railroad Facts, 1977*,[12] of the **28,5** billion freight car miles on Class I railroads in 1976, 55.5 percent were made by loaded cars. If it is assumed that this percentage was similar in both 1966 and 1974, the increase in revenue tons/freight car over the 9 years is 14.1 percent, The use of heavier cars and the increase in track-related accidents has led to increased research by both AAR and FRA.

These two factors, the level of deferred maintenance and the increased axle loadings, appear to be related with increased track-caused train accidents.

The FRA has designated train accidents into three major classes. These include derailments,

'Annual Report by the President to the Congress on the Administration of the Federal Railroad Safety Act of 1970, 1975,

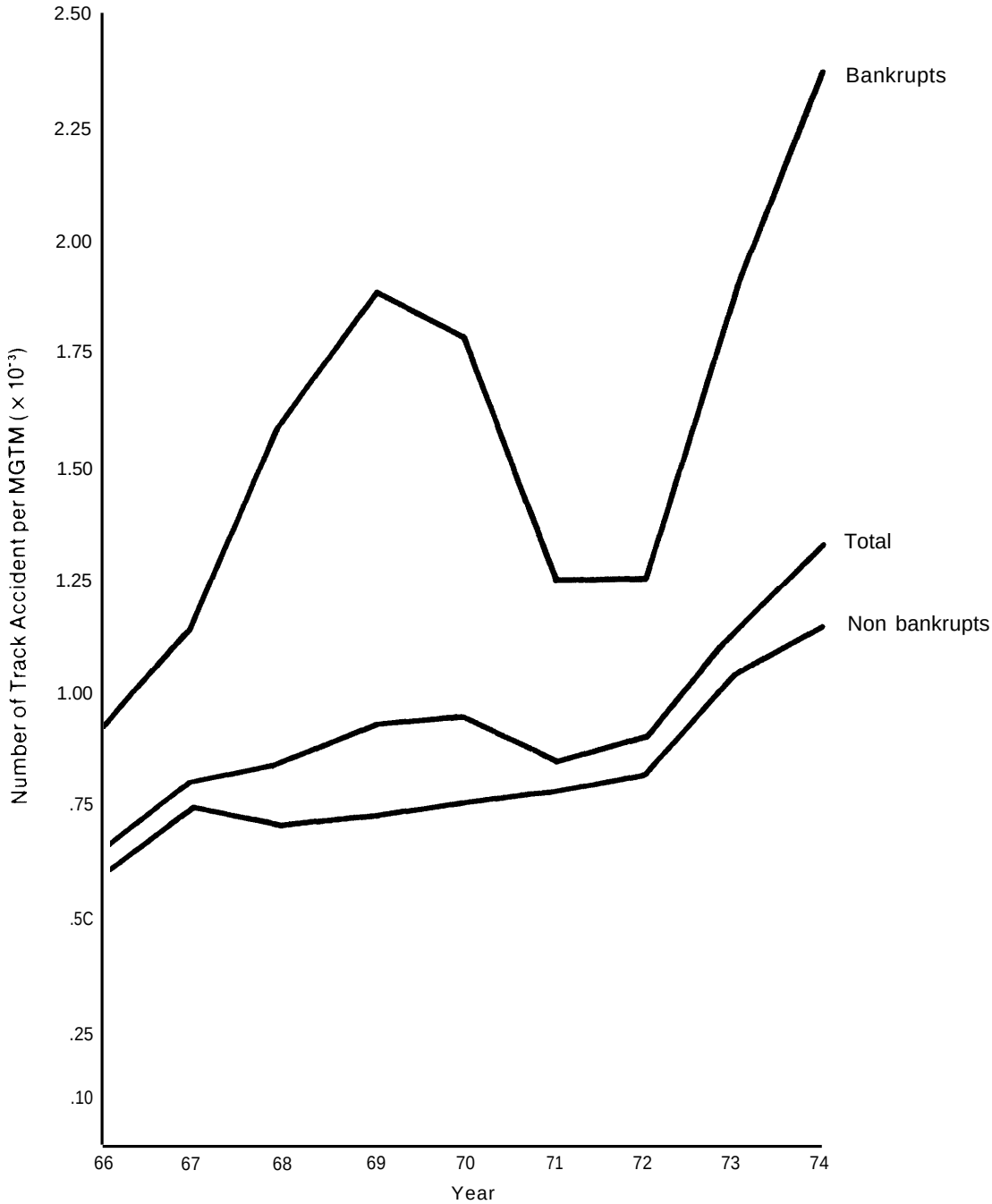
"Richard J. Barber, Associates, The Railroads, Coal and the National Energy Plan: An Assessment of the Issues, 1977.

[10] A.E. Shulman, C.E. Taylor, Analysis of Nine Years of Railroad Accident Data, 1966-1974, Association of American Railroads, April 1976.

[11] Yearbook of Railroad Facts, Association of American Railroads, 1977 Edition.

[12] Ibid.

Figure 7.—Track Accidents Normalized by Million Gross Ton-Miles: Total, Bankrupt and Nonbankrupt Roads, 1966-74



Source A E Shulman, C E Taylor Analysis of Nine *Years of Railroad Accident Data* 1966 1974 Association of American Rail roads, April 1976

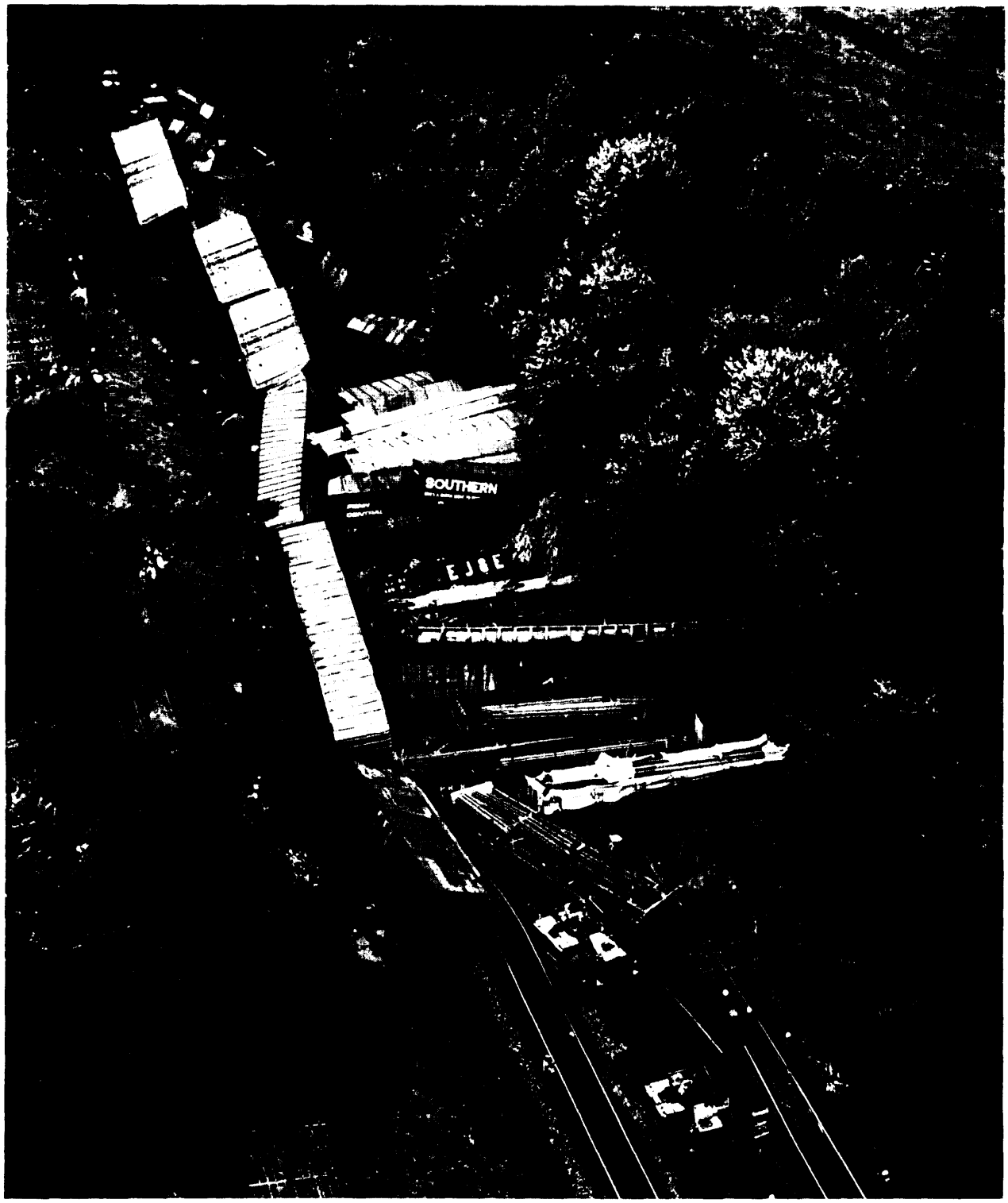


Photo: Courtesy of National Transportation Safety Board

Conrail derailment, Leetonia, Ohio, June 1975. Human error.

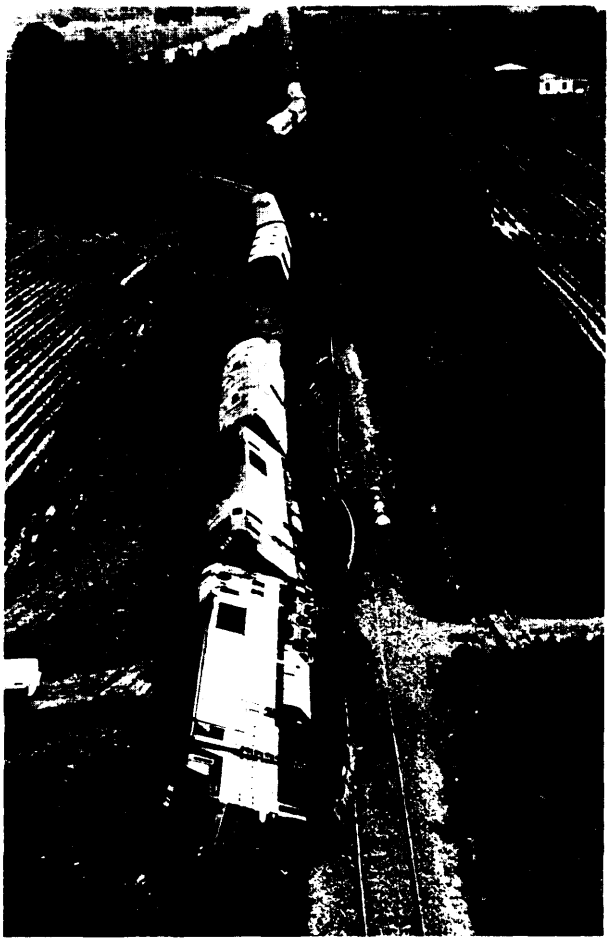


Photo Courtesy of National Transportatuib Safety Board

Amtrak derailment, Goodman, Miss., June 1976. Bad track.

Photo Courtesy of National Tramper/af/on Safety Board

New Haven, Ind.; Head-on collision of two Norfolk & Western Railway trains; October 1976. Human error.

Photo Courtesy of National Transportation Safety Board

Louisville and Northern; Tank car derailment; Pensacola, Fla., November 1977; Leaking anhydrous ammonia.

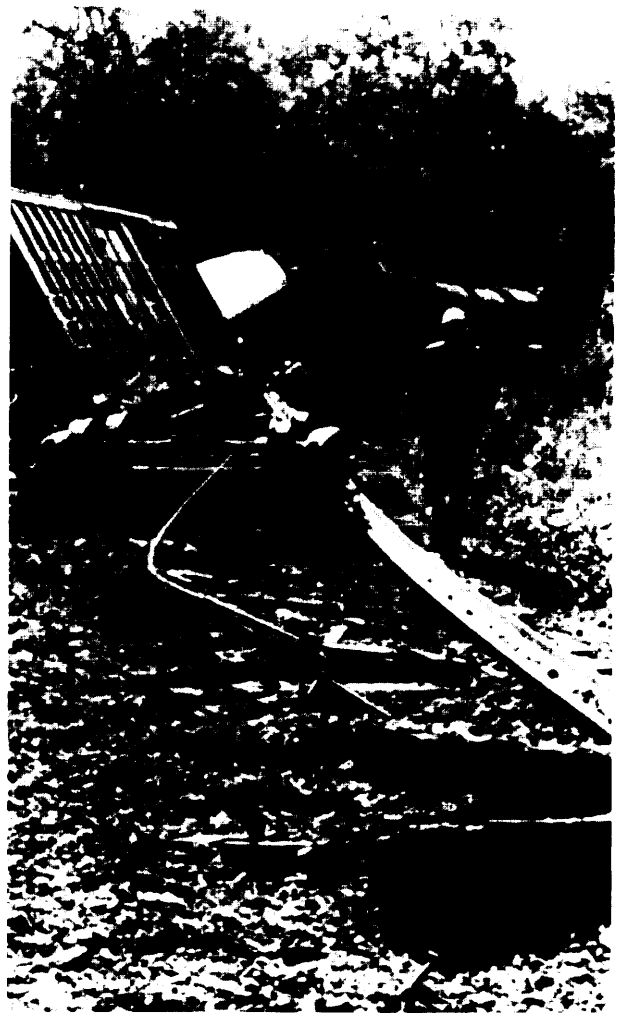
Photo Courtesy of *ST LOUIS Post Dispatch*

East St. Louis, Ill.; Tank car puncture in switching yard; 1972; Carrying propylene.

collisions, and other train accidents. Table 25 presents train accidents by these three classes over the 9-year period 1966-74. It can be seen from the table that while the number of collisions remained the same over the 9 years, the "other" train accidents have decreased by 24.7 percent, and derailments increased by 91.4 percent.

When these classes of train accidents are adjusted for the monetary threshold and normalized for changes in operating practices (ton-mileage) during the 9 years, collisions decreased by approximately 15 percent, while derailments increased by over 40 percent.

One type of derailment which has recently received much attention is that involving tank cars. The potential disaster resulting from a tank car derailment could significantly affect not only the railroads' physical property, but also the health and well-being of the public as well as possible damage to third-party property. As an example, during 1969-75, there were 44,432 derailments reported. Of those derailments, more than 500 involved uninsulated pressure-tank cars, of which more than 170 lost some or all of their lading. Several major accidents resulted in 20 deaths, 855 injuries, and 45 major evacuations of approximately 40,000 persons. Although specific costs are not available, it has been estimated that accidents involving these tank cars resulted in approx-



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"42 Fed. Reg. 46312 (Sept. 15, 1977).

Table 25.—Train Accidents by Class

	Derailments	Collisions	Other	Total train accidents
1966	4,447	1,552	794	6.793
1967	4,960	1,522	**812**	7;294
1968	5,487	1,727	**814**	8,028
1969	5,960	1,810	**773**	8,543
1970	5,602	1,756	**737**	8,095
1971 ..., ...	5,131	1,529	**644**	7,304
1972	5,509	1,348	**675**	7,532
1973	7,389	1,657	**652**	9,698
1974	8,513	1,551	**630**	10.694

SOURCE: Federal Railroad Administration.

imately 10 percent annually of all damage to railroad property. Damage to third-party property and loss of lading could not be isolated for this study. Since this area presents a potential danger to both people and safety, further efforts must be taken to ensure that the safety of people and property are realized with respect to tank car accidents. (See chapter X.)

Because derailments exhibited significant increases over the 9 years, they were selected for further analysis by contributing cause. Table 26 shows the total number of derailments by contributing cause for the years 1966-74. This table indicates that the cause "defects in track" was the 1argest and most rapidly increasing single cause of derailments during the 9-year period.

Appendix C presents the trends for each major subclass of derailments for all Class I railroads during 1966-74. As seen from these graphs, derailments due to defects in track, bridges, switches, and signals, or other defects in roadway; derailments due to negligence of employees, and nonclassified derailments all increased significantly.

Table 26.— Derailments by Contributing Cause

Year	Track	Equipment	Human factors	Miscellaneous	Total
1966	1,388	1,550	647	**862**	*4,447*
1967	1,800	1,611	668	**881**	*4,960*
1968	2,062	1,745	743	**937**	*5,487*
1969	2,400	1,863	816	**881**	*5,960*
1970	2,393	1,602	765	**842**	*5,602*
1971	2,194	1,389	721	**827**	*5,131*
1972	2,481	1,344	792	**892**	*5,509*
1973	3,477	1,755	1,017	**1,140**	*7,389*
1974.	4,196	1,967	1,043	**1,307**	*8,513*

SOURCE: Federal Ral Iroad Admlnlstration

Photo: Courtesy of National Transportation Safety Board

Oneonta, N. Y.; Delaware & Hudson; Tank car derailment; February 1974. Equipment failure.