Wrecks Preventable by Train Control

An Analysis of Statistics to Show That Only Few Accidents Can Be Eliminated Automatically

By G. E. Ellis

Secretary of Train Control Committee, A. R. A., Chicago

ACCIDENTS on American railroads have been the subject of criticism from many sources, including the press and governmental agencies, for a number of years, and, as is well known, all sorts of remedies have been proposed for the different classes of accidents which have occurred. Automatic train control has been a popular one of these remedies and it has been urged from many sources.

So far as can be ascertained, while train control has been proposed as a preventer of collisions and by some is even considered to be a preventer of every form of accidents, little study has been given to the efficiency of such devices or to the extent that they may be expected to save accidents. When an unsatisfactory condition exists, the logical method is to analyze carefully the conditions leading up to this state and then look for a remedy; it is entirely a reversal of all logical procedure to have what is assured to be a remedy and then try to find ills to which it is applicable.

In the matter of train accidents it would seem obvious that before a remedy could be suggested, an analysis of these accidents should be made and the different causes leading up to them determined. After this analysis is made, remedies may be sought and tested to determine if the different solutions proposed meet the apparent requirements. In the question of automatic train control it would seem to be self-evident that an analysis of collisions as shown by the records of government investigation which now cover the period dating from June, 1911, should give information of value. It is certain that not all collisions can be prevented by train control, and many which might be prevented occur in such locations that it will be many years, if ever, before it will be possible to extend train control to the territories upon which they occurred.

Some attempt has been made to analyze these different accidents, but it is a matter requiring time and a careful search of records. The figures given herewith are all based upon the reports of the Interstate Commerce Commission or have been collected from the published reports of accidents investigated by the Bureau of Safety. The work is that done by the writer personally, and does not represent in any way the work of any organization dealing with train control problems.

Perhaps the first question of interest will be the extent to which train control may be effective as based on the number of accidents which can reasonably be expected to be prevented.

In the report of the United States Railroad Administration Committee dated December 31, 1922, there was a table showing the number of accidents of different classes and the percentage of each class to the total. This table indicated that the fatalities due to all collisions averaged a little over 5 per cent for the years 1914 to 1918 inclusive, the average number of deaths being about 275 annually. This table has been revised to show the 5 years 1918 to 1922, inclusive, and the annual average of deaths due to collisions for that period has been 5.5 per cent with 260 fatalities. This indicates the small proportion of deaths that it is possible for train control to save, and it will be noted this includes collisions of all characters, many of which obviously could not be prevented by train control and certainly not until a very large percentage of the mileage of the country had been so equipped.

The tables also show that the relative number of fatalities due to collisions is on the whole decreasing. In the case of injuries, the number due to collisions is much smaller, relatively than from other causes, but it is only fair to say that no account is taken of the degree of injury, and those due to collisions doubtless include more serious injuries than are included in the other classifications, many of which are known to be minor.

The above tables indicate, in a general way, the most that can be expected from train control systems. When we make a closer analysis and include only those classes

Non-Trespassers Killed or Injured on Railways of U. S.

Killed	1918	Per cent	1919	Per cent	1921	Per cent	1921	Per cent	1922	Per cent
Collisions	499	8.27	238	5.38	253	5.28	130	3.70	183	4.70
Derailments	290	4.81	175	3.95	194	4.05	132	3.75	154	3.95
Other train accidents	168	2.78	72	1.63	89	1.86	47	1.34	32	0.82
Train service accidents	4,485	74.37	3,475	78.12	3,793	79.15	2,797	79.57	3,052	78.36
Non-train service accidents	589	9.77	483	10.92	463	9.66	409	11.64	474	12.17
Total	6,031	100	4,425	100	4,792	100	3,515	100	3,895	100
Injured										
Collisions	4,431	2.58	3,931	2.69	3,840	2.31	1,839	1.56	2,525	1.91
Derailments	3,978	2.32	2,979	2.04	3,549	2.14	1,854	1.58	2,184	1.65
Other train accidents	929	0.54	702	0.48	743	0.45	231	0.20	155	0.12
Train service accidents	52,001	30.27	42,331	28.92	53,286	32.11	36,329	30.88	40,281	30.51
Non-train service accidents	110,431	64.29	96,462	65.87	104,523	62.99	77,363	65.78	86,882	65.81
Total	171,770	100	146,395	100	165,941	100	117,616	100	132,027	100

(Note: Non-train service accidents cover all persons killed or injured)

*Paper presented at meeting of Signal Section A. R. A., at Swampscott, Mass.

of collision to which train control particularly seems to apply, we find the possibilities of train control are apparently much less. Consideration has been given to a number of accidents investigated by the Bureau of Safety of the I. C. C., and which have been cited as examples of what train control might accomplish.

In the order of June 13, 1922, reference was made to a number of collisions which have been investigated by the Interstate Commerce Commission covering a period of three and one-half years from January 1, 1918 to June 30, 1921. These investigations covered 181 accidents, mostly head-on and rear-end collisions, although a few unclassified collisions are separately shown in the tables below. These collisions have been roughly divided into those occurring in automatically signaled territory and those in non-automatically signaled territory.

	Automatic Territory								
	Head on			Rear end			Unclassified		
	No.	Killed	Injured	No.	Killed	Injured	No.	Killed	Injured
1918	3	21	45	8	82	227	..	..	..
1919	4	8	70	13	63	338	1	3	1
1920	6	12	69	14	37	162	3	22	48
6 mos. 1921	2	5	24	1	2	6	3	37	63
	Non-Automatic Territory								
1918	13	141	269	17	63	270	..	..	..
1919	15	52	407	11	20	131	..	..	..
1920	21	44	395	24	59	170	4	4	19
6 mos. 1921	3	4	28	5	11	67	8	17	62
Grand Total..	67	287	1307	93	337	1371	19	83	193

From a careful study of the report of these accidents, it seems quite evident that a number would not have been preventable by any form of train control that is proposed. In addition there are included in this number 15 accidents on electric lines resulting in 73 deaths and 552 injuries. Inasmuch as the hearing at which these statistics were presented related solely to accidents on steam roads, it would seem proper that these collisions on electric lines should be excluded, especially as their operating practices differ materially from those on steam roads.

Causes of Accidents

A number of the accidents were due to the following causes: Trains running against regular current of traffic, runaway cars, absence of usual switch protection in automatic territory, collisions in yards or on sidings, improper handling of air brakes, failure of air brakes, collisions with wreckage, switch opened ahead of train, fouling main track, accidents to engine, collisions after derailment, running under "calling-on-arm."

These number 37 in all, resulted in 139 deaths and 537 injuries. In analyzing these various causes, those due to the trains running against traffic have been excluded, since with very few exceptions, installations in progress are being made to protect trains running in the proper direction only, and further, the Commission apparently does not require such protection, as evidenced by their decision on the Rock Island installation. Collisions due to run-away cars cannot be guarded against by train control, although it is possible by stopping the train with which the cars collided, the severity of the collision might be lessened. Train control would not be effective where switch protection circuits in automatic territory are defective, either through improper maintenance or malicious tampering. Neither is it proposed to install train control in yards or sidings, and such accidents should be excluded. Accidents caused by the failure of or improper handling of the air brake system should also be excluded, since the train control apparatus does not go beyond that system. Accidents due to wreckage thrown on the adjoining track by previous accidents cannot be always considered as preventable by train control, since an approaching train may not be stopped by the wreckage, rendering the protection effective. When a switch is opened immediately ahead of the train no protection can be furnished by the train control system; nor would cars fouling the main track give the proper protection in every case. Accidents due to engine failures, which are the primary cause of collisions, could not be prevented by train control. Those collisions happening under the slow speed limit imposed by a "calling-on-arm" would not be prevented, since such movements are authorized in automatic train control territory.

From the accidents referred to, those from the above causes should be excluded, leaving the net number preventable by train control as 127, resulting in 412 deaths and 1589 injuries, covering the period of 3½ years.

It would be of interest to consider the total number of collisions as reported by the Commission for the periods of time above mentioned, and in the following tables all the collisions that are shown in the annual bulletins of the Commission are summarized.

1918				
Class	Total No.	Killed	Injured	Damage
Rear-end	1,157	182	1,399	$1,762,370
Head-on	496	195	1,405	1,284,120
Broken train	469	1	66	303,570
Side	1,656	47	590	1,065,700
Crossings	114	9	109	187,980
Trains with non-train cars	552	9	209	266,290
Switching	3,281	25	297	1,184,260
Not otherwise classified	990	31	356	756,700
Total	8,715	499	4,431	$6,810,990

1919				
Class	Total No.	Killed	Injured	Damage
Rear-end	672	100	1,270	$1,440,570
Head-on	340	61	1,154	954,140
Broken train	406	2	45	282,490
Side	481	17	275	464,460
Crossings	110	4	109	102,490
Trains with non-train cars	311	13	376	274,350
Switching	4,227	32	485	1,907,860
Not otherwise classified	357	9	217	270,240
Total	6,904	238	3,931	$5,696,600

1920				
Class	Total No.	Killed	Injured	Damage
Rear-end	876	86	1,028	$1,951,600
Head-on	368	72	1,333	1,550,560
Broken train	423	1	41	348,560
Side	698	28	341	907,130
Crossings	131	4	119	189,470
Trains with non-train cars	345	13	213	314,130
Switching	6,678	39	638	3,385,150
Not otherwise classified	591	10	127	431,510
Total	10,110	253	3,840	$9,078,110

Six months—1921				
Class	Total No.	Killed	Injured	Damage
Rear-end	276	18	137	$ 394,490
Head-on	82	6	141	348,440
Broken train	152	0	5	133,150
Side	131	1	91	121,520
Crossings	34	38	76	103,920
Trains with non-train cars	82	7	83	157,820
Switching	1,683	5	100	885,640
Not otherwise classified	174	2	74	114,900
Total	2,514	77	707	$2,259,880

The totals of these are given in the table below, and the second table following gives the number of head-on and rear-end collisions.

ALL COLLISIONS				
	Total No.	Killed	Injured	Damage
1918	8,715	499	4,431	$6,810,990
1919	6,904	238	3,931	5,696,600
1920	10,110	253	3,840	9,078,110
1921 (6 months)	2,514	77	707	2,259,880
Total	28,239	1,067	12,909	$23,845,580

HEAD ON AND REAR-END COLLISIONS				
	Total No.	Killed	Injured	Damage
1918	1,653	377	2,804	$3,046,490
1919	1,012	161	2,424	2,394,710
1920	1,244	158	2,361	3,502,160
1921 (6 months)	258	24	278	742,930
Total	4,167	720	7,867	$9,686,290

It will be noted from the above that the head-on and rear-end collisions account for 14.8 per cent of the total collisions with 67.5 per cent of the deaths, 60.9 per cent of the injuries and 46.3 per cent of the damage.

Switching accidents account for a relatively large property damage, but it is probable that train control could

not affect these. The crossing accidents include those at highway crossings. Apparently the commission considers that head-on and rear-end collisions are the ones most readily remedied by train control and it is evident that either class is accountable for more casualties than any other class.

Referring back to the collisions investigated by the commission for 3½ years we find that 160 head-on and rear-end collisions reported upon, or 3.8 per cent of all the head-on and rear-end collisions for that period, accounted for 86.6 per cent of the deaths, and 34.0 per cent of the injuries, indicating that the more serious accidents were investigated. The "preventable" collisions investigated averaged annually 118 deaths and 454 injuries for the 3½ years under consideration. If the same proportion holds between total head-on and rear-end collisions and those investigated, the average number of deaths and injuries which might have been saved for the 3½ years, would have been 136 and 1,335 respectively out of a possible average number of deaths and injuries of 206 and 2,220 respectively.

The records of the Interstate Commerce Commission show the cost of railroad accidents including the personal damage and damage to property. This information can be secured only by a considerable search, so that the figures have not been available. We find, however, from the evidence submitted by the Interstate Commerce Commission at the first hearing on train control, that in the 16 years from January 1, 1906, to January 1, 1922, there were 26,297 head-on and rear-end collisions, resulting in 4,326 deaths and 60,682 injuries. The damage to railroad property amounted to $40,969,663. The average per year, therefore, was 1,643 collisions, 270 deaths, 3,792 injuries and a property damage of $2,560,603.

At the same hearing figures were presented showing the personal damages of 9 accidents on three Eastern roads, some of the accidents being of considerable magnitude, amounting to $1,869,152. These accidents were responsible for 174 deaths and 795 injuries.

It is interesting to compare the record of accidents with the original 49 roads and the territory upon which automatic train control was designated on those roads. A careful check indicates that 100 accidents have been investigated on these different territories, 32 of which were not preventable by train control. Of the 49, 18 roads had no accidents or accidents which were not preventable by train control, 31 roads had accidents that were preventable by train control. The 67 accidents on these 31 roads accounted for 451 deaths and 1,517 injuries, with a property damage of $797,233 in 57 of the collisions. This covers a period of over 10 years, from the time accident investigation was inaugurated by the I. C. C.

Two hundred accidents taken from the Interstate Commerce Commission reports as they were shown, without selection, from July, 1919, to February, 1923, resulted in 652 deaths and 3,335 injuries. Nineteen of these were such as would not have been preventable by train control, for the reasons stated above. In addition 29 others probably would not have been prevented on account of reverse running, speed of trains, etc. In 185 of these accidents, 114 or about 62 per cent, resulting in 334 deaths and 1912 injuries, occurred on single track and 71 or about 38 per cent, resulting in 261 deaths and 1,183 injuries, occurred on multiple track. Seventeen of the number on single track were side, yard or miscellaneous collisions. Of the remaining 97, 34 were rear-end collisions and 63 head-on collisions. It, therefore, seems to be apparent that while fewer accidents occurred on multiple track, they are relatively more serious. Seven accidents occurred at non-interlocked grade crossings and these resulted in 9 deaths and 114 injuries. Without doubt these accidents would have been prevented by interlockings.

Accidents on Signaled Territory

In 184 accidents, 39 occurred on manual block territory, 67 on automatic block territory and 77 without any form of block system. The latter classification was responsible for 249 deaths and 1,147 injuries, and it is a question whether many of these would not have been saved had there been some form of block system.

The following table shows the various causes assigned to the collisions taking place on automatic territory:

1.	Signal not observed	17
2.	Signal observed but no proper action taken	10
3.	Account death questionable whether or not signal observed	7
4.	Signal improperly observed	4
5.	In automatic territory but on a track not signaled	4
6.	On interlocking plant	5
7.	Unavoidable account runaway train, etc	4
8.	Malicious tampering	1
9.	Defective brakes	3
10.	Fouling main track in face of train	1
11.	Faulty signaling	2
12.	Weather conditions such that signal could not be observed	3
13.	Signal indication recognized but speed too high	2
14.	Reverse running	3
15.	False clear account of jumpered connections by maintainer	1

The accident bulletins of the commission yearly contain tables giving the number of employees in service, per employee killed and injured, per trainman killed and injured and the number of passengers carried, per passenger killed and injured. For the year ending June 30, 1889, there were 375 employees in service, per employee killed and 35 per employee injured; for the year ending December 31, 1922, these figures were 1003 and 14. Also for the same periods 1,523,000 passengers were carried, per passenger killed and 220,000 per passenger injured, but for the year ending December 31, 1922, these figures were 4,881,000 and 159,000. It will be noted that while the record for injuries is slightly worse, that for the fatalities is greatly improved. In reference to the apparent relative increase of injuries, this may be due in part to the greater detail now used in reporting minor accidents. In other words, there are now only about one-third the number of employees killed and three times as many passengers are carried per passenger killed as in 1889. These figures are clearly brought out by diagrams shown in annual accident bulletin No. 87 for 1922, the last one issued. This shows conclusively that the accident record is rapidly improving, and the improvement has been generally uniform. This is in face of increased density of traffic, in which normally the hazard of accidents would be greater.

It may be of interest to refer to the report of the Automatic Train Control Committee, appointed under the authority of the English Ministry of Transport, which refers to 193 accidents which have been fully analyzed. It is understood from the report that these accidents are all of those that were investigated from September 30, 1911, to September 30, 1921, but, as in this country, covers only a portion of accidents actually occurring. These have been sub-divided into three classes:

(a) Accidents not preventable by train control.
(b) Accidents mainly due to signalman's errors ordinarily preventable by track circuits in connection with signaling.
(c) Accidents preventable by train control.

In class (a) accidents include:

(1) Freight trains beyond control on grades due to failure to apply sufficient number of hand brakes.
(2) Run-a-way portions of parted trains.

(3) Miscellaneous cases, include boiler explosions, grade crossing accidents, casualties to employees, etc.
(4) Derailments due to equipment or track and structure failures.
(5) Head-block collisions.
(6) Collisions due to failure of air brakes, careless switching of passenger cars, misunderstanding of hand signals, etc.

It is stated the remedy for these cases is the use of continuous brakes on freight trains, better maintenance of track and equipment and greater care and experience on part of employees.

The class (b) accidents include the following:

(1) Collisions with trains with inter-station limits, the presence of which has been overlooked.
(2) Accidents on lines insufficiently protected for passenger traffic.
(3) Irregular handling of trains at junctions.
(4) Misunderstanding between signalmen in station movements.
(5) Defective apparatus, unauthorized use of block and malicious interference.
(6) Failure to place signal in stop position.
(7) Irregular use of release key on lock block system.

The third class comprises 71 cases or 36.8 per cent of the whole, and are classed as follows:

(1) Those preventable by some form of speed control, which apparently means accidents due to high speed for the location in question.
(2) Those preventable by continuous control systems, such as will be indicated by the track circuits.
(3) Those in which intermittent control would have been beneficial.

These accidents have been tabulated as follows:
(a) Non-preventable, 73, or 37.8 per cent.
(b) Due to signalmen's errors, 49, or 25.4 per cent.
(c) Preventable by train control, 71, or 36.8 per cent.

These accidents are typical of a much greater number which were reported but not investigated by the government. In six years—1915-1920—there were 1,770 accidents of certain classes reported. The number investigated was 105, about 6 per cent. In 1919 and 1920 there were 646 accidents with 55 investigations or about 8.5 per cent. It is considered that train control would, therefore, have been beneficial in about ten times as many cases as were accidents investigated, or probably about 100 cases yearly.

It is probably true in England as in this country, that the accidents investigated cover the more serious ones and it is perhaps not a fair conclusion that the saving would have been in proportion, as the number of accidents investigated bears to the total number of accidents, as many of those not investigated cover yard accidents and other accidents of that kind which are not preventable by train control and probably difficult to prevent by any method. These are minor in themselves and do not attract much attention although their total is considerable.

Several classes of accidents referred to in the British report are due to different operating and engineering conditions, as, for instance, the fifth item under class (a), head block collisions, which are apparently those due to backing trains into stations without continuous brakes being in service. The number of accidents under class (b) which would apparently have been largely avoidable under signaling practice in this country is notable.

Annual I. C. C. Accident Bulletin

THE Interstate Commerce Commission has issued Accident Bulletin No. 92 for the calendar year 1923, containing a record of collisions, derailments and all other accidents occurring on the railroads, as well as comparative tables for preceding years. This period was one of exceptionally heavy traffic on the steam railways in the United States; there being an increase in the volume of freight transported of 21.7 per cent over the preceding year. The bulletin shows that during the year 1923, there were 7,385 persons killed and 171,712 injured as a result of accidents of all kinds including: train, train-service, and non-train accidents, as compared with 6,325 persons killed and 134,871 injured in 1922. Most of the totals of 1923 are larger than those of 1922.

It would be expected that the handling of heavy traffic causes an increased exposure of employees and others to the hazard of accidents, which in general is reflected in the accident statistics presented in the bulletin. Considering only those accidents claimed as train and train service accidents, it is shown that there was a total increase in casualties of 17.7 per cent, corresponding to an increase in locomotive miles for all roads, of 13.5 per cent. Trespassers as a class suffered the greatest fatal injuries due to train and train service accidents during the year 1923, but with respect to non-fatal injuries railway employees sustained the greatest number.

There is, however, an exception to the general increase in casualties, in the item of passengers killed and injured. With one exception, the total fatal casualties, 138, are the lowest on record. Passenger miles were 7.2 per cent more than in 1922, but both years were subnormal as to passenger traffic. The number of passengers killed in train accidents is probably of more interest to railroad officers than the total number of passengers killed from all causes including their own carelessness; this smaller total, 54, is only slightly more than 51 per cent of the average annual total for the preceding four years. The larger item includes many casualties that are unpreventable, as far as the railroads and their employees are concerned. Hence the latter total, which is generally used for comparison includes those fatalities for which the railroads are alone responsible.

The damage to railroad property from collisions, derailments, and other train accidents is $27,624,880, which is heavier than for either of the two years preceding, yet the total is still below the enormous sum, $34,129,860, reported in 1920.

Of greater importance than train and train service accidents are those occurring at highway grade crossings. The year 1923 showed an increase of 458 fatalities and of 931 non-fatal injuries, or 25 per cent and 17 per cent respectively over the preceding year, as a result of accidents at highway crossings. Of the total number of casualties occurring at public grade crossings with steam railways in 1923; automobiles were involved in 84 per cent of the accidents, according to one of the illustrated charts. However, it is important to consider that the registration of passenger automobiles and motor trucks increased from 12,238,375 in 1922 to 15,092,177 in 1923, representing an increase of 23 per cent. It is almost a coincidence that the relative increase in fatalities resulting from highway crossing accidents is approximately equal to that observed in motor vehicle registration.

The last table in the appendix, that showing the number of grade crossings on Class I roads on December 31, 1923, gives as the total of all crossings, 258,786, which includes 10,358 with other roads, 4,643 with electric railways and 243,785 with public highways. A total of 60 crossings with steam railroads, 98 with electric lines, and 972 with highways, were eliminated in 1923. Of the total number of crossings, 39,587 are protected and 219,199 are unprotected; yet there is nothing to indicate the portion of each that are railroad crossings or highway crossings.

As to the various causes of train accidents, it is revealed that the majority are due to defects in or failures of equipment.