Highway-Railway Grade Crossing Protection

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STOP, LOOK and LISTEN. Once upon a time that was about all the crossing protecting that was needed. All you had to do to stop was say "Whoa." You had plenty of time to look. Listening was easy. You weren't shut up in a tightly sealed, heated, insulated, radio equipped chariot like the one you ride around in now.

Today you can look; but with all the gadgets on the dashboard, the traffic in front of you, and the rear view mirror with the possible image of a motorcycle cop behind you, nothing can get more than a glance.

You don't want to stop. This eternal urge to keep going has encouraged the development of grade crossing protective devices which can be seen, which attract the attention of the driver, and which have a long range of visibility so that a stop can be made even from high speed before the danger point is reached.

These modern forms of protection are the automatic flashing light signal and the automatic gate, both devices which have been developed through cooperation of the signal manufacturers with the signal section of the Association of American Railroads and the American Railway Engineering Association. Several installations of each of these modern types are in operation along the Wabash Railroad line in Lafayette.

Last year at the annual convention of the American Railway Engineering Association, I presented a report entitled "The Achievement of Grade Crossing Protection" which has been rather well received. I'm going to present the essential parts of that report and then give you the results of some further studies which I have just completed, bringing the conclusions still more up to date.

Those of us who are interested in highway-railway crossing problems know something of the value of crossing protection but we are not always sure that the achievement measured in number of lives saved, injuries prevented and property damage avoided is worth the effort, measured in terms of time devoted to design and programming and dollars spent in the installation of new and improved crossing protection devices.

And I don't say this in a spirit of cynicism or callousness. You all know that we still have accidents at protected crossings. You know that some automobile drivers, either through carelessness or just plain cussedness, continue to ignore the warnings provided for their benefits and protection. It is small wonder that we become skeptical, sometimes hypercritical.

Even so, we on the Wabash Railroad have continued to believe that there is at least some value in our efforts to improve grade crossing protection on our lines. We have continued to work cooperatively with those state, county and municipal authorities who are responsible for the safety of vehicular traffic. And may I say that we consider highway-railway grade crossing protection to be in a large measure the obligation of those highway agencies.

Having been at this cooperative work for some time now, we decided it would be well to try to find out what our achievements had been. We are fortunate enough to have available a complete record of all the changes made in crossings and crossing protection and of all the accidents which have occurred at highway crossings on Wabash lines since January 1, 1929. Last December 31st completed 20 years of this record and I would like to show you something of what it now contains.

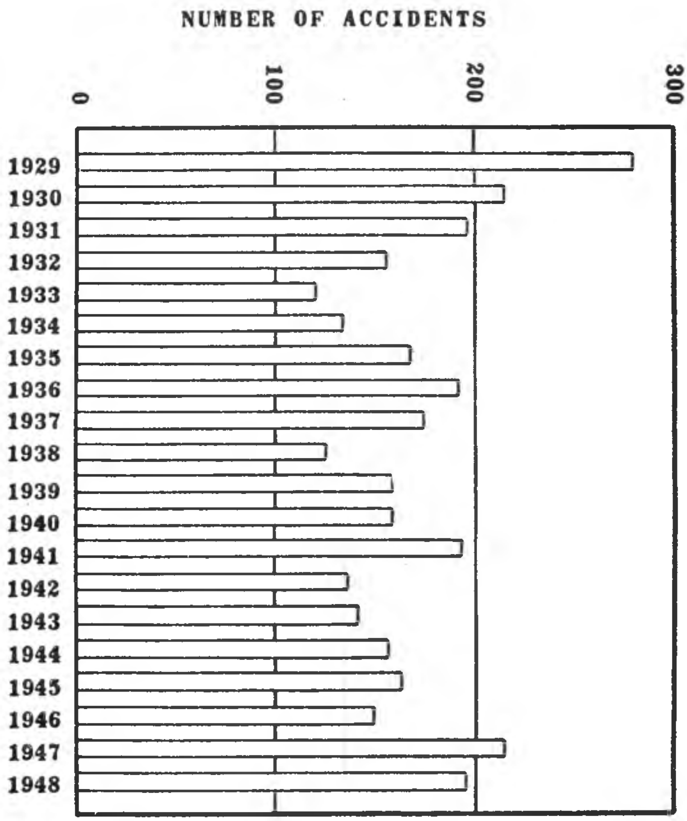
TABLE 1

NUMBER OF ACCIDENTS AT GRADE CROSSINGS

Year	Number of Accidents	Year	Number of Accidents
1929	279	1939	159
1930	215	1940	159
1931	197	1941	194
1932	157	1942	137
1933	121	1943	143
1934	135	1944	157
1935	169	1945	164
1936	192	1946	149
1937	175	1947	215
1938	126	1948	196
	Total Number in 20 Years		3439

This tabulation shows the total number of accidents which have occurred each year at all of the highway crossings on the 2,000-odd miles of line presently owned, maintained and operated by Wabash Railroad company. The statistics I will give you in this report do not include any figures accruing from crossings on lines which have been abandoned during the 20-year period. In this report an accident has been recorded for each occurrence involving a collision between a train, engine or cars and a vehicle or a pedestrian, for each occurrence in which a vehicle was damaged or a person injured in the course of avoiding such collision, and for each occurrence in which a person was injured as a result of a collision with a crossing gate arm or any other part of a protective device. No account has been taken of the mere breaking of a gate arm or other damage to a protective device unless there was a resultant personal injury. You will note the 1929 figure of 279 accidents and the 1948 figure of 196. These show a reduction of approximately 30 per cent in the 20-year period.

Let's look at these figures expressed graphically.



There is considerable variation from year to year. The over-all trend is downward, although that is not too evident. We know that there have been variations in the volume of traffic during the period and it is reasonable to suppose that some of the variations in the accident record may have followed these traffic fluctuations.

We do not have a traffic count each year at each crossing but there are some statistics available which serve very well as a measure of the general traffic fluctuations at these crossings on Wabash lines.

TABLE 2

TRAIN MILES OPERATED BY WABASH RAILROAD

Year	Train Miles	Year	Train Miles
1929	16,273,797	1939	9,931,808
1930	14,127,425	1940	10,105,024
1931	12,347,677	1941	10,846,089
1932	10,179,451	1942	12,534,253
1933	9,244,268	1943	12,597,373
1934	9,434,194	1944	12,552,119
1935	9,648,708	1945	11,973,716
1936	10,377,738	1946	11,180,357
1937	10,702,102	1947	11,237,125
1938	9,565,312	1948	11,112,778

Here is a record of train miles operated by Wabash Railroad. You will note the maximum figure of more than 16 million in 1929 and the minimum, slightly more than 9 million in 1933, with increases to a level above 12½ million during the war years 1942, 1943 and 1944, and subsequent decrease to 11 million plus train miles in 1948.

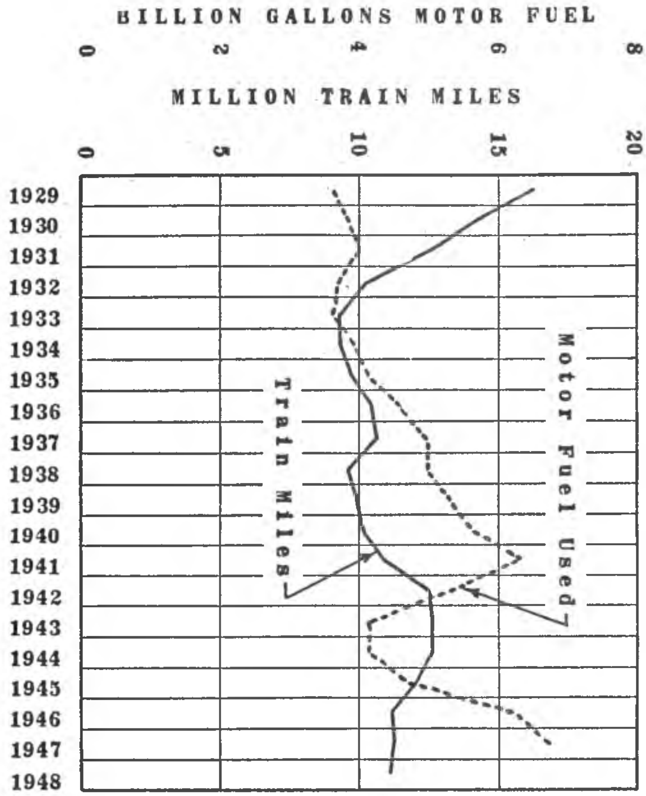
TABLE 3

HIGHWAY USE OF MOTOR FUEL IN SIX STATES

Year	1,000 Gallons	Year	1,000 Gallons
1929	3,610,063	1939	5,290,684
1930	3,824,177	1940	5,641,988
1931	4,001,250	1941	6,266,435
1932	3,708,035	1942	5,298,742
1933	3,637,515	1943	4,150,116
1934	3,922,446	1944	4,123,890
1935	4,137,733	1945	4,715,942
1936	4,611,214	1946	6,222,174
1937	4,962,514	1947	6,779,144
1938	4,964,580	1948	

Source: Public Roads Administration, Federal Works Agency.

As a measure of fluctuations in vehicular traffic this record was secured from the Public Roads Administration. The figures show highway use of motor fuel. Such records are accumulated each year from each state and here I have consolidated the figures for the six states—Michigan, Ohio, Indiana, Illinois, Missouri and Iowa—in which Wabash lines are located. The fluctuations in each individual state follow a quite similar pattern. Variations in the highway use of motor fuel are a good measure of the fluctuations in volume of highway traffic.

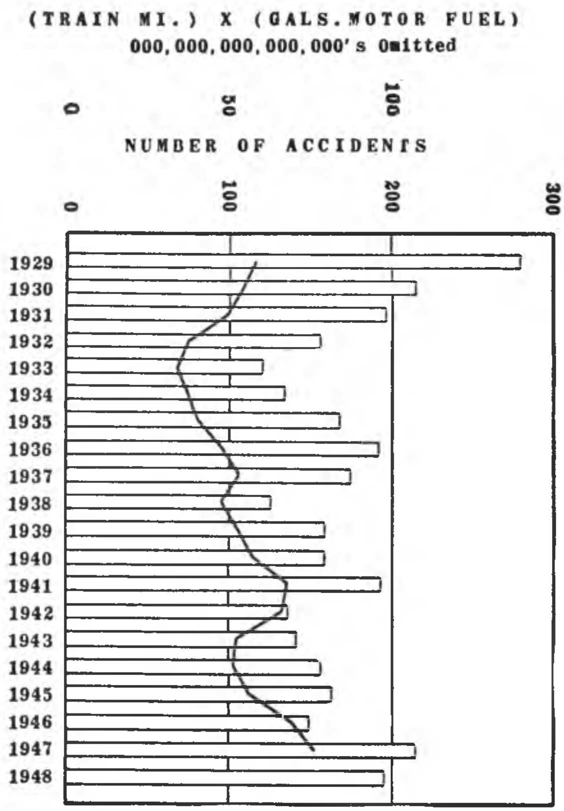


A chart gives a good picture of these fluctuations in the volume of rail and highway traffic. The rail traffic variations show clearly, down to the low point in 1933, up again through the war years, and again on a downward trend to date. The highway traffic index shows a continual upward trend except for two periods. The depression years of 1932, 1933 and 1934 show a minor dip in the curve and the war years—1942, 1943, 1944 and 1945—show a major dip, the

1943 and 1944 figures being only about 2/3 of those in 1941 and 1946. The trend is now again definitely upward.

The effect of traffic variations on grade crossing accidents should be measurable. If you run twice the number of trains over a line, it is rather obvious that the accident potentiality is doubled. Likewise, if highway traffic is increased two-fold, the possibility of accident is doubled. If these increases in volume of the two conflicting traffic streams is concurrent, the accident potentiality is increased 4 times. This analysis may seem over-simplified, but I believe that, upon reflection, you will agree with it as a sound, broad principle.

Based upon this principle I have taken the figures representing these volumes of rail and highway traffic each year, multiplied them, and thereby obtained a factor—(train miles) x (highway motor fuel used)—which should represent the relative accident potential year by year.



This yearly accident potential factor has been plotted to scale on the chart showing the number of accidents. You will note that the two—the accident potential factor and the number of accidents—follow the same general pattern. They fall off to a low point in 1933, then rise; dip again in 1938; rise to 1941, dip during the war years and generally rise afterward. However, on careful inspection you will note a general upward trend in the accident potential factor over the 20-year period, while the accident figures have a general trend slightly downward.

It is very reasonable and logical that there should have been a decrease in accidents. During the 20 years we built 77 grade separations, changed protection at 321 crossings and closed 129 crossings which were abandoned, usually in connection with grade separation or crossing protection projects.

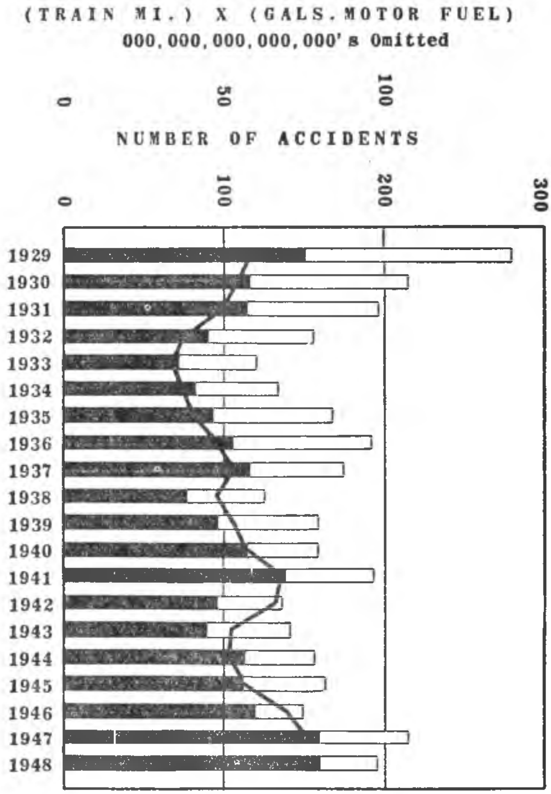
The thought then naturally occurred to us: What has been the accident experience with the two groups of crossings; those where changes have been made, and those where no changes have been made.

TABLE 4

ACCIDENTS AT CROSSINGS WHERE PROTECTION WAS NOT CHANGED

Year	Number of Accidents	Year	Number of Accidents
1929	150	1939	97
1930	115	1940	114
1931	114	1941	138
1932	90	1942	96
1933	72	1943	88
1934	81	1944	113
1935	93	1945	110
1936	104	1946	119
1937	116	1947	159
1938	77	1948	159
		Total Number in 20 Years	2205

First, let's consider the latter group: Those crossings where protection has remained the same throughout the 20-year period. This table shows the number of accidents which occurred at the 2,555 crossings in that group. As was the case with the crossings as a whole, the accidents in this group dropped down from 1929 when there were 150 to a low point in 1933 when only 72 accidents occurred. Then there were fluctuations up and down, but you will notice that for each of the last two years the number 159 is a figure somewhat higher than the 150 in 1929.



Now, I want to show you something which possibly is only natural, yet I consider it rather remarkable: the correlation between the accident potential and the number of accidents which actually occurred at all the crossings in the group where no changes were made in protection. As before, the relative accident potential is shown by the zigzag line. The columns on the chart have been filled in at the base so that the number of accidents which occurred at crossings where protection was not changed is shown by the top of the heavy black part of the column. Note carefully how the number of these accidents fluctuates year by year, following almost exactly the accident potential factor obtained from train miles and highway motor fuel used. I have no doubt that if it were possible to have accident potential factors based on the actual number of train and vehicle movements over these particular crossings, the correlation would be even closer.

One more significant figure can be obtained at this point. The accidents which occurred at the crossings in the group where changes were made during the 20 years are shown on the upper portion of the columns on the chart. In 1929 this number, the difference between 279 and 150, was 129; in 1948 the corresponding number, the difference between 196 and 159, was 37. The decrease in accidents in that group was 7.3 percent.

You may say that is not extraordinary. When grades are separated and crossings abandoned, grade crossing accidents no longer occur. That is quite right; and to a very considerable extent the reduction in accidents thus may be accounted for. But, having a desire to determine the effect of crossing protection, I have made a further analysis of the accident records of those crossings where, during the 20-year period, protection was changed from one form to another. That group consists of 321 individual crossings, at 20 of which protection was changed twice during the 20 years. And as I show you the results of this analysis, keep this fact in mind: This group constitutes all of the highway grade crossings on Wabash owned and operated lines at which crossing protection was changed during the 20-year period; it is not a specially selected or hand picked group.

TABLE 5 *Part 1*

AVERAGE NUMBER OF ACCIDENTS PER EQUATED CROSSING YEAR

Type of Protection		Accidents Per Year	
Before	After	Before	After
Ptd. X-buck signs	Refl. signs-AREA	0.1602	0.1116
Ptd. X-buck signs	Refl. signs-Mich.	0.0416	0.0686
Ptd. X-buck signs	Automatic bell	0.0	0.1596
Ptd. X-buck signs	Wig-wag	0.0462	0.0
Ptd. X-buck signs	Fl. lights-S. Tr.	0.2081	0.0736
Ptd. X-buck signs	Fl. lights-M. Tr.	0.2224	0.1379
Ptd. X-buck signs	Watchman	0.5263	0.4972
Ptd. X-buck signs	Automatic gates	0.2875	0.0598
Refl. signs-AREA	Fl. lights-S. Tr.	0.6849	0.0308
Refl. signs-AREA	Automatic gates	0.4878	0.1220
Refl. signs-Mich.	Fl. lights-M. Tr.	0.2970	0.1005
Refl. signs-Mich.	Automatic gates	0.3491	0.0601

Now, in this set of figures there is some real meat. Here in the left column is shown the average number of accidents a year before protection was changed and, in the right column, the average number of accidents a year after the change was made. Take the top figures as an example. They show that at the crossings where painted cross-buck signs were changed to reflector signs of the A.R.E.A. type, the accident rate before change was 0.1602 and after change it was

0.1116, a reduction of about 30 percent. Next, look at the figures in the 8th line showing the change from painted crossbucks to automatic gates. Before the change the accident rate was 0.2875; after, it was 0.0598; a reduction of almost 80 percent.

TABLE 5 *Part 2*

AVERAGE NUMBER OF ACCIDENTS PER EQUATED CROSSING YEAR

Type of Protection		Accidents Per Year	
Before	After	Before	After
Automatic bell	Fl. lights-S. Tr.	0.2925	0.1581
Automatic bell	Fl. lights-M. Tr.	0.1132	0.0946
Automatic bell	Automatic gates	0.4762	0.725
Wig-wag	Fl. lights-M. Tr.	0.2730	0.3635
Wig-wag	Automatic gates	0.1299	0.0288
Fl. lights-M. Tr.	Automatic gates	0.4202	0.1054
Watchman	Fl. lights-M. Tr.	0.3055	0.2787
Watchman	Man. gates 24 Hr.	4.2857	0.3409
Watchman	Automatic gates	0.5400	0.1429
Man. gates-Pt. T.	Fl. lights-M. Tr.	0.0	0.1596
Man. gates-Pt. T.	Man. gates-24 Hr.	0.3427	0.1473
Man. gates-24 Hr.	Fl. lights-M. Tr.	0.2167	0.4193
Man. gates-24 Hr.	Automatic gates	0.1615	0.0
Average		0.2355	0.1201

However, now that we have these several comparisons obtained from the experience at crossings where protection has been changed from one specific type to another specific type, it would be very desirable to put them all on a comparable basis; to relate them to each other.

One available medium through which to accomplish this is found in the experience at automatic gate protected crossings. Protection installations of several other types have been changed to automatic gates.

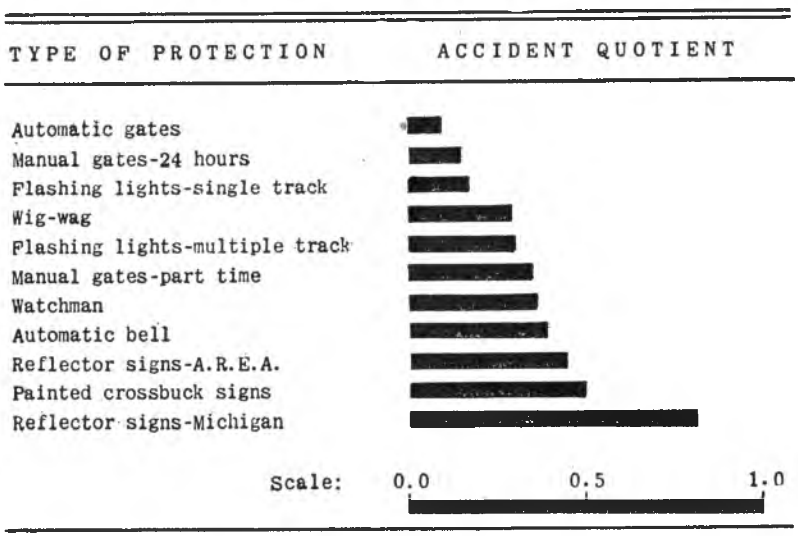
Earlier we found that the average rate of accidents at all of the 54 crossings with automatic gate protection was 0.0925 accidents per equated crossing year. As you will remember, the accident rates at crossings where painted crossbuck signs were changed to automatic gates were 0.2875 before and 0.0598 after the change. Now if these crossings had been of the average at which automatic gates were installed, the accident rate afterward would have been 0.0925 and as this example shows, the rate for painted crossbuck signs at these crossings on a comparable basis would have been 0.4447 accidents per equated crossing year.

EXAMPLE 1

	Average Accidents Per Equated Crossing Year
At all 54 crossings with automatic gates...........	0.0925
At 16 crossings changed from painted signs to automatic gates:	
Before change	0.2875
After change	0.0598
Accident factor for painted X-buck signs related to overall average of experience with automatic gates:	
$\frac{0.2875 \times 0.0925}{0.0598} =$	0.4447

Here they are shown graphically in preferential order. At the top of the list are automatic gates. Having the smallest accident quotient, they have constituted the most effective form of protection.

STATED GRAPHICALLY IN PREFERENTIAL ORDER



Next in order are manual gates operated 24 hours daily. The accident quotient for this type of protection is about 60 percent greater than that for automatic gates. Following these two types of gates come flashing light signals at single track crossings. They are only about 15 percent less effective than full time manual gates.

Following these three, come the other types which give warning of train movements. They rank in order: wig-wags, flashing lights at multiple track crossings, manual gates-part time, watchman and automatic bell. The range of accident quotients is from about 0.3 or 3¼ times the automatic gate figure for wig-wags and flashing lights at multiple track crossings to about 0.4 or 4¼ times the automatic gate figure for an automatic bell. You will note that watchman protection ranks next to an automatic bell as being the least effective form of protection other than fixed signs.

The fixed signs rank in order of effectiveness; reflector signs, A.R.E.A. type, painted crossbuck signs and reflector signs of the Michigan type with 4-foot blades and yellow backgrounds.

I think these figures are very interesting and informative. Possibly you will say there is nothing new or startling about the results. They may only confirm what you already thought you knew. But I think this is the first rational analysis that has been made to measure and determine the relative effectiveness of various forms of crossing protection. If the statistical information is available, I hope other similar studies will be made on other groups of crossings.

TABLE 6

ACCIDENT QUOTIENTS RELATED TO THE QUOTIENT FOR PAINTED CROSSBUCK SIGNS

Type of Protection	Percent
Painted crossbuck signs	*100*
Reflector signs-Michigan	162
Reflector signs-A.R.E.A.	88
Automatic bell	78
Watchman	71
Manual gates-part time	70
Flashing lights-multiple track	60
Wig-wag	58
Flashing lights-single track	35
Manual gates-24 hours	30
Automatic gates	18

Until that is done, I commend these figures to you. Remember, they are based on a 20-year record. They are backed by more than 6,300 crossing years of experience. They have been adjusted for fluctuations in accident potential resulting from periodic changes in traffic volume, and the comparisons between types of protection are based fundamentally on the use of two types at the very same crossings.

At these 321 crossings in 1929 we had 83 accidents: in 1948, with somewhat more accident potential, we had only 37. That is a measure of the achievement of grade crossing protection.

Since resuming this study this year. I have another concept of the relationship between these several forms of protection. Inasmuch as painted crossbuck signs represent the basic protection for all public crossings, the accident quotients for each type of protection are shown here on a percentage basis with that for painted crossbuck signs as 100. On that basis, for example, the accident quotient for flashing light signals at single track crossings is 35 per cent and that for automatic gates is 18 per cent.

TABLE 7

REDUCTION IN ACCIDENT QUOTIENTS BELOW THAT FOR PAINTED CROSSBUCK SIGNS

Type of Protection	Percent
Painted crossbuck signs	0
Reflector signs-Michigan	62*
Reflector signs-A.R.E.A.	12
Automatic bell	22
Watchman	29
Manual gates-part time	30
Flashing light-multiple track	40
Wig-wag	42
Flashing lights-single track	65
Manual gates-24 hours	70
Automatic gates	82

* Increase

It it then interesting to see what beneficial accident experience resulted from a change from painted crossbuck signs to each of the other forms of protection. In the case of a change to flashing light signals at single track crossings, accidents were reduced 65 percent, in the change to automatic gates, the reduction was 82 percent.

Now I have added to the study the experience of the calendar year 1949 and here is the record for 21 years. I have also sub-divided the types of protection somewhat more, separating old style flashing light signals from those meeting the current standards of aspect and circuit arrangement. Generally speaking, the new style signal was installed first in 1936 and all installations since 1939 have been modern. With another year of experience added, the accident quotient for automatic gates is 0.0933 accidents per equated crossing year whereas for the 20 year period, it was 0.0925—not much change.

TABLE 8

ACCIDENT QUOTIENTS

21 Years, 1929 to 1949, Inclusive

Type of Protection	Experience Factor (Years)	Accident Quotient
Automatic gates	353.4	0.0933
Painted crossbuck signs	988.5	0.6363
Reflector signs-AREA	292.1	0.5405
Reflector signs-Michigan	558.5	1.0027
Automatic bells	174.1	0.4842
Wig-wag	40.7	0.3269
Fl. lights-old, single track	33.5	0.7918
Fl. lights-old, multiple trk	246.4	0.4326
Fl. lts.-modern, single trk	323.5	0.1605
Fl. lits.-modern, multiple trk	477.5	0.3195
Watchman-part time	103.2	0.7593
Watchman-24 hours	121.0	0.4814
Manual gates-part time	33.4	0.4201
Manual gates-24 hours	33.4	0.2383

TABLE 9

ACCIDENT QUOTIENTS RELATED TO THE QUOTIENT FOR PAINTED CROSSBUCK SIGNS

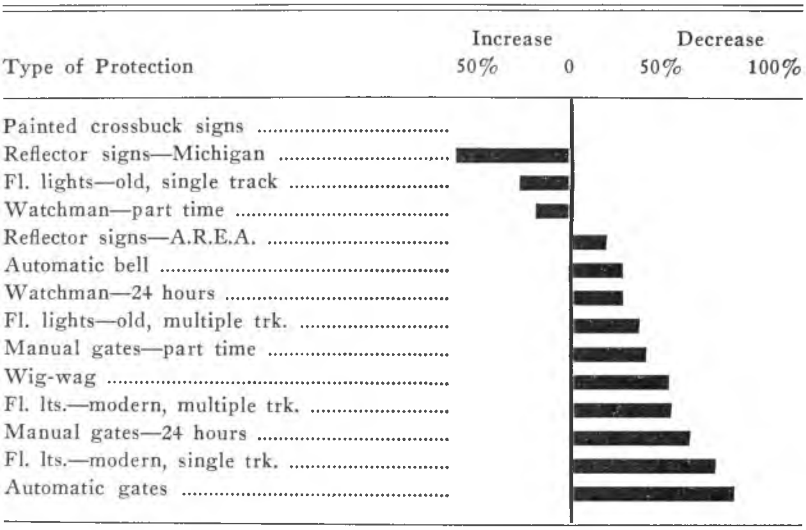
21 Years, 1929 to 1949, Inclusive

Type of Protection	Percent
Painted crossbuck signs	*100*
Reflector signs—Michigan	158
Flashing lights—old, single track	124
Watchman—part time	119
Reflector signs—A.R.E.A.	85
Automatic bell	76
Watchman—24 hours	76
Flashing lights—old, multiple track	68
Manual gates—part time	66
Wig-wag	51
Flashing lights—modern, multiple track	50
Manual gates—24 hours	38
Flashing lights—modern, single track	25
Automatic gates	15

The comparative relationships have not changed much. Flashing light signals of the modern type at single track crossings now show a 25 percent accident quotient with painted crossbuck signs at 100. The figure for automatic gates is 15 percent.

CHART 6

ACCIDENT QUOTIENTS, USING PAINTED CROSSBUCK SIGNS AS A REFERENCE BASE



Here these changes are shown graphically.

There are a few indications of inconsistency in these results but I believe they are explainable. The reflector type sign used in Michigan shows a poor record. Its record is not as good as that for painted crossbuck signs. The Michigan sign has blades only 4 feet long, whereas the painted signs have 6-foot blades. The Michigfan sign has a yellow background, whereas the painted sign has white. These Michigan signs have a very poor daytime attention getting factor. They are used mostly on rural roads where daytime traffic predominates. Thus, the sign gives a better indication at night for a very small amount of traffic but has a poor design as to size and color for the predominant daytime traffic.

Two other types show an increase rather than a decrease in accident quotient compared with that for painted crossbuck signs. In the case of old, single track flashing lights, the experience factor is low—only 33.5 years. I believe that quotient is distorted and additional experience will be the only proof.

I believe we all recognize that part-time watchman protection is not very effective.

You will note that even full-time watchman protection shows only a 24 percent improvement over painted crossbuck signs whereas at multiple track crossings—and most crossings having watchman protection are of multiple tracks—modern flashing light signals show a 50 percent improvement and automatic gates show 85 percent. It is thus indicated that a change from full-time watchman protection to automatic flashing light signals—assuming of course that automatic protection can be satisfactorily operated—would result in a reduction in the accident quotient from 76 percent to 50 percent, an improvement of approximately 33⅓ percent. Similarly a change from full-time watchman to automatic gates would result in a change from 76 percent to 15 percent, an improvement of approximately 80 percent.

To me these figures are very interesting. The whole study has been interesting. If it hadn't been, I would not have spent those many hours—nights, Sundays and odd times—on it. I hope I have projected some of my interest to you.