# American Railway Signaling Principles and Practices

CHAPTER III

## Principles and Economics of Signaling

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## ECONOMICS OF RAILROAD SIGNALING

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CHAPTER III

## Principles and Economics of Signaling

REVISED APRIL 1946

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ASSOCIATION OF AMERICAN RAILROADS, SIGNAL SECTION
30 VESEY STREET, NEW YORK 7, N. Y.

# PRINCIPLES OF RAILROAD SIGNALING

The purpose of railroad signals is the transmitting of information to employees in charge of the operation of trains.

Safety was undoubtedly the original purpose for which signals were installed and the fundamental principles were centered around this original purpose, although in actual application it is impracticable to separate the principles pertaining to safety from those pertaining to facility of train movement, and since they are so interrelated they will be stated without regard to either safety of train movement or the facilitation thereof.

The principles are submitted as fundamentals of fixed signaling regardless of whether they be of the semaphore, color light, position light or color position light type. They do not refer to construction details, which details may properly be covered by specifications prepared, or in the course of preparation, by the Signal Section, Association of American Railroads.

Modern signaling is developed from three fundamental indications which were approved by the American Railway Association in 1910:

1. Stop.
2. Caution.
3. Proceed.

These indications modified to meet present-day operating conditions are published by the Association of American Railroads in the current issue of the Standard Code.

The principles of railroad signaling as they relate to design, construction and installation of signal systems and to train operation are as follows:

*Design and Construction*

Reliability
Uniformity
Expansive capabilities
Simplicity
Selectivity
Distinctiveness
Limitation

Reliability: This requirement is given priority over all other factors so that safety and facility of train movement may be obtained.

Uniformity: To avoid confusion in the engineman's mind and possible delay to trains, uniformity in aspects and indications is necessary.

Expansive capabilities: Light traffic and simplicity in track layout requires a less elaborate signal system than does heavy traffic and more complicated track layouts; however, the signaling for the light traffic or the simple track layout should, for economic reasons, be capable of expansion to provide for increasing traffic to the ultimate capacity of the railroad.

Simplicity: Consistent with requirements, simplicity is an important factor in the design and construction of a signal system.

Selectivity: A signal system should give definite information as to permissible speeds at the point involved.

Distinctiveness: Signal systems being of different kinds, the signals used in each system should be distinctive either in design or marking so that they can be readily classified.

Limitation: By limitation is meant the restriction imposed by the indication given by the signal such as stop at next signal, pass next signal at medium speed, proceed at restricted speed, etc. Limitations as transmitted by the signal indications should be readily understandable for safe movement of trains.

*Installation*

Location
Stopping distance
Protection
Visibility

Location: Signals should, as far as practicable, be located:

1. To the right of and adjoining the track to which they refer.
2. Back of fouling point to protect converging and opposing train movements.

Stopping distance: Signals should be spaced to provide proper stopping distance. This may be accomplished by one or more restrictive approach aspects.

Protection: The protection desired must be given careful consideration and the installation should be in accordance with the recommended practices of the Signal Section, A.A.R.

Visibility: Signals should be so located as to give the best possible view to enginemen on approaching trains.

*Requisites.*

The Signal Section, A.A.R., prescribes requisites applicable to the installation of interlockings, automatic block signaling systems and centralized traffic control, and they are as follows:

*Interlocking*

1. The apparatus shall, so far as possible, be so installed and circuits so arranged that failure of any part of the system affecting the safety of train operation will cause all signals affected to give the most restrictive indications which conditions require.

2. Signals shall be located preferably to the right of and adjoining the track to which they refer.

3. Signal indications shall be given by positions, by colored lights, or by both.

4. Approach and home signals shall be spaced at least stopping distance apart, or where not so spaced an equivalent stopping distance shall be provided by two or more signals arranged to display restrictive indications approaching home signal, the indication of which requires such restrictive indications.

5. Track circuits shall be provided throughout interlocking limits, except when otherwise authorized.

6. Signals governing movements over switches, movable point frogs, and derails shall be so controlled that indications to proceed can be displayed only when such units are in proper position.

7. Mechanical locking to insure predetermined order of level movement, or circuits to insure proper correlation of the units of the interlocking, shall be provided.

8. Except at automatic interlocking, signals which form a part of an automatic block signal system shall be controlled semi-automatically.

9. Approach or time locking shall be provided in connection with signals governing movements at high or medium speed.

10. Electric switch locking shall be provided at manually operated interlocking, except when otherwise authorized.

11. Facing point lock or switch-and-lock movement shall be provided for mechanically operated switch, movable point frog, or split point derail.

12. Power switch operating and locking mechanism shall be provided with means to indicate on interlocking machine or to the operator when movement is completed and unit is locked.

13. Indication locking or equivalent shall be provided for approach signals of the semaphore type and power-operated home signals.

14. Movable bridge shall be equipped with mechanism to surface and align bridge and track accurately and fasten them securely in position.

15. When movable bridge is protected by interlocking, provision shall be made to insure that movements of the bridge devices succeed each other in a predetermined order, and that the movable span, tracks, and switches within interlocking limits are locked in proper positions.

*Automatic Block Signaling Systems*

1. The apparatus shall, so far as possible, be so installed and circuits so arranged that failure of any part of the system affecting the safety of train operation will cause all signals affected to give the most restrictive indications which conditions require.

2. Signals shall be located preferably to the right of and adjoining the track to which they refer.

3. Signal indications shall be given by positions, by colored lights, or by both. A single white light shall not be used for a Proceed indication.

4. Signals shall be spaced at least stopping distance apart or, where not so spaced, an equivalent stopping distance shall be provided by two or more signals arranged to display restrictive indications approaching signal where such indications are required.

5. Signals shall be automatically controlled by continuous track circuits on main track and on other track where medium speed is permitted.

6. Signals governing movements over switch shall be so controlled that proper restrictive indications will be displayed when such switch is not in proper position.

7. On track signaled for movements in both directions, signals shall be so arranged and controlled that proper restrictive indications will be provided to protect both following and opposing movements.

8. The circuits shall be so installed that:

(a) So far as possible, the failure of any part of a circuit affecting the control of a signal will not result in the signal displaying a more favorable indication than intended.

(b) When a train, engine, or car is in a block, a switch is misplaced or its points not in proper position, an independently operated fouling point derail equipped with switch circuit controller is misplaced or not in derailing position, or a track or the signal control relay is in de-energized position, each signal governing a train movement into the block will display its proper restrictive indication.

(c) When there is no train, engine, or car in a block, all switches and independently operated fouling point derails equipped with switch circuit controllers are in normal position, and all track and signal control relays in energized position, each signal governing a train movement into the block will display its proper indication for approaching train to proceed.

9. Signal control relay circuit shall not be opened through the contacts of switch, station, or tower indicator or annunciator in which the indicating element is attached to the armature.

10. The battery or power supply for signal control relay circuits shall be located at the end of the circuit farthest from the relay.

11. Signal control relay shall be controlled by track circuits extending through the entire block.

### *Centralized Traffic Control*

1. The apparatus shall, so far as possible, be so installed and circuits so arranged that failure of any part of the system affecting the safety of train operation will cause all signals affected to give the most restrictive indications which conditions require.

2. Signals shall be located preferably to the right of and adjoining the track to which they refer.

3. Signal indications shall be given by positions, by colored lights, or by both. A single white light shall not be used for a Proceed indication.

4. Signals shall be spaced at least stopping distance apart or, where not so spaced, an equivalent stopping distance shall be provided by two or more signals arranged to display restrictive indications approaching signal where such indications are required.

5. Signals shall be automatically controlled by continuous track circuits on main track and on other tracks where medium speed is permitted, and in addition at controlled point by control operator, and at manually operated interlocking manually in cooperation with control operator.

6. Signals at a controlled point shall be so interconnected that they cannot be clear for opposing or conflicting movements.

7. Signals at adjacent controlled points shall be so interconnected that they cannot be clear for opposing or conflicting movements.

8. Signals governing movements over switches shall be so controlled that indications to proceed can be displayed only when such switches are in proper position.

9. Means shall be so provided to insure that after a signal has been cleared, and the locking is effective, it cannot be restored manually to Stop by the operation of any lever other than its controlling lever.

10. A track diagram or other means shall be provided at control station to indicate occupancy of track sections at controlled points.

11. Approach or time locking shall be provided.

12. Section or route locking shall be provided where switches are power operated.

13. Means shall be provided to indicate on the control machine when power-operated switch has completed its movement and is locked.

14. Hand-operated switch electrically locked shall be operative as provided for in Requisites for Electric Locks Applied to Hand-Operated Switches for Protection of Main Track Movements.

*Train order system.*

This method of directing trains is a time interval method and provides authority for the movement of regular trains subject to the rules. Under normal operation when trains conform to the time-table schedules there is no delay, but if the schedules are interrupted or extra trains are run, it then becomes necessary to issue orders to authorize train movements. Density of traffic will determine the number of train order offices required and the form of train orders to be issued.

Unless otherwise provided, a fixed signal must be used at each train order office. Freight and passenger train movements and "meets," as well as "passes," are made on time-table and train order authority. In the time interval method of directing train movements, the safety of train operation is dependent upon the exact observance of the many rules governing train operation not only in the operating book of rules adopted by each railroad, but also the special instructions in the time-table or otherwise.

*Manual block system.*

The Standard Code defines Manual Block System as: A series of consecutive blocks, governed by block signals operated manually, upon information by telegraph, telephone or other means of communication.

In the manual block system of directing train movements, a manual block signal, normally at stop, is used for spacing trains between block offices; the train order signal, previously referred to, is sometimes used as the manual block signal. Trains may be permitted to follow one another into a block, although an absolute block is generally maintained for passenger trains. In the latter case it is essential to have shorter block sections and sufficient offices to expedite traffic without delays. Manual block operation is a slower method of protecting train movements than the train order system. Railroads adopted this system in an endeavor, even at the expense of additional block offices, to surround train operation with greater safety, particularly passenger trains, than is possible in the time interval method. On light traffic lines, block lengths of 5 to 7 miles do not cause excessive delays, but with a traffic density of 20 or more trains per day, the use of an absolute block for passenger trains, which permits only one train in the 5 or 7 mile block section, results in considerable delay time. The manual block system is operated by rules without electrical or mechanical check on the block operator.

*Controlled manual block system.*

The Signal Section, A.A.R., defines Controlled Manual Block System as: A series of consecutive blocks governed by block signals, controlled by continuous track circuits, operated manually upon information by telegraph, telephone or other means of communication, and so constructed as to require the cooperation of the signalmen at both ends of the block to display a Clear or a Permissive block signal.

*Automatic block system.*

The Standard Code defines Automatic Block System as: A series of consecutive blocks governed by block signals, cab signals, or both, actuated by a train, or engine, or by certain conditions affecting the use of a block.

With the train order and manual block systems the safe operation of the system is more or less dependent upon the human agency. With the automatic block system the train automatically controls the signals.

The fundamental element of the automatic block system is the continuous track circuit which provides an economical and safe method of maintaining a space interval between following and opposing train movements. The space interval or block may vary in length from a few hundred feet to two or more miles, the average length being about one and one-half miles.

*Interlocking.*

The Standard Code defines Interlocking as: An arrangement of signals and signal appliances so interconnected that their movements must succeed each other in proper sequence and for which interlocking rules are in effect. It may be operated manually or automatically.

Its use was largely influenced by considerations of economy. It was early recognized as a necessity in the large passenger terminals because the cost of switchmen to operate hand-throw switches became excessive and the possibility of collisions due to fog, bad weather conditions and the delays necessary to guard against accidents, often placed serious limitations on traffic. Interlockings were also found advantageous at yards, junctions, crossings and other points.

*Centralized traffic control.*

The Signal Section, A.A.R., defines Centralized Traffic Control as: A term applied to a system of railroad operation by means of which the movement of trains over routes and through blocks on a designated section of track or tracks is directed by signals controlled from a designated point without requiring the use of train orders and without the superiority of trains.

Centralized traffic control is a method of train operation by signal indication which makes it economically possible to greatly extend the territory controlled from one station. This system of train operation is considered by many to be among the outstanding developments in the railroad field and it is extensively used as a means of directing trains because of the economies in operation which it effects. It not only affords direct economies in transportation, but it makes possible a more extensive use of track facilities.

Centralized traffic control basically involves the control of signals and switches governing the use of a series of consecutive blocks from a central point and provides for the movement of trains by authority of the signals so controlled. Most installations include the control and operation of switches because of additional advantages which come about through the elimination of train stops.

Inherent in a centralized traffic control system is the combination of the utility of interlocking control of switches and the protection of automatic block signaling.

## *Systems of Signaling in Service*

*General.*

Basically all signal systems now in service on the railroads are arranged to meet, as nearly as possible, the conditions set forth in the principles. Three general schemes of signaling are now in service, and these are known as one-arm, two-arm and three-arm signaling. For convenience, semaphore symbols are used, the indications of which are given by positions of arms and color of lights. With light signals the indications are given by color, the position of lights, or both.

Speeds applicable to signal indications are defined by the Standard Code as follows:

*Limited Speed.*—A speed not exceeding ........ miles per hour
*Medium Speed.*—A speed not exceeding ........ miles per hour
*Slow Speed.*—A speed not exceeding ........ miles per hour
*Restricted Speed.*—Proceed prepared to stop short of train, obstruction, or switch not properly lined and to look out for broken rail.

The blank spaces for limited, medium and slow speeds are determined by each railroad. It is usually 45 miles for Limited Speed, 30 miles for Medium Speed and 15 miles for Slow Speed.

The Standard Code prescribes for the use of fixed signals as follows:

## FIXED SIGNALS.

Rules 281 to 292, inclusive.

Aspects may be shown by the position of semaphore arms, color of lights, position of lights, flashing of lights, or a combination of color, position, and flashing of lights. (Rev. 1-14-1946)

Day and night aspects for color light signals shall have the same colors as the night aspects of the semaphore signals.

Day and night aspects for position light signals shall have the same positions as the day aspects of the semaphore signals.

Aspects shown are typical. Each road should show the aspects and colors of lights it uses.

NOTE.—In the following illustrations of typical signal aspects, Rules 281 to 292, inclusive.

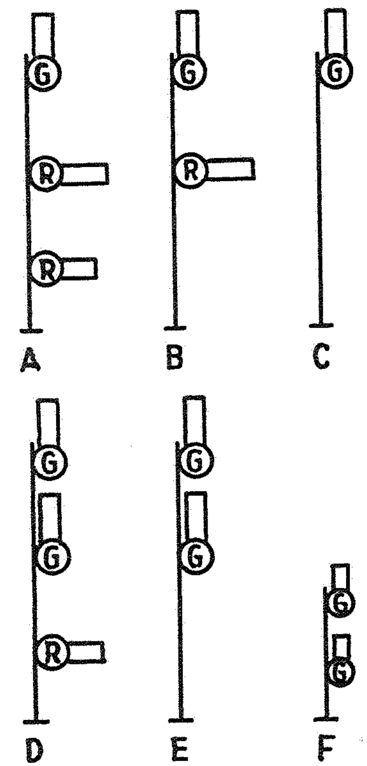
R = Red
Y = Yellow
G = Green

NOTE.—When flashing color lights are used, they shall be indicated as follows:

FR = Flashing Red
FY = Flashing Yellow
FG = Flashing Green

(Second Note adopted 1-14-1946)

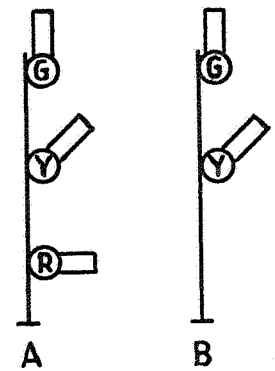
## RULE 281




Indication — Proceed.

Name: Clear.

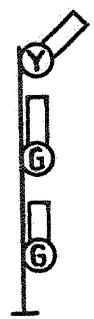
## RULE 281 A




Indication — Proceed approaching second signal at medium speed.

Name: Advance approach medium.

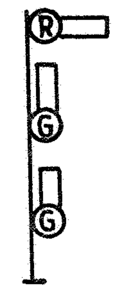
## RULE 281B




Indication — Proceed approaching next signal at limited speed.

Name: Approach limited.

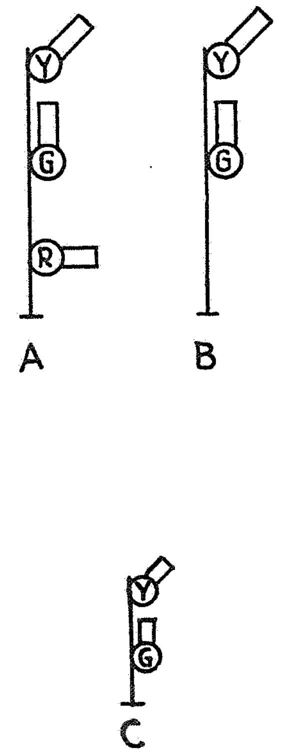
## RULE 281C




Indication — Proceed; limited speed within interlocking limits.

Name: Limited – clear.

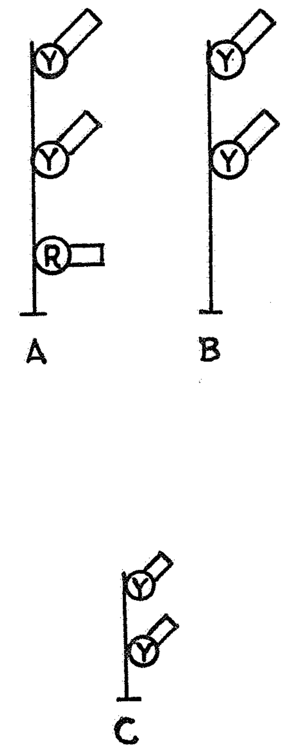
## RULE 282




Indication — Proceed approaching next signal at medium speed.

Name: Approach medium.

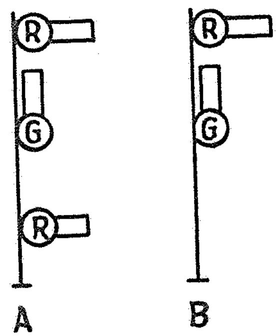
## RULE 282A




Indication — Proceed preparing to stop at second signal.

Name: Advance approach.

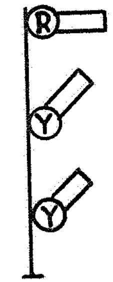
## RULE 283




Indication — Proceed; medium speed within interlocking limits.

Name: Medium-clear.

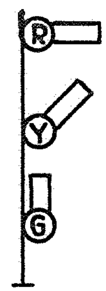
## RULE 283 A




Indication — Proceed preparing to stop at second signal; medium speed within interlocking limits.

Name: Medium — advance approach.

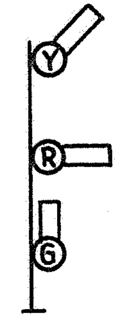
## RULE 283 B




Indication – Proceed at medium speed approaching next signal at slow speed.

Name: Medium-approach slow.

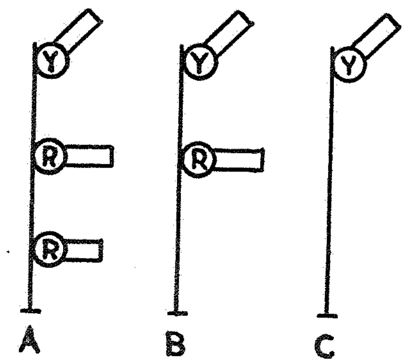
## RULE 284




Indication – Proceed approaching next signal at slow speed. Train exceeding medium speed must at once reduce to that speed.

Name: Approach slow.

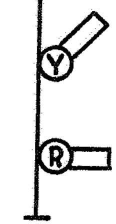
## RULE 285




Indication — Proceed preparing to stop at next signal. Train exceeding medium speed must at once reduce to that speed.

Name: Approach.

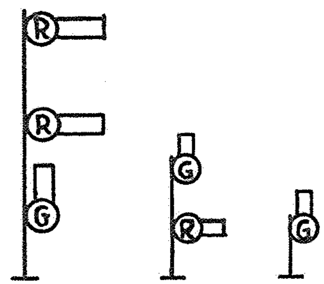
## RULE 286




Indication — Proceed at medium speed preparing to stop at next signal.

Name: Medium — approach.

## RULE 287

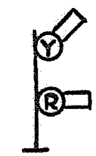


A B C

Indication — Proceed; slow speed within interlocking limits.

Name: Slow – clear.

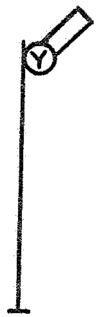
## RULE 288



Indication — Proceed preparing to stop at next signal; slow speed within interlocking limits.

Name: Slow – approach.

## RULE 289



Designate by

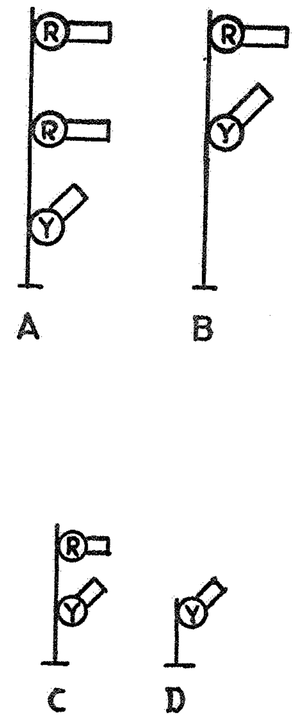
1 - Letter plate
or
2 - Marker light
or
3 - Shape of arm
or
4 - Combination of these distinguishing features.

Indication — Block occupied; proceed prepared to stop short of train ahead.

Name: Permissive.



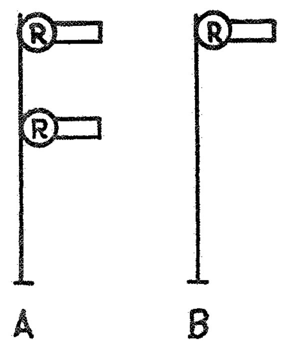
## RULE 290




Indication — Proceed at restricted speed.

Name: Restricting.

## RULE 291



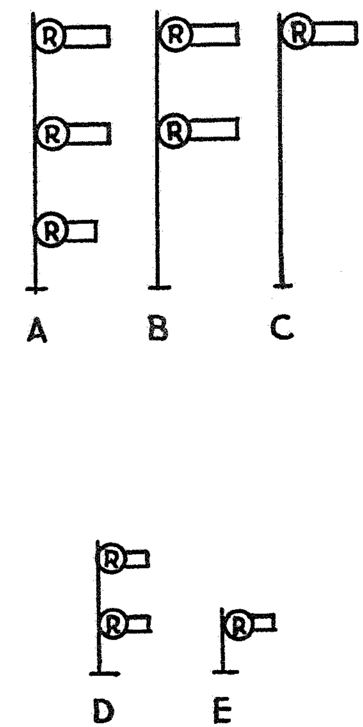

Designate by: 1-Number plate
or
2-Marker light
or
3-Pointed blade
or
4-Combination of these distinguishing features.

Indication – Stop; then proceed at restricted speed.

Name: Stop and proceed.

NOTE–Railroads desiring to avoid stopping trains may arrange accordingly.

## RULE 292




Indication – Stop.

Name: Stop.

Certain railroads have adopted as their standard either the color light, position light, or color position light signals, and their system is arranged accordingly. Chapter II—Symbols, Aspects and Indications explains in detail the aspects and indications displayed by the different types of signals, as well as the various systems in effect, and it is recommended that the student study Chapter II carefully in order to obtain complete information of all details regarding any particular system and type of signal.

*Cab signals and cab indicators.*

A detailed description of the aspects and indications of cab signals and cab indicators is given in Chapter II.

## ECONOMICS OF RAILROAD SIGNALING

### INTRODUCTION

The purpose of this portion of the chapter is to present, in summary form, data showing the economic results actually accomplished by modern signal systems and to suggest methods for determining the probable economic benefits to be derived from proposed installations. Its 24 tables and references to over 330 published articles amplify the summaries.

In the early days of railroad signaling little attention was paid to economics, as installations were made primarily for increased safety. At present, the safety of train operation is taken for granted and signaling is justified by the reduced operating expenses. The insurance value of automatic block signals, interlocking, centralized traffic control or other signaling, is recognized as having an economic value, although it is not always included in an economic report.

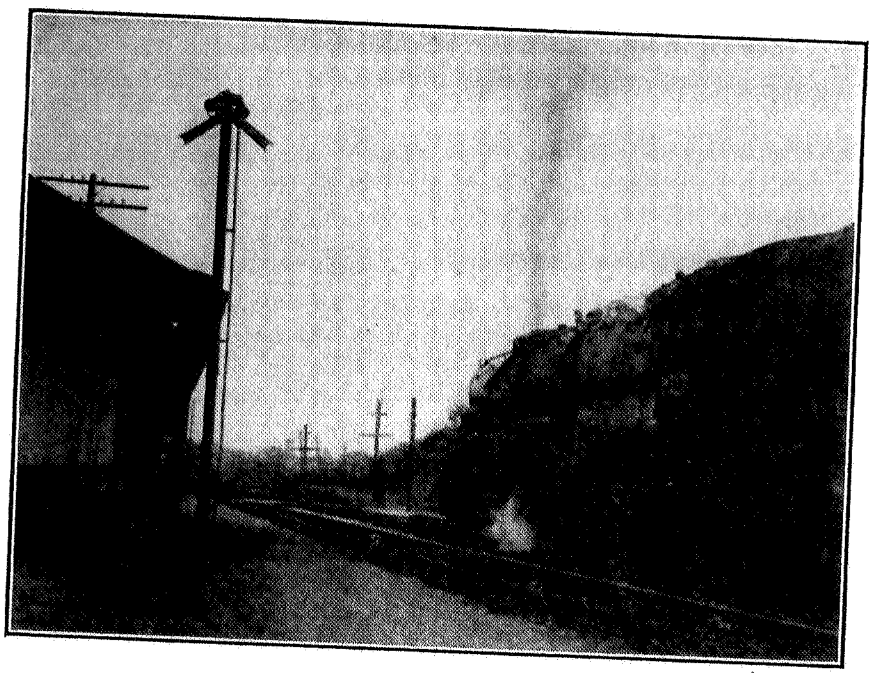
Railroad signaling development has been continuous from the early days of automatic block signals and mechanical interlocking to the present time when refinement of apparatus and developments have made possible many new applications without sacrificing any of the basic principles. The development of power interlocking, remote control, automatic interlocking, automatic train control, continuous cab signals, centralized traffic control and car retarders has given impetus to railroad signaling. These later developments have been designed for the promotion of transportation efficiency, increased safety and economy. It is logical that the additional cost of a proposed signal system over and above the basic requirements of safety should be justified by the saving in operating expenses or through the saving in capital costs because of the greater capacity and operating facility.

Economics of railroad signaling involves the determination of the financial and operating reasons for the expenditure. It may also involve a comparative analysis of the proposed signaling and alternative improvements so that it can be shown whether signaling is the most desirable solution for expediting train movements and increasing the capacity of the railroad.

Railroad signaling offers a means of improving operating performance by providing facilities for the more intensive utilization of existing trackage, generally at a lower unit operating cost and a lower unit fixed cost than could be achieved by other types of improvements and therefore gives more increased capacity and facility of operation with a higher return on the investment. As traffic growth is normally at a slow steady rate, it is generally more economical to provide for greater utilization of existing facilities than to provide larger sums for additional capacity which could not be utilized because the traffic would not be great enough for a number of years to bring about a suitable saving on the additional capital expenditure.

Signal apparatus is of a type that may be used to advantage even if changes are made in the original track layout. For example, if a single-track line equipped with automatic block signals is later made two main tracks, the signal apparatus may be relocated to fit the new track arrangement. Practically every signal installation contains an assemblage of certain basic apparatus which is largely interchangeable with that of other signal installations on the railroad and therefore signaling may be economically applied to a relatively temporary traffic situation as well as to a situation which promises to be more permanent.

A modern signal system will frequently provide the additional capacity needed to handle a seasonal peak traffic of relatively short duration in the most economical manner because the capacity required is furnished at the lowest possible capital investment. Such a system will not only reduce the investment required to handle this traffic expeditiously, but will also bring about sufficiently improved operation during the periods of normal traffic throughout the balance of the year to make an attractive operating saving even at the periods of minimum traffic density. Modern signal systems do not require traffic at or near peak densities in order to justify the expenditure, although the rates of saving increase rapidly with increased traffic. The modern conception is to design the signaling to suit the traffic requirements.



Train Order Signal on Norfolk & Western

In the train order and manual block methods of directing train movements the number of block stations may be increased or decreased as traffic varies seasonally and the cost of operation may be made somewhat proportional to the traffic density. The first cost and the maintenance expense are low although the cost of operation is high due to the wages of the operators and the train delay due to inflexibility of the system in handling increases in business. Generally, the block stations, operated one or more tricks per day depending upon traffic conditions, are 2 to 5 miles apart although blocks of 7 to 10 miles are used in some cases while, during light traffic periods, blocks of 20 to 40 miles are not unusual.

The cost of operation per block station per year varies with the number of operators on duty per day and generally averaged in 1945 about $3,000 per trick. This amount includes not only the wages and taxes but also the heat, light, and other expenses incident to maintaining and operating a block station. As traffic increases and more blocks are added, the cost of the manual block method of directing trains increases. It is therefore desirable to compare the cost of operation with the alternate methods of automatic block signals or operation by signal indication, as to economy and increased safety. An increasing mileage of these latter methods of directing train movements is being installed as shown by the statistics of the Interstate Commerce Commission, Bureau of Safety. According to these reports, 145,636 miles of track were protected by either automatic or non-automatic block signals as of January 1, 1945 as compared with about 86,000 miles in 1910. Miles protected by non-automatic block signals decreased to about 45,900 as of January 1, 1945 from about 62,000 in 1910.

On the following pages will be found the various applications of signaling in the field of railroad transportation and the economic advantages actually accomplished by automatic block signals, interlockings, train operation by signal indication, remote control, centralized traffic control, car retarders, and railroad highway grade crossing protection.

The economy of train operation in an automatic block system results from a decreased number of operators and from providing facilities for several times the number of trains in the same track length with block protection and less train delays. The increased safety of train operation and the operating benefits obtained account for the steady increase in track mileage of automatic block signals in the United States from about 23,800 in 1910 to over 99,735 as of January 1, 1945.

The first cost of automatic block signals on 8 railroads, as reported in returns to the Interstate Commerce Commission questionnaire* of July 22, 1927, is shown in Table I.

TABLE I

Cost of Automatic Block Signals

| Railroad | Type of signals† | Direct current or alternating current | Single track or two main track | Road miles | Cost per track mile |
|---|---|---|---|---|---|
| A. T. & S. F. | 3 CL | A. C. | T. M. T. | 229.7 | $2,898 |
| B. & O. | 4 CPL | D. C. | T. M. T. | 106.0 | 2,782 |
| I. C. | 3 CLO | D. C. | S. T. | 108.9 | 3,005 |
| L. A. & S. L. | 3 CLO | D. C. | S. T. | 130.0 | 3,038 |
| M. P. | 3 CLO | D. C. | S. T. | 391.1 | 3,822 |
| N. C. & St. L. | 3 CLA | D. C. | S. T. | 83.7 | 3,308 |
| N. Y. C. (E.) | 3 CL | D. C. | T. M. T. | 64.2 | 3,569 |
| N. P. | 3 CLA | D. C. | S. T. | 33.9 | 2,532 |

† Abbreviations:

3 CL =3 color, light signal
3 CLA=3 color, light signal, APB system
3 CLO=3 color, light signal, overlap system
4 CPL=4 color, position light signal

The variation in these cost figures per mile of track is due to the difference in the track and signal layouts, traffic conditions, pole line and power conditions, local operating conditions, interlocking changes and additions, railroad highway grade crossing protection, and date of installation, and shows the impossibility of using an average cost per mile of automatic block signals unless the requisites of installation are known.

Data on 29 installations of automatic block signals on 19 railroads are shown in Tables II and III. Table IV shows the advantages of modernizing automatic block signals on 4 railroads.

* *Railway Signaling*, April 1928, p. 142.

## TABLE II

### Automatic Block Signal Installations

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day Frt. | Trains per day Pass. | Trains per day Max. | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|
| B. & O. | Parkersburg, W. Va.—Midland City, Ohio | 1937 | 150.0 | 160.0 | 6 | 12 | 20 | 213 |
| C. P. | St. Martin Jct.—Louiseville, Que., Can. | 1936 | 62.0 | 62.0 | 6 | 10 | 22 | 214 |
| C. P. | Chapleau—Schreiber, Ont., Can. | 1944 | 250.0 | 250.0 | 8 | 6 | 30 | 161 |
| C. & O. | Upper Sandusky—Walbridge, Ohio | 1937 | 51.0 | 102.0 | 34 | 4 | 38 | 215 |
| C. R. I. & P. | Bureau—Peoria, Ill. | 1937 | 46.5 | 46.5 | 6 | 8 | 14 | 216 |
| C. R. I. & P. | Herington, Kans.—Tucumcari, N. Mex. | 1938 | 467.0 | 467.0 | 10 | 6 | 34 | 217 |
| C. St. P. M. & O. | Merriam—Mankato, Minn. | 1937 | 50.2 | 50.2 | 9 | 6 | 26 | 218 |
| C. C. C. & St. L. | Crestline—Berea, Ohio | 1922 | 63.2 | 126.4 | 20 | 30 | 50 | 1 |
| C. C. C. & St. L. | Cincinnati, Ohio—Greensburg, Ind. | 1927 | 58.3 | 116.6 | 18 | 16 | 34 | 2 |
| E. J. & E. | Rondout—Barrington, Ill. | 1937 | 14.0 | 14.0 | 20 | .... | 20 | 219 |
| G. N. | Coon Creek, Minn.—Boylston, Wis. | 1942 | 132.0 | 132.0 | 6 | 4 | 10 | 159 |
| M. P. | Pleasant Hill—Rich Hill, Mo. | 1936 | 52.0 | 52.0 | 10 | 8 | 18 | 202 |
| M. P. | McCracken, Kans.—Sugar City, Colo. | 1937 | 235.0 | 235.0 | 7 | 4 | 18 | 221 |
| N. & W. | Portsmouth—Cincinnati, Ohio | 1926 | 100.0 | 100.0 | 10 | 8 | 18 | 6 |
| P. R. R. | Wampum Jct.—Rochester, Pa. | 1939 | 16.0 | 32.0 | 8 | .... | 8 | 286 |
| P. R. R. | Conpitt Jct.—Kiski Jct., Pa. | 1940 | 49.9 | 99.8 | 10 | .... | 10 | 286 |
| R. R. "A" | Section A-C | 1924 | 42.0 | 42.0 | 18 | 8 | 26 | 3 |
| R. R. "A" | Section A-E | 1924 | 66.0 | 66.0 | 16 | 10 | 26 | 4 |
| R. R. "B" | Section A-B | 1926 | 48.0 | 48.0 | 28 | 28 | 64 | 5 |
| R. R. "C" | Division "E" | 1925 | 148.2 | 157.1 | 22 | 12 | 34 | 8 |
| St. L.-S. F. | Memphis, Tenn.—Amory, Miss. | 1936 | 121.0 | 121.0 | 8 | 6 | 14 | 222 |
| St. L. S. W. | Illmo—Dexter, Mo. | 1941 | 47.0 | 62.0 | 34 | 2 | 40 | 287 |

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TABLE II—Concluded.

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day Frt. | Trains per day Pass. | Trains per day Max. | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|
| S. A. L. | Richmond, Va.—Norlina, N. C. | 1926 | 98.4 | 98.4 | 15 | 18 | 33 | 7 |
| S. A. L. | Norlina—Raleigh, N. C. | 1926 | 87.7 | 87.7 | 16 | 18 | 34 | 7 |
| S. A. L. | Raleigh—Hamlet, N. C. | 1926 | 96.1 | 96.1 | 15 | 18 | 33 | 7 |
| Wabash | Orland Park—Lodge, Ill. | 1937 | 116.1 | 116.1 | 12 | 8 | 24 | 223 |
| Wabash | Tolono—Tilton, Ill. | 1940 | 34.1 | 34.1 | 8 | 4 | 16 | 288 |
| Wabash | Markham—Kinderhook, Ill. | 1943 | 50.0 | 50.0 | 18 | 2 | 20 | 160 |
| W. M. | Hagerstown—Cumberland, Md. | 1918 | 79.0 | 97.2 | 7 | .... | 7 | 9 |

* For publication references, see p. 88.

## TABLE III

### Advantages of Automatic Block Signals

| Railroad | Previous operation* | Operating advantages |
|---|---|---|
| B. & O. | M. B. | Improved train operation, increased capacity and safety. |
| C. P. | T. I. | Eliminated delays especially during peak periods and increased safety. |
| C. P. | T. I. | Eliminated delays, increased capacity and safety. |
| C. & O. | M. B. | Block lengths reduced, reduced delays in foggy weather and increased safety. |
| C. R. I. & P. | T. O. | Reduced delays and increased safety for high-speed Rocket trains. |
| C. R. I. & P. | T. O. | Reduced delays, expedited traffic and increased safety. |
| C. St. P. M. & O. | T. O. | Eliminated delays and increased safety, especially in foggy and stormy weather. |
| C. C. C. & St. L. | M. B. | Saved 65-83 minutes per freight train and 45.5 per cent on total cost. |
| C. C. C. & St. L. | M. B. | Saved 18-30 minutes per freight train and 18 per cent on total cost. |
| E. J. & E. | T. I. | Expedited freight train movements and increased safety. |
| G. N. | T. O. | Reduced delays and increased safety. |
| M. P. | T. O. | Reduced delays and increased safety. Use of "19" orders expedited traffic. |
| M. P. | T. O. | Reduced delays and increased safety, especially during dust storms. |
| N. & W. | M. B. | Saved 104 minutes per freight train and $34,800 per year. |
| P. R. R. | M. B. | Saved 20 minutes per freight train and increased safety. |
| P. R. R. | M. B. | Saved 17.8 minutes per freight train and increased safety. |
| R. R. "A" | T. O. | Saved 31 minutes per freight train and increased capacity 37.2 per cent. |
| R. R. "A" | T. O. | Saved 64 minutes per freight train and increased capacity 51.6 per cent. |
| R. R. "B" | T. O. | Saved 25 minutes per freight train and increased capacity 35 per cent. |
| R. R. "C" | M. B. | Saved 100 minutes per freight train and 16.6 per cent on total cost. |
| St. L.-S. F. | T. O. | Reduced delays and increased safety. |
| St. L. S. W. | T. O. | Reduced delays and increased safety. |
| S. A. L. | M. B. | Saved 52 minutes per freight train and 13.4 per cent on total cost. |

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TABLE III—Concluded

| Railroad | Previous operation* | Operating advantages |
|---|---|---|
| S. A. L. | M. B. | Saved 39 minutes per freight train and 14.4 per cent on total cost. |
| S. A. L. | M. B. | Saved 56 minutes per freight train and 10.2 per cent on total cost. |
| Wabash | M. B. | Reduced delays and increased safety. |
| Wabash | M. B. | Reduced delays and increased safety. |
| Wabash | M. B. | Expedited trains and increased safety. |
| W. M. | M. B. | Saved 272 minutes per freight train and reduced overtime hours 92 per cent |

* Abbreviations:
M. B.=Manual block
T. I. =Time interval
T. O. =Train orders

## TABLE IV

### Advantages of Modernizing Automatic Block Signals

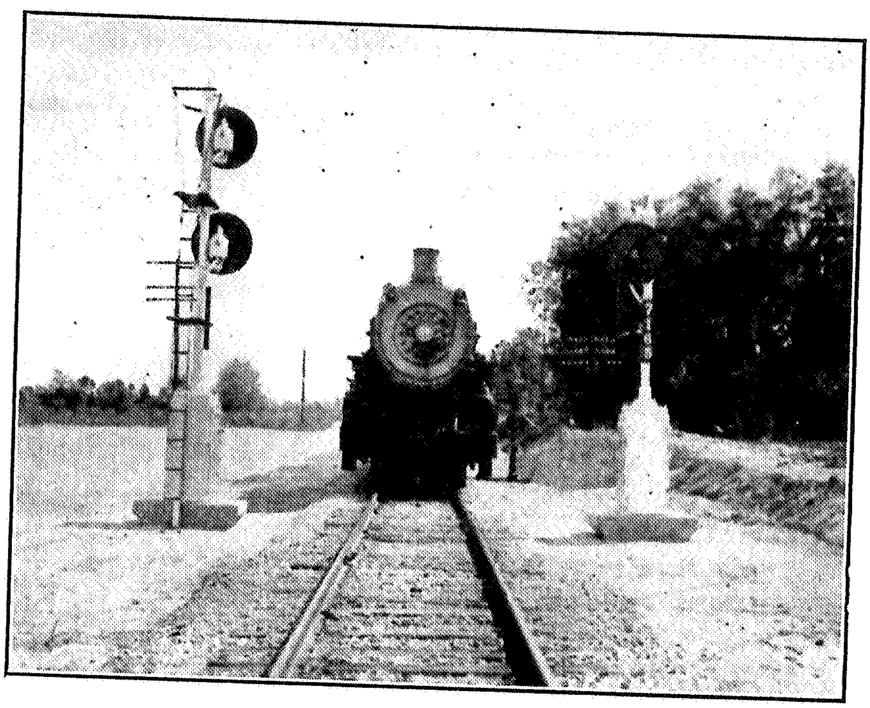
| Railroad | Location | Miles of Road | Miles of Track | In service | Trains per day | Types of signals Before | Types of signals After | Saving Per year | Saving Per cent | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|---|---|
| C. & N. W. | Wilmette, Ill.—Milwaukee, Wis. | 70 | 140 | 1936 | 95 | Disc. | C. L. | $13,360 | 7.9 | 224 |
| | Former 2-position disc signals with oil lamps in service 30 years replaced with 3-4 indication color light signals. Former block lengths of 6,000-7,000 feet in two-block territory increased to 7,000-8,000 feet with 3,500-5,000 foot blocks in three-block territory. | | | | | | | | | |
| C. B. & Q. | Ottumwa—Osceola, Iowa | 82 | 164 | 1938 | 25 | Sema. | C. L. | | | 225 |
| | Two-position lower-quadrant home and distant signals installed in 1913 replaced with 3-indication color light signals. Spacing increased to 8,000-15,000 feet. | | | | | | | | | |
| N. & W. | Roanoke—Walton, Va. | 40 | 80 | 1936 | 38 | Sema. | P. L. | | | 226 |
| | Two-arm, 2-position lower-quadrant signals installed in 1908 replaced with 3-indication position light signals. Former block lengths of 4,000-6,000 feet were lengthened, 10 signals being eliminated. | | | | | | | | | |
| P. R. R. | Crestline, Ohio—Hobart, Ind. | 245 | 490 | 1935 | 64 | Sema. | P. L. | $10,621 | 46.0 | 227 |
| | Three-position upper-quadrant semaphore signals installed in 1910 replaced with 3-indication position light signals, 40 per cent of original signals being eliminated. Block lengths increased from 4,800 to 8,500 feet. | | | | | | | | | |

* For publication references, see p. 88.

*Economics of replacing semaphore signals with light signals.*

Eight railroads* reported savings and other advantages of replacing semaphore signals with light signals as follows:

1. Reduced maintenance cost by elimination of the motor, contacts, etc.
2. Reduced store stock.
3. Increased time and opportunity for other duties by maintenance force, due to elimination of mechanisms and their parts and reduction of periodical inspections.
4. When, because of obsolescence, extensive repairs are required to semaphore signals, light signals may prove more economical.
5. Light signals, being lower in height, have the advantage of being in line with engineman's vision and because of lower height, result is reduced cost of poles and foundations.
6. When used as approach signal to interlockings, light signals in some cases may reduce cost of installation and maintenance due to minimized locking circuits required.
7. A saving of from 5 to 7 seconds per indication, due to indication of light signals being practically instantaneous.



Automatic Block Signals on Atlantic Coast Line

*Cost of maintenance and operation of automatic block signals.*

The cost of maintenance and operation of automatic block signals on three installations on two railroads was reported** as follows:

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* A.A.R. Signal Section 1940 Proceedings, Vol. XXXVIII, p. 19.
** A.A.R. Signal Section 1936 Proceedings, Vol. XXXIV, pp. 24, 430.

| Railroad | Year | Track miles | Annual cost maintenance and operation | No. A.A.R. units | Per A.A.R. unit | Per track mile | Per cent of total cost |
|---|---|---|---|---|---|---|---|
| M. P. | 1934 | 78 | $8,000 | 1,072 | $7.46 | $103 | 3.1 |
| M. P. | 1934 | 48 | 4,500 | 486 | 9.26 | 94 | 3.1 |
| Wabash | 1930 | 37 | 5,865 | 618 | 9.49 | 159 | .. |
| Total.......... | | 163 | $18,365 | 2,176 | | | |
| Average........ | | 54.3 | $6,122 | 725.3 | $8.44 | $113 | 3.1 |

*Increased safety of automatic block signals.*

The reduced cost of accidents on single-track divisions of two railroads, average for 5-10 years, effected by automatic block signals, averaged $190 to $206 per mile of road per year. A minimum figure of $100 per mile of road per year has been used in some economic reports.

This item will vary on different railroads due to the methods of previous train operation, traffic conditions, open or mountainous territory, amount of obscured view, weather conditions, curves or tangent track conditions, and local conditions peculiar to each installation. The reduced cost of accidents will sometimes offset the cost of maintenance and operation of the automatic block signals.

Automatic block signals will show increased safety of train operation and also intangible savings by providing the following:

1. Protection against accidents due to track being occupied, open switch points, cars fouling main track, derails out of normal position, broken rails and, in some cases, slides.
2. An approach indication, facilitating train operation at meeting and passing points.
3. Improved service to the shippers and traveling public.
4. Increased capacity.
5. Postponement of more costly alternative improvements.
6. Easing of the mental strain on dispatchers, enginemen, trainmen, signalmen and others.
7. An advertising value.

The value of these intangible savings and operating benefits which should be credited to the automatic block system cannot always be ascertained but they are of economic value.

The Signal Section, A.A.R., conclusion and findings on Automatic Block Signals are as follows:

*Conclusion.*

Automatic block signals are recommended as an economic means to be considered for reducing operating expenses by increasing track capacity and improving train operation where manual block, train staff or time interval spacing of trains is in use.

*Findings.*

First cost, economy of installation and the return on the expenditure will vary with local conditions.

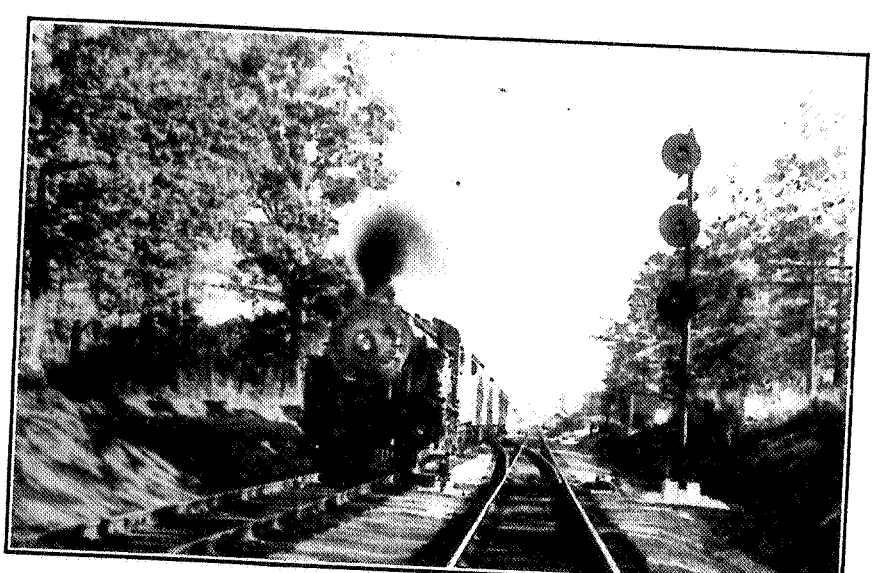
Interlockings were established to permit increased flexibility of operation so that trains could be diverted from one track to another or over railroad grade crossings without stopping. The earliest interlockings were of the mechanical type but in later years power interlockings have been more often used. The number and kinds of interlockings in service as of January 1, 1945, reported by the railroads to the Interstate Commerce Commission, Bureau of Safety, are shown in Table V.

## TABLE V

Interlockings in the United States

January 1, 1945

| | | |
|---|---|---|
| Interlockings on line of reporting railroad | | 6,629 |
| Interlockings maintained by reporting railroad | | 4,387 |
| Railroads reporting | | 245 |
| Automatic | 389 | |
| Electric | 1,435 | |
| Electro-mechanical | 425 | |
| Electro-pneumatic | 387 | |
| Mechanical | 1,693 | |
| Pneumatic | 3 | |
| Other types | 55 | |
| Total | 4,387 | |
| Remotely controlled | 486 | |



Centralized Traffic Control Controlled Interlocking Signal on Boston & Maine

The improvements in train operation following the installation of 9 interlockings on 8 railroads are shown in Table VI.

The Signal Section, A.A.R., conclusion and findings on Manually Operated Interlockings are as follows:

*Conclusion.*

Manually operated interlocking is recommended as an economic means to be considered for reducing operating expenses and expediting traffic.

*Findings.*

First cost, economy of installation and the return on the expenditure will vary with local conditions.

## TABLE VI

### Advantages of Interlocking Installations

| Railroad | Location | In service | Layout | Type machine | Lever size | Trains per day | Cost | Saving Per year | Saving Per cent | Note | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C. & O. | Lynchburg, Va. | 1925 | Crossing | E. P. | 23 | 93 | $32,182. | $14,101 | 43.8 | 1 | 11 |
| C. & O. | Russell, Ky. | 1925 | Yard | E. P. | 24 | 100 | 14,500 | 13,709 | 94.5 | | 12 |
| C. & A. | Delavan, Ill. | 1929 | Crossing | Mech. | 24 | 30 | 27,000 | | | 2 | 10 |
| C. St. P. M. & O. | Lakeland Jct., Minn. | 1931 | Crossing | Elec. | 7 | 27 | 13,000 | 10,000 | 77 | 3 | 13 |
| D. & H. | Albany, N. Y. | 1930 | Junction | Elec. | 4 | 100 | 8,242 | 5,500 | 67 | | 14 |
| I. U. T. | Indianapolis, Ind. | 1931 | Terminal | E. P. | 111 | 200 | 360,000 | | | 4 | 15 |
| N. Y. C. | E. E. Gibson Yard, Ind. | 1927 | Yard | Elec. | 30 | 500 | 57,200 | 12,858 | 22.5 | | 1 |
| N. P. | Tacoma, Wash. | 1929 | Junction | Mech. | 32 | 75 | 32,000 | 7,000 | 21.8 | | 16 |
| P. & L. E. | Beck's Run, Pa. | 1929 | Yard | Elec. | 38 | 60 | 96,343 | 87,450 | 90.7 | | 17 |
| Total of 7 of the above 9 installations | | | | | | | $253,467 | $150,618 | 59.4 | | |

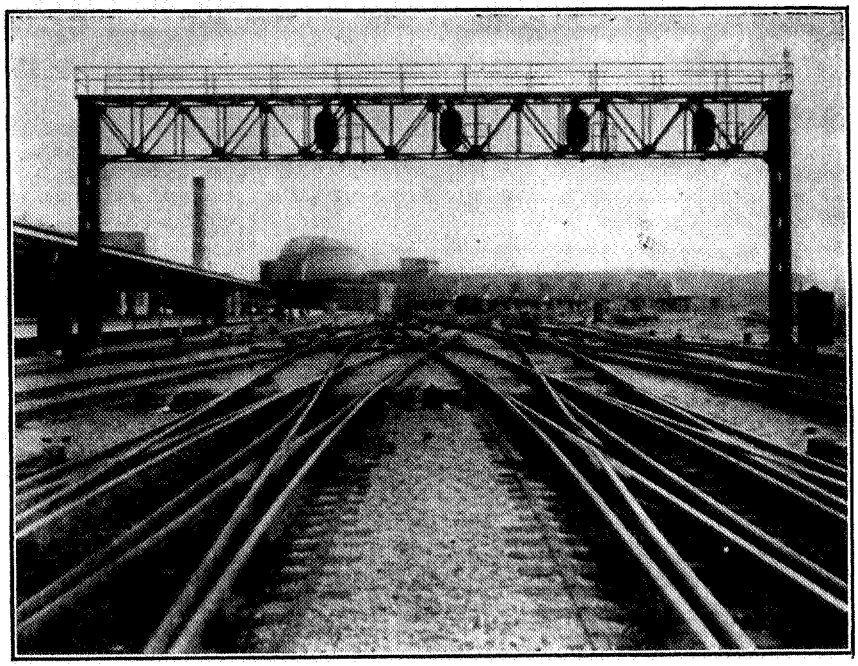
* For publication references, see p. 88.

*Note* 1. Reporting railroad only. Saved over 29,400 train stops yearly.

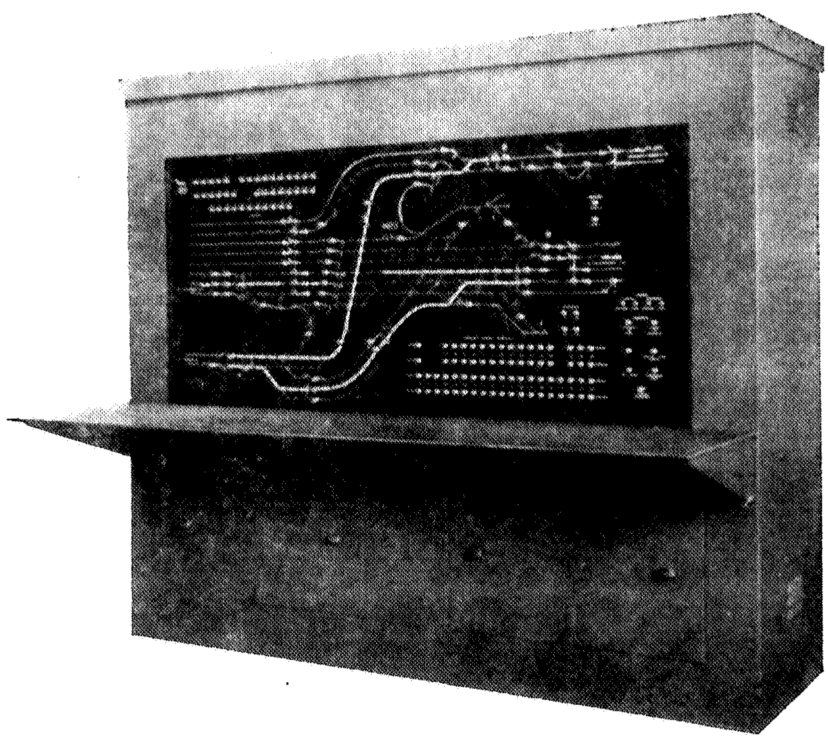
2. Saved 6,000 train stops yearly.

3. Saved over 20,000 train stops yearly.

4. Savings exceeded interest, depreciation and maintenance.



Interlocking Signals on Cincinnati Union Terminal



"UR" Interlocking Machine on Central of New Jersey

In recent years there has been a tendency to consolidate interlockings in order to reduce operating expenses and centralize the direction of train movements. Examples of this practice and the operating advantages of 29 installations on 11 railroads are shown in Table VII.

The Signal Section, A.A.R., conclusion and findings on Consolidation of Interlockings are as follows:

*Conclusion.*

Consolidation of interlockings is recommended as an economic means to be considered for reducing operating expenses and avoiding the expense of duplicate buildings.

*Findings.*

First cost, economy of installation and the return on the expenditure will vary with local conditions.

## TABLE VII

### Advantages of Consolidation of Interlockings

| Railroad | Location | In service | No. of inter-lockings | Type machine | Lever size | Trains per day | Cost | Saving Per year | Saving Per cent | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|---|---|
| A. T. & S. F. | Galveston, Tex. | 1928 | 3 | E. P. | 87 | 135 | $35,000 | $14,000 | 40.0 | 18 |
| B. & M. | Salem, Mass. | 1928 | 2 | E. M. | 12 | 170 | 37,200 | 6,102 | 16.5 | 19 |
| B. & M. | Salem, Mass. | 1935 | 3 | T. L. | 12 | 70 | | | | 228 |
| C. R. R. of N. J. | Elizabethport, N. J. | 1938 | 3 | Route | 54 | 500 | | | | 229 |
| C. & O. | Alleghany, Va. | 1936 | 3 | C. T. C. | 44 | 40 | | | | 230 |
| C. & N. W. | Nelson, Ill. | 1930 | 2 | Elec. | 10 | 58 | 30,000 | 3,615 | 12.0 | 165 |
| C. & N. W. | Boone, Iowa | 1931 | 2 | Elec. | 4 | 36 | 14,715 | 4,592 | 31.2 | 166 |
| C. & N. W. | Des Plaines, Ill. | 1933 | 2 | Elec. | 12 | 80 | 31,000 | 4,240 | 13.7 | 167 |
| C. B. & Q. | Lincoln, Nebr. | 1930 | 2 | Elec. | 88 | 54 | 153,430 | 24,667 | 16.0 | 20 |
| C. B. & Q. | Lincoln, Nebr. | 1929 | 2 | Elec. | 4 | 24 | 20,525 | 4,363 | 21.2 | 21 |
| C. M. St. P. & P. | Bensonville, Ill. | 1933 | 2 | C. T. C. | 6 | 40 | 14,121 | 4,660 | 33.0 | 168 |
| C. M. St. P. & P. | Techny, Ill. | 1933 | 2 | C. T. C. | 6 | 40 | 13,272 | 6,105 | 46.0 | 168 |
| N. C. & St. L. | Howell, Ga. | 1928 | 2 | Elec. | 107 | 480 | 10,057 | 4,995 | 49.6 | 22 |
| N. Y. C. | Stanley, Ohio | 1928 | 2 | Elec. | 152 | 180 | 211,000 | 39,424 | 18.7 | 23 |
| N. Y. C. | Albany, N. Y. | 1933 | 2 | E. M. | 40 | 144 | 3,500 | 6,000 | 171.4 | 169 |
| N. Y. N. H. & H. | Readville, Mass. | 1936 | 3 | E. M. | 35 | 165 | | | | 231 |
| N. Y. N. H. & H. | Bridgeport, Conn. | 1938 | 4 | Elec. | 27 | 170 | | | | 232 |
| P. R. R. | Aspinwall, Pa. | 1923 | 3 | E. P. | 51 | 150 | 203,000 | 36,691 | 18.0 | 24 |
| P. R. R. | Birdsboro, Pa. | 1929 | 3 | Elec. | 20 | 36 | 59,139 | 14,253 | 24.1 | 25 |
| P. R. R. | Bullis Mills, N. Y. | 1929 | 3 | Elec. | 7 | 30 | 24,142 | 10,799 | 44.7 | 26 |
| P. R. R. | Crosscut, Pa. | 1929 | 2 | E. M. | 4 | 46 | 14,202 | 5,206 | 36.6 | 27 |

(Concluded on next page)

## TABLE VII—Concluded

| Railroad | Location | In service | No. of inter-lockings | Type machine | Lever size | Trains per day | Cost | Saving Per year | Saving Per cent | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|---|---|
| P. R. R. | Denholm, Pa. | 1929 | 4 | E. M. | 6 | 33 | $35,366 | $10,580 | 29.9 | 28 |
| P. R. R. | Enola, Pa. | 1930 | 2 | Elec. | 5 | 95 | 17,000 | 5,331 | 31.3 | 29 |
| P. R. R. | Kouts, Ind. | 1930 | 2 | Elec. | 6 | 60 | 24,802 | 5,890 | 23.7 | 30 |
| P. R. R. | Laurel Hill, Pa. | 1929 | 2 | E. M. | 59 | 78 | 13,927 | 5,862 | 42.0 | 31 |
| P. R. R. | New Portage, Pa. | 1929 | 2 | E. M. | 32 | 25 | 5,649 | 5,726 | 101.0 | 32 |
| P. R. R. | Rich, Pa. | 1929 | 2 | T. L. | 4 | 58 | 20,039 | 4,770 | 23.8 | 170 |
| P. R. R. | Mohican, Pa. | 1931 | 2 | C. T. C. | 7 | 67 | 23,099 | 5,203 | 22.5 | 171 |
| P. R. R. | Delair, N. J. | 1938 | 4 | C. T. C. | 60 | 81 | 119,275 | 13,197 | 11.1 | 233 |
| Total of 24 of the above 29 installations | | | | | | | $1,133,460 | $246,271 | 21.7 | |

* For publication references, see p. 88.

## AUTOMATIC INTERLOCKINGS

Automatically controlled signals and other signaling devices for the protection of train movements over railroad grade crossings and other simple layouts have come into considerable prominence since 1923, 243 installations being made on 40 railroads in 34 states between the years 1925 and 1930. These installations operate upon the approach of a train and have been called "automatic interlockings."* As of January 1, 1945, there were 389 automatic interlockings in service.

This type of signaling not only eliminates the necessity for attendants for operation of the interlocking, but also the interlocking machine, other interlocking appliances, the interlocking station and other buildings, and in addition saves the yearly cost of maintaining and operating these facilities. The first installations were brought about by the necessity for providing an economic means of eliminating statutory stops for non-interlocked railroad grade crossings on light traffic lines. They have been installed for signal protection of gauntlet tracks over bridges and through tunnels, at junctions of branch lines with main lines, at ends of two main tracks, and at single and multiple track crossings.

The operating advantages of 81 automatic interlockings on 26 railroads are shown in Table VIII.

The costs of the automatic interlockings shown in Table VIII show a wide spread due to the differences in the types of installations and the fact that in many cases the installations replaced existing manually operated interlockings. In one case it was found that saving two train stops per day, and in another case a time saving of 14 minutes per day, would pay the annual charges on an automatic interlocking.

The Signal Section, A.A.R., conclusion and findings on Automatic Interlockings are as follows:

*Conclusion.*

Automatic interlockings replacing manually operated interlockings at railroad grade crossings, gauntlets, or junctions, or replacing non-interlocked arrangements is recommended as an economic means to be considered for reducing operating expenses and expediting traffic.

*Findings.*

First cost, economy of installation and the return on the expenditure will vary with local conditions.

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* For automatic interlocking report see A.R.A. Signal Section 1931 Proceedings, Vol. XXIX, pp. 58, 449.

## TABLE VIII

### Advantages of Automatic Interlockings

| Railroad | Location | In service | Type layout† | Trains per day | Cost | Saving Per year | Saving Per cent | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|
| A. & S. | E. St. Louis, Ill. | 1933 | S. T. Crossing | 30 | $15,850 | $5,700 | 36 | 172 |
| A. T. & S. F. | Camp, Okla. | 1929 | S. T. Crossing | 15 | 6,866 | 4,898 | 71 | 33 |
| A. T. & S. F. | Lost Springs, Kans. | 1929 | S. T. Crossing | 28 | 13,277 | 16,864 | 127 | 33 |
| A. T. & S. F. | Marion, Kans. | 1929 | S. T. Crossing | 28 | 8,703 | 15,088 | 173 | 33 |
| A. T. & S. F. | Nadeau, Calif. | 1930 | S. T.-T. M. T. Crossing | 24 | 5,600 | 5,064 | 90 | 234 |
| A. T. & S. F. | Burrton, Kans. | 1937 | S. T.-T. M. T. Crossing | 26 | 12,829 | 5,500 | 43 | 235 |
| B. & O. C. T. | Hammond, Ind. | 1930 | Gauntlet | 20 | 2,800 | 5,551 | 198 | 34 |
| B. & O. C. T. | 4 Interlockings | 1932 | S. T. Crossing | Swtg. | 18,680 | 7,184 | 39 | 173 |
| B. M. T. | Brooklyn, N. Y. | 1934 | Junction | 496 | 15,000 | 4,261 | 28 | 174 |
| B. R. T. | Brooklyn, N. Y. | 1923 | End T. M. T. | 335 | 2,300 | 4,300 | 187 | 35 |
| C. N. | St. Augustin, Que., Can. | 1925 | S. T. Crossing | 16 | 12,389 | 4,637 | 37 | 236 |
| C. N. | Lachevrotiere, Que., Can. | 1936 | S. T. Crossing | 36 | 11,101 | 5,521 | 50 | 237 |
| C. N. | Coniston, Ont., Can. | 1936 | S. T. Crossing | 12 | 9,326 | 3,631 | 39 | 238 |
| C. P. | Komoka, Ont., Can. | 1934 | S. T.-T. M. T. Crossing | 49 | 14,600 | 4,416 | 30 | 175 |
| C. & A. | Streator, Ill. | 1929 | S. T. Crossing | 22 | 10,487 | 3,000 | 29 | 36 |
| C. & A. | 4 Interlockings | 1931–32 | S. T. Crossing | 14 | 24,500 | 21,000 | 86 | 176 |
| C. & E. I. | Sullivan, Ind. | 1928 | S. T. Crossing | 50 | 11,600 | 12,000 | 103 | 37 |
| C. B. & Q. | Forman, Ill. | 1933 | S. T. Crossing | 20 | 4,523 | 1,619 | 36 | 177 |
| C. G. W. | Waverly, Iowa | 1927 | S. T. Crossing | 16 | 6,500 | 5,000 | 77 | 38 |

(Continued on next page)

† Abbreviations:
S. T. =Single track
T. M. T.=Two main tracks

* For publication references, see p. 88.

TABLE VIII—Continued

| Railroad | Location | In service | Type layout† | Trains per day | Cost | Saving Per year | Saving Per cent | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|
| C. G. W. | Rochester, Minn. | 1931 | S. T. Crossing | 14 | $10,500 | $2,400 | 23 | 178 |
| C. G. W. | Wilkinson, Ill. | 1935 | S. T. Crossing | 13 | 7,065 | 5,724 | 81 | 239 |
| C. M. St. P. & P. | 22 Interlockings | 1921–28 | S. T.-T. M. T. Crossing | 20 | 132,000 | 92,400 | 70 | 39 |
| C. M. St. P. & P. | Sinclair, Mont. | 1936 | S. T. Crossing | 15 | 8,732 | 3,405 | 39 | 240 |
| C. R. I. & P. | Laurens, Iowa | 1926 | S. T. Crossing | 12 | 5,000 | 4,500 | 90 | 40 |
| C. R. I. & P. | Pleasant Hill, Mo. | 1929 | S. T. Crossing | 29 | 5,500 | 4,500 | 82 | 41 |
| C. R. I. & P. | Hampton, Iowa | 1936 | S. T. Crossing | 20 | 8,313 | 5,081 | 61 | 241 |
| G. N. | Wayzata, Minn. | 1927 | T. M. T. Junction | 25 | 11,118 | 5,000 | 45 | 45 |
| G. N. | Barnesville, Minn. | 1929 | S. T. Junction | 16 | 5,800 | 2,310 | 40 | 46 |
| G. N. | Pacific Jct., Mont. | 1928 | Junction | 18 | 3,700 | 5,400 | 146 | 179 |
| G. N. | Lohman, Mont. | 1928 | End T. M. T. | 18 | 1,280 | 2,888 | 226 | 180 |
| G. N. | Atwater and Pennock, Mont. | 1933 | Ends T. M. T. | 14 | 1,540 | 3,058 | 199 | 181 |
| I. C. | Scotland, La. | 1936 | S. T. Crossing | 21 | | | | 242 |
| I. C. | Springfield, Ill. | 1937 | T. M. T. Crossing | 31 | 6,080 | 4,450 | 73 | 243 |
| I. C. | El Paso, Ill. | 1937 | S. T. Crossing | 12 | 12,600 | | | 244 |
| L. & N. | Nashville, Tenn. | 1929 | Gauntlet | 40 | 3,846 | 5,000 | 130 | 42 |
| M. & St. L. | 3 Interlockings | 1930 | S. T. Crossing | 32 | 30,000 | 16,000 | 53 | 43 |
| N. Y. C. | Raisin Center, Mich. | 1927 | S. T.-T. M. T. Crossing | 38 | 11,560 | 2,181 | 19 | 44 |
| N. P. | Philbrook, Minn. | 1933 | End T. M. T. | 13 | 4,000 | 3,600 | 90 | 182 |
| S. N. | Sankey, Calif. | 1933 | S. T. Crossing | 18 | 19,782 | 2,651 | 13 | 183 |
| St. L.-S. F. | Ft. Scott, Kans. | 1936 | S. T. Crossing | 26 | 4,045 | | | 245 |
| St. L.-S. F. | Ardath, Kans. | 1936 | S. T. Crossing | 20 | 3,195 | 4,665 | 146 | 245 |
| St. L.-S. F. | Winfield, Kans. | 1937 | S. T.-T. M. T. Crossing | 24 | 11,500 | | | 246 |
| St. L.-S. F. | Liberal, Mo. | 1939 | S. T. Crossing | 15 | 8,179 | 3,910 | 48 | 247 |

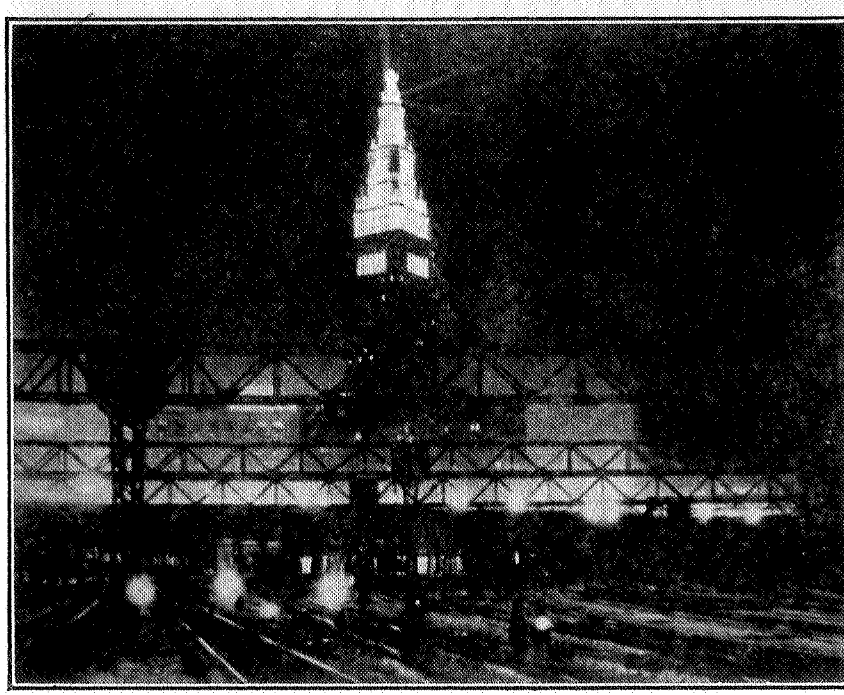
(Concluded on next page)

## TABLE VIII—Concluded

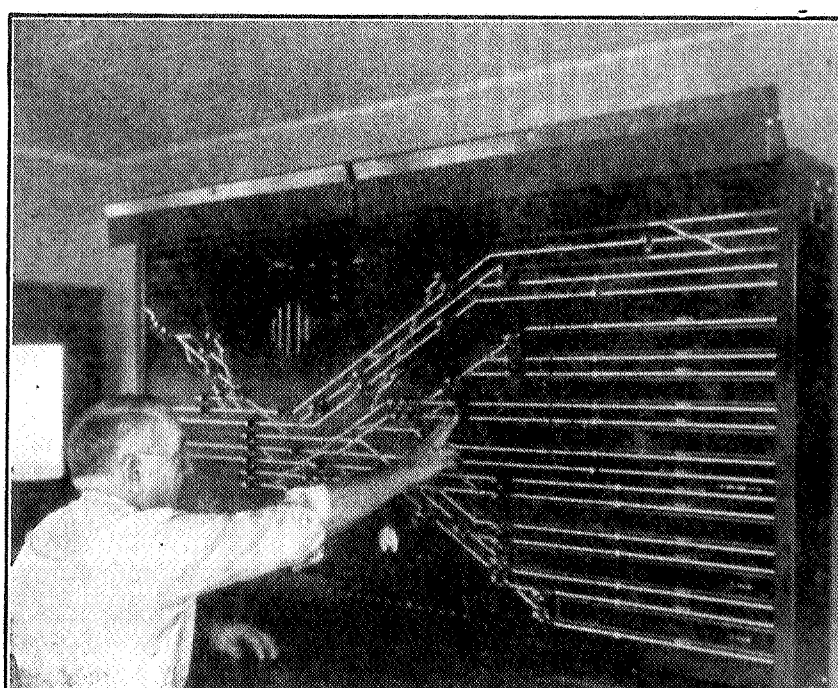
| Railroad | Location | In service | Type layout† | Trains per day | Cost | Saving Per year | Saving Per cent | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|
| S. A. L. | Center Hill, Fla. | 1935 | S. T. Crossing | 16 | | | | 248 |
| S. A. L. | Mabel, Fla. | 1935 | S. T. Crossing | 10 | | | | 248 |
| T. & N. O. | LaRosen, La. | 1934 | S. T. Crossing | 19 | $2,139 | $3,610 | 169 | 249 |
| T. & P. | Paris, Tex. | 1933 | S. T. Crossing | 12 | | | | 250 |
| T. & P. | Texarkana, Ark. | 1936 | S. T. Crossing | 40 | | | | 251 |
| T. & O. C. | Charleston, W. Va. | 1919 | Gauntlet | 30 | 1,650 | 8,145 | 493 | 47 |
| Wabash | Steubenville, Ind. | 1929 | S. T. Crossing | 28 | 18,334 | 5,000 | 27 | 48 |
| Wabash | Moravia, Iowa | 1934 | S. T. Crossing | 18 | 7,792 | 3,245 | 42 | 184 |
| Total of 73 of the above 81 installations | | | | | $524,036 | $334,357 | 63.8 | |

† Abbreviations:
S. T. =Single track
T. M. T.=Two main tracks

* For publication references, see p. 88.



Interlocking at Cleveland Union Terminal



"NX" Interlocking Machine on New York Central

Since the first installation of train operation by signal indication without train orders was made on 5.5 miles of single track and 2.5 miles of two main tracks in 1882, the number and types of installations have increased until January 1, 1945, when there were 42,116.9 miles of track on 98 railroads, as shown in Table IX.

The three methods of directing train movements are:

1. By time-table and train orders.
2. By time-table, train orders and block signals.
3. By time-table and signal indications.

In the first two methods using time-table and train orders, the train order plays the leading part, particularly in directing train movements on single track.

In the signal indication method of directing train movements, the following Standard Code rules, or similar rules, apply:

251. On portions of the railroad, and on designated tracks so specified on the time-table, trains will run with reference to other trains in the same direction by block signals whose indications will supersede the superiority of trains.

261. On portions of the railroad, and on designated tracks so specified on the time-table, trains will be governed by block signals whose indications will supersede the superiority of trains for both opposing and following movements on the same track.

## TABLE IX

Installations of Train Operation by Signal Indication*
without Train Orders, in the United States
January 1, 1945

| Method of directing trains | No. of railroads | Miles of Road | Miles of Track |
|---|---|---|---|
| One-direction operation by signal indication: | | | |
| (a) Centralized traffic control | 8 | 130.3 | 195.5 |
| (b) Manual block | 13 | 2,178.4 | 3,005.9 |
| (c) Controlled manual block | 2 | 7.7 | 9.5 |
| (d) Automatic block | 56 | 13,408.3 | 29,796.3 |
| Either-direction operation by signal indication: | | | |
| (e) Centralized traffic control | 56 | 4,961.9 | 5,663.4 |
| (f) Controlled manual block | 19 | 271.5 | 279.9 |
| (g) Automatic block in both directions | 47 | 1,991.1 | 2,717.4 |
| (h) Automatic block in one direction, traffic locking, reverse direction | 25 | 236.5 | 449.0 |
| Total reported by 98 railroads | | 23,185.7 | 42,116.9 |

* Interstate Commerce Commission, Bureau of Safety.

A study of the methods of directing train movements as shown in Table IX shows a wide application of signal indication operation without train orders by the following methods:

Centralized traffic control
Manual block
Controlled manual block
Automatic block in one or both directions
Automatic block in one direction, traffic locking, reverse direction

Twenty-six examples of the operating advantages of train operation by signal indication on single and multiple track lines of 20 railroads are shown in Table X.

Train operation by signal indication is applicable to a variety of tracks and operating conditions for expediting traffic. While a large percentage of the installations has been made on single and two main track lines, it has also been installed on three, four and five track lines. On 10 of the installations, the increased capacity deferred the necessity of providing additional trackage, thus effecting substantial savings in both construction and maintenance costs, and made it possible to utilize the existing trackage to a greater capacity for a smaller investment. The cost of installation depends on whether automatic block signals and track changes are included, the signaling required at interlockings, and local conditions.

These installations have been made to improve railroad operation by:

1. Reducing delays caused by:
   (a) Fleeting of trains causing congestion of traffic during certain periods of the day.
   (b) Congestion on grades.
   (c) Congested sections of track, affecting train operation over entire divisions.
   (d) Train stops entering and leaving sidings.
   (e) Meeting of trains.
   (f) Interference with yard switching.
   (g) Interference with roadway repairs and renewals.
   (h) Operation of trains by "31" orders, manual block and other methods of directing trains.
2. Providing:
   (a) Increased capacity and facilitating traffic in terminal and suburban areas.
   (b) Postponement of additional track facilities.
   (c) A higher per cent of "on-time" performance.
   (d) Faster schedules for competitive traffic.
   (e) Improved train operation through tunnels, gauntlets, and other congested sections.
   (f) Signaling for rush hour traffic conditions at a minimum expenditure.
   (g) Modern signaling for larger motive power and increased train loading.
   (h) Economical train operation.
   (i) Increased safety of train operation.
   (j) Expedited train movements thereby saving locomotives, cars, and train stops.
   (k) Reduced operating expenses due to the saving in train hours, overtime hours, train stops, locomotives and cars.

## TABLE X

### Installations of Train Operation by Signal Indication

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day | Annual saving | Per cent on investment | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|
| A. T. & S. F. | Fort Madison, Iowa—Pequot, Ill. | 1927 | 175.7 | 351.4 | 60 | .... | .... | 49 |
| | Reduced delays. Increased capacity 30 to 35 per cent. Discontinued siding extensions. | | | | | | | |
| A. T. & S. F. | Holliday—Olathe, Kans. | 1931 | 12.2 | 24.4 | 34 | .... | .... | 50 |
| | Tonnage trains saved 9 minutes in 12.2 miles. Eliminated delays due to 0.6 per cent grade. Increased track capacity and deferred third track. | | | | | | | |
| B. & O. | Millers—Orleans Road, W. Va. | 1914 | 24.3 | 24.3 | 27 | .... | .... | 51 |
| | Materially increased track capacity. Postponed fourth track. | | | | | | | |
| B. & O. | Rosemont—Parkersburg, W. Va. | 1929 | 89.2 | 89.2 | 40 | .... | .... | 52 |
| | Reduced train ord.rs 1,000 per month. Eliminated train stops at sidings. Facilitated train operation. | | | | | | | |
| B. & M. | Hoosac Tunnel—North Adams, Mass. | 1928 | 6.5 | 14.5 | 65 | .... | .... | 53 |
| | Eliminated congested section of division and staff operation for reverse traffic through 5 mile tunnel. Electric operation and "fleeting" of trains caused congestion adjacent to tunnel. | | | | | | | |
| B. & M. | North Chelmsford—Ayer, Mass. | 1929 | 13.5 | 27.0 | 57 | $37,847 | .... | 54 |
| | Reduced delays, bunching of trains, yard engine interference, and increased track capacity. | | | | | | | |
| C. P. | Glacier, B. C., Can. | 1929 | 7.6 | 15.2 | 28 | .... | .... | 55 |
| | Automatic operation expedites traffic through 5 mile tunnel. | | | | | | | |
| C. of Ga. | Carman—Terre Cotta, Ga. | 1927 | 23.6 | 23.6 | 52 | $20,264 | 21 | 56 |
| | Eliminated congestion. Postponed second track. Maximum capacity 80 trains per day. | | | | | | | |

* For publication references, see p. 88.

(Continued on next page)

TABLE X—Continued

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day | Annual saving | Per cent on investment | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|
| C. & O. | Cheviot—Brighton, Ohio | 1928 | 5.0 | 5.0 | 47 | $26,209 | 101 | 57 |
| | Eliminated absolute block on 1.91 per cent grade, reducing delays, and greatly facilitated traffic. | | | | | | | |
| C. & O. | Cincinnati, Ohio—Covington, Ky. | 1929 | 3.6 | 9.2 | 178 | .... | .... | 58 |
| | Reverse traffic over two main track Ohio River Bridge and a mile section of four track eliminated delays. | | | | | | | |
| C. & O. | Scott—"DK" Cabin, W. Va. | 1923 | 28.0 | 56.0 | 80 | $6,228 | 34.6 | 59 |
| | Reduced delays and facilitated traffic. | | | | | | | |
| C. & N. W. | Des Plaines—Barrington, Ill. | 1930 | 13.5 | 13.5 | 120 | .... | .... | 60 |
| | Eliminated delays, reduced schedules 3 to 5 minutes, increased on-time performance and increased track capacity. | | | | | | | |
| C. M. St. P. & P. / C. R. I. & P. | Polo—Birmingham, Mo. | 1931 | 37.7 | 75.4 | 36 | .... | .... | 61 |
| | Either-direction signaling on new single and two main track line facilitated train operation. | | | | | | | |
| C. C. C. & St. L. | Terre Haute, Ind.—Pana, Ill. | 1928 | 97.0 | 98.5 | 34 | .... | .... | 62 |
| | Eliminated congested section on this division. Reduced time 45 minutes on EB and 15 minutes on WB freights. Postponed second main track and increased capacity 15 per cent. | | | | | | | |
| D. L. & W. | West End—Millburn, N. J. | 1923 | 15.3 | 15.3 | 260 | .... | .... | 63 |
| | Expedited trains and improved on-time performance. | | | | | | | |
| D. & R. G. W. | Helper—Colton, Utah | 1929 | 25.0 | 50.0 | 49 | .... | .... | 64 |
| | Eliminated delays on 2.4 per cent grade, expedited train movements and increased track capacity. | | | | | | | |
| Erie | Tusten—Lackawaxen, N. Y. | 1931 | 9.5 | 19.0 | 42 | .... | .... | 65 |
| | Reduced delays, expedited preference trains and increased track capacity. | | | | | | | |

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TABLE X—Concluded

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day | Annual saving | Per cent on investment | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|
| I. C. | Otto—Gilman, Ill. | 1924 | 21.0 | 42.0 | 60 | .... | .... | 66 |
| | Saved 9 to 24 minutes per freight train, postponed extra tracks and improved operation. | | | | | | | |
| M.-K.-T | Muskogee—Wybark, Okla. | 1925 | 5.0 | 5.0 | 36 | $4,500 | .... | 67 |
| | Facilitated train movements between junction point and terminal. | | | | | | | |
| M. P. | HD Jct.—Valley Park, Mo. | 1931 | 32.0 | 64.0 | 40 | .... | .... | 68 |
| | Running trains in either direction on either track is a decided operating advantage. | | | | | | | |
| M. P. | Leeds, Mo.—Osawatomie, Kans. | 1925 | 50.1 | 50.1 | 36 | .... | .... | 69 |
| | Increased average train speed 22.6 per cent and GTM per train hour 20.9 per cent. Reduced train hours and increased efficiency of train operation. | | | | | | | |
| N. C. & St. L. | Cowan—Sherwood, Tenn. | 1911 | 13.5 | 16.0 | 40 | $33,653 | .... | 70 |
| | Relieved traffic congestion and increased track capacity. | | | | | | | |
| N. Y. C. | Grand Central—Mott Haven, N. Y. | 1931 | 5.0 | 20.0 | 850 | .... | .... | 71 |
| | Reduced delays at Mott Haven Jct. and in running time of trains into Grand Central Terminal. Increased track capacity for rush hour train movements. | | | | | | | |
| N. Y. N. H. & H. | Highland—Maybrook, N. Y. | 1909 | 13.2 | 13.2 | 46 | .... | .... | 72 |
| | Reduced freight train hours and overtime. Deferred second main track. | | | | | | | |
| P. R. R. | Louisville Bridge, Ky. | 1882 | 8.0 | 10.5 | 87 | .... | .... | 73 |
| | Successful 50 year operation reduced delays, eliminated train orders and facilitated traffic. | | | | | | | |
| P. R. R. | Spruce Creek—Tyrone Forge, Pa. | 1913 | 6.8 | 6.8 | 35 | .... | .... | 74 |
| | Increased capacity 25 per cent, reduced congestion and postponed fourth track. | | | | | | | |

* For publication references, see p. 88.

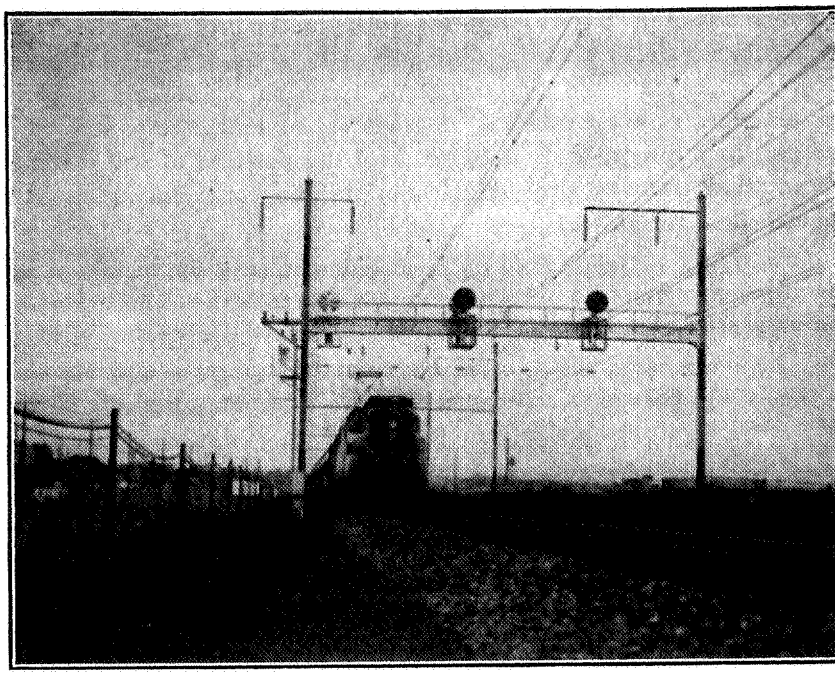
The Signal Section, A.A.R., conclusion and findings on Train Operation by Signal Indication are as follows:

*Conclusion.*

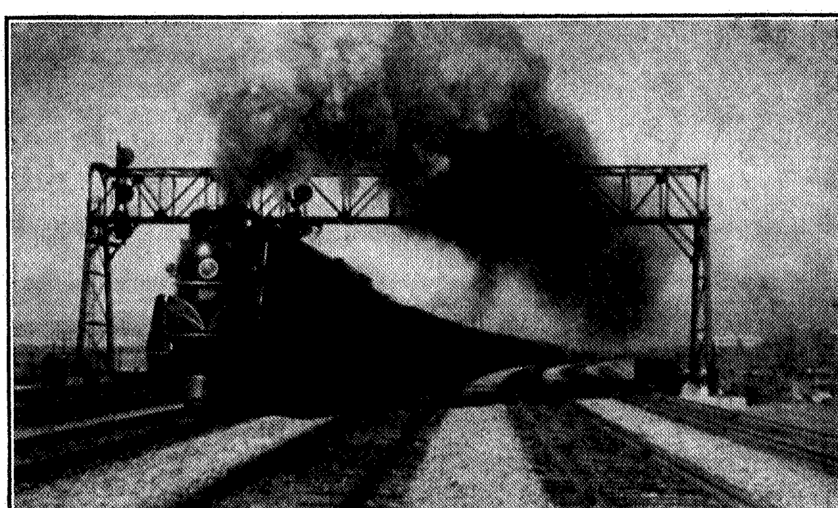
The operation of trains by signal indication on single or multiple-track lines is recommended as an economic method to be given consideration for the possible postponement of expenditures for additional trackage and reducing operating expenses by relieving congestion, increasing track capacity, improving train operation and eliminating written train orders.

*Findings.*

First cost, economy of installation and the return on the expenditure will vary with local conditions.



Signals in Electrified Territory on Pennsylvania

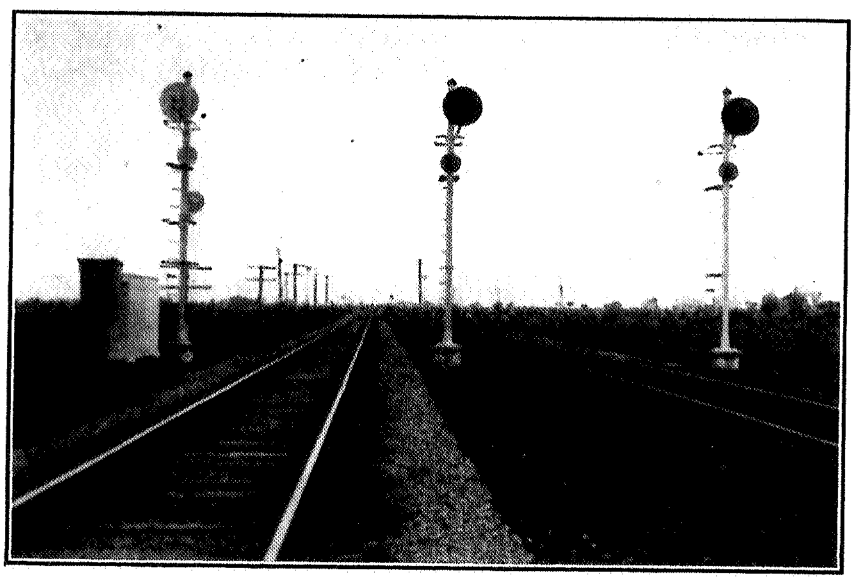


Signals on Canadian National

Remote control is a term applied to a method of operating outlying signal appliances from a designated point. It is used to advantage where switches are located some distance from a station, at an end of two main tracks, junction, railroad crossing at grade, or at entrance to a yard where an operator at a nearby station can control the position of the switches and signals to allow trains to proceed without stopping or reducing speed below that specified in the rules.

While outlying switches may be operated manually by trainmen, switchmen or other designated employees, remote control shows the lowest annual cost of operation. The economic value of operating outlying switches by remote control is dependent upon the cost of stopping and starting the trains that could pass over controlled switches without stopping. It becomes economically advantageous to remote control an outlying switch when the cost of stopping and starting the trains or the payroll saving is greater than the fixed and operating charges accruing from the installation.

The number of remote control installations in service on January 1, 1945 was 486.



Remote Control Signals on Wabash

The time saved per train stop eliminated at an outlying switch location will vary with the train, grade, and other local conditions. The average time saved per freight train stop eliminated in a number of reports is shown in Table XI.

TABLE XI

Time Saved per Freight Train Stop

| Railroad | Average minutes saved per freight train stop | Pub. ref.* |
|---|---|---|
| C. & O. | 10.0 | 77 |
| C. & O.** | 14.1 | 78 |
| C. C. C. & St. L. | 5.5–8.0 | 62 |
| I. C.** | 9.0 | 79 |
| 17 railroads | 13.24 | 80 |
| 11 railroads | 10.4 | 81 |
| 6 railroads | 10.4 | 82 |
| T. & O. C. | 8.0 | 83 |
| T. & P. | 15.0 | 84 |

While the time saved per freight train stop eliminated averaged 11.9 minutes in the 40 cases shown in Table XI, the time saved per passenger train stop eliminated varied from 2 to 5 minutes.

The cost of remote control will vary with the type and amount of signaling, depending on local conditions. The average cost per power switch on a large number of installations varied as shown in Table XII.

TABLE XII

Cost of Remote Control

| Number of remote control switches | Total cost | Cost per power switch | Pub. ref.* |
|---|---|---|---|
| 126 | $510,602 | $4,052 | 80 |
| 17 | 86,784 | 5,105 | 81 |
| 473 | 2,822,077 | 5,966 | 85 |

The advantages of 40 remote control installations on 21 railroads are shown in Table XIII.

The saving made by remote control installations is due to:

1. Reduction in delay time due to train stops eliminated.
2. Reduction in cost of train operation.
3. Reduction in cost of maintaining and operating block or interlocking stations.
4. Increased safety of train operation.
5. Increased capacity.
6. Increased on-time performance.
7. Deferring more expensive alternative improvements.

The Signal Section, A.A.R., conclusion and findings on Remote Control are as follows:

*Conclusion.*

The use of remote control for outlying signals or switches is recommended as an economic means to be considered for reducing operating expenses and expediting traffic.

*Findings.*

First cost, economy of installation and the return on the expenditure will vary with local conditions.

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* For publication references, see p. 88.

** Based on dynamometer car tests.

## TABLE XIII

Advantages of Remote Control

| Railroad | Location | In service | Type layout† | No. of switches | Type machine† | Trains per day | Cost | Saving Per year | Saving Per cent | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|---|---|
| A. T. & S. F. | Neva, Kan. | 1933 | Junction | 6 | C. T. C. | 43 | $22,426 | $5,300 | 23.6 | 185 |
| B. & A. | Brookline Jct., Mass. | 1932 | Junction | 2 | C. T. C. | 120 | 25,000 | 6,000 | 24.0 | 186 |
| C. P. | Vaudreuil, Que., Can. | 1933 | Junction | 3 | C. T. C. | 40 | 18,000 | 2,400 | 13.3 | 187 |
| C. P. | Cobourg, Ont., Can. | 1934 | Crossing | 2 | C. T. C. | 30 | 7,500 | 4,729 | 63.0 | 188 |
| C. P. | Delson, Que., Can. | 1935 | Crossing | 6 | C. T. C. | 32 | 31,000 | 5,611 | 18.1 | 252 |
| C. P. | Montreal, Que., Can. | 1935 | Yard | 5 | C. T. C. | 195 | 21,000 | 4,482 | 20.7 | 253 |
| C. of Ga. | Americus, Ga. | 1926 | End T. M. T. | 4 | T. L. | 37 | 10,425 | 3,756 | 36.0 | 86 |
| C. of Ga. | Americus, Ga. | 1930 | End T. M. T. | 4 | T. L. | 27 | 404 | 2,418 | 591.0 | 86 |
| C. of Ga. | Griffin, Ga. | 1929 | End T. M. T. | 4 | T. L. | 35 | 16,306 | 3,997 | 24.5 | 87 |
| C. & O. | Balcony Falls, Va. | 1925 | End T. M. T. | 1 | T. L. | 24 | 11,607 | 8,370 | 72.1 | 77 |
| C. & O. | East Clayton, Ohio | 1930 | End T. M. T. | 1 | T. L. | 13 | 14,570 | 4,774 | 32.7 | 75 |
| C. & O. | Greenway, Va. | 1932 | End T. M. T. | 1 | C. T. C. | 16 | 11,000 | 5,000 | 45.5 | 189 |
| C. & O. | Edgington, Ky. | 1935 | Junction | 5 | C. T. C. | 50 | | | | 254 |
| C.C.C.&St.L. | DeGraff, Ohio | 1932 | Sidings | 8 | C. T. C. | 33 | 36,000 | 6,000 | 16.7 | 190 |
| C. & N. W. | Chaldron, Nebr. | 1929 | Junction | 1 | C. T. C. | 26 | 37,200 | 14,465 | 38.9 | 88 |
| C. & N. W. | Green Bay, Wis. | 1929 | Junction | 4 | C. T. C. | 32 | 27,500 | 31,855 | 115.8 | 89 |
| C. B. & Q. | Concord, Ill. | 1928 | Ends T. M. T. | 2 | C. T. C. | 26 | 26,000 | 7,128 | 27.4 | 90 |
| C. B. & Q. | Lincoln, Nebr. | 1929 | Crossing | 5 | C. T. C. | 28 | 17,664 | 4,396 | 24.9 | 91 |
| C. G. W. | Rice, Ill. | 1931 | End T. M. T. | 2 | C. T. C. | 24 | 18,000 | 7,000 | 38.9 | 92 |
| L. & N. | Montfort, Tenn. | 1936 | End T. M. T. | 1 | C. T. C. | 30 | 8,628 | 4,980 | 57.7 | 255 |
| L. & N. | Maplewood, Tenn. | 1936 | Junction | 4 | C. T. C. | 60 | 9,334 | 5,157 | 55.2 | 255 |
| L. & N. | Birmingham, Ala. | 1935 | Yard | 4 | C. T. C. | 34 | 9,018 | 5,627 | 62.4 | 256 |
| M. C. | Rochester Jct., Mich. | 1930 | Crossing | 0 | P. B. | 22 | 17,900 | 5,000 | 27.9 | 93 |

(Concluded on next page)

TABLE XIII—Concluded

| Railroad | Location | In service | Type layout† | No. of switches | Type machine† | Trains per day | Cost | Saving Per year | Saving Per cent | Pub. ref.* |
|---|---|---|---|---|---|---|---|---|---|---|
| M. C. | Kalamazoo, Mich. | 1937 | Yard | 2 | C. T. C. | 30 | $11,127 | $5,490 | 49.3 | 257 |
| M. P. | Harviell, Mo. | 1932 | End T. M. T. | 1 | Knife sw. | 25 | 5,100 | 5,000 | 98.0 | 191 |
| M. P. | Cliff Cave, Mo. | 1933 | End T. M. T. | 1 | Knife sw. | 25 | 6,500 | 5,500 | 84.6 | 192 |
| M. P. | Chester, Ill. | 1933 | Lap siding | 5 | C. T. C. | 36 | 13,000 | 4,966 | 38.2 | 193 |
| N. C. & St. L. | Stevenson, Ala. | 1923 | End T. M. T. | 1 | T. L. | 24 | 6,277 | 8,894 | 141.7 | 94 |
| N. & W. | North Roanoke, Va. | 1928 | End T. M. T. | 2 | C. T. C. | 16 | 15,000 | 4,400 | 29.3 | 95 |
| N. P. | Muir, Mont. | 1933 | Tunnel | 2 | T. L. | 32 | 9,438 | 5,284 | 56.0 | 194 |
| P. R. R. | Big Elk, Del. | 1936 | Begin 4 Tr. | 1 | C. T. C. | 110 | 30,045 | 6,200 | 20.6 | 258 |
| P. R. R. | North East, Md. | 1936 | End 3 Tr. | 5 | C. T. C. | 110 | 76,795 | 6,200 | 8.1 | 258 |
| P. R. R. | Winans, Md. | 1936 | Begin 4 Tr. | 5 | C. T. C. | 110 | 85,307 | 6,200 | 7.3 | 258 |
| P. R. R. | Oakington, Md. | 1937 | End 4 Tr. | 5 | C. T. C. | 100 | 28,831 | 6,200 | 21.5 | 259 |
| Reading | Bethayres, Pa. | 1937 | Crossing | 0 | C. T. C. | 79 | 9,977 | 6,544 | 65.6 | 260 |
| St. L.-S. F. | Edward, Kans. | 1935 | Junction | 4 | C. T. C. | 28 | 14,699 | 1,896 | 12.9 | 261 |
| T. & N. O. | West Jct., Tex. | 1930 | Junction | 2 | C. T. C. | 16 | 13,000 | 5,700 | 43.8 | 195 |
| T. & O. C. | Centerburg, Ohio | 1922 | End siding | 1 | T. L. | 20 | 5,100 | 4,712 | 92.4 | 83 |
| U. P. | Menoken, Kans. | 1936 | Junction | 1 | T. L. | 34 | | | | 262 |
| U. P. | Salt Lake City, Utah | 1938 | Crossing | 0 | C. T. C. | 25 | | | | 263 |
| Total of 37 of the above 40 installations | | | | | | | $726,678 | $231,631 | 31.9 | |

† Abbreviations:
T. M. T.=Two main tracks
T. L. =Table lever
P. B. =Push button

* For publication references, see p. 88.

In 1945, 57 railroads of the United States and Canada were using centralized traffic control for directing train movements and are securing operating advantages impossible to attain with other methods of dispatching trains. Since the first application of this system in 1927, there have been 321 installations and more are under construction.

Centralized traffic control makes operation by the signal indication method available to all kinds of railroad operating conditions. The advantages of this method of operation are many. The time element in the transmission of orders is practically eliminated and results in more efficient dispatching. Direct control of each train movement is made possible without dependence upon a system of control involving intermediate operators for the delivery of orders. The train order in the signal indication method is given by the signal to the engineman at the point and time desired.

Typical examples of the application of centralized traffic control are shown in Table XVII. While many installations are on short single-track sections, several installations include operating divisions up to 171 miles in length and a number of multiple-track installations are in service.* Thirteen installations, totaling 332 track miles, postponed additional trackage at an estimated cost of $18,888,500 and at a cost of $1,908,750 for annual charges.

The number of centralized traffic control installations on the various railroads in the United States and Canada, as of January 1, 1945, is shown in Table XIV.

Examples of the cost of centralized traffic control on 15 railroads are shown in Table XV.

TABLE XIV

Centralized Traffic Control Installations
in the United States and Canada
January 1, 1945

| Railroad | No. of installations | Miles of | | No. of controlled | |
|---|---|---|---|---|---|
| | | Road | Track | Switches | Signals |
| Alton | 3 | 18.6 | 18.6 | .... | 14 |
| A. T. & S. F. | 9 | 261.4 | 304.3 | 131 | 353 |
| A. C. L. | 1 | 3.5 | 7.1 | 8 | 17 |
| B. & O. | 3 | 101.5 | 104.4 | 64 | 155 |
| B. & L. E. | 1 | 49.9 | 88.6 | 13 | 58 |
| B. & G. | 1 | 16.0 | 16.0 | 3 | 50 |
| B. & M. | 18 | 153.8 | 310.1 | 363 | 382 |
| C. N. | 4 | 192.5 | 220.7 | 116 | 296 |
| C. P. | 9 | 26.1 | 26.1 | 3 | 62 |
| C. of Ga. | 4 | 32.5 | 33.6 | 12 | 58 |
| C. R. R. of N. J. | 1 | 4.4 | 17.6 | 4 | 10 |
| C. & O. | 12 | 68.7 | 99.7 | 76 | 139 |
| C. & N. W. | 3 | 9.7 | 9.7 | 6 | 25 |
| C. B. & Q. | 20 | 337.0 | 366.7 | 195 | 617 |
| C. G. W. | 2 | 2.7 | 2.7 | 3 | 13 |
| C. M. St. P. & P. | 16 | 167.8 | 174.1 | 46 | 223 |
| C. R. I. & P. | 12 | 233.8 | 377.3 | 82 | 349 |

* A.R.E.A. Proceedings, Vol. 33, p. 514.

TABLE XIV—Concluded

| Railroad | No. of installations | Miles of Road | Miles of Track | No. of controlled Switches | No. of controlled Signals |
|---|---|---|---|---|---|
| D. & H. | 8 | 52.0 | 97.0 | 80 | 113 |
| D. & R. G. W. | 5 | 328.9 | 345.3 | 150 | 566 |
| D. M. & I. R. | 2 | 11.9 | 17.2 | 16 | 46 |
| Erie | 15 | 102.0 | 114.3 | 29 | 142 |
| G. T. W. | 1 | 5.3 | 5.3 | .... | 4 |
| G. M. & O. | 1 | 1.0 | 1.0 | 2 | 4 |
| I. C. | 4 | 15.5 | 18.8 | 7 | 52 |
| P. & I. | 1 | 14.8 | 14.8 | 13 | 30 |
| K. C. S. | 1 | 46.1 | 46.1 | 18 | 51 |
| L. & N. E. | 1 | 1.3 | 1.3 | 3 | 9 |
| L. V. | 2 | 12.5 | 12.5 | 2 | 13 |
| L. & N. | 7 | 288.2 | 288.2 | 78 | 359 |
| M.-K.-T. | 1 | 4.2 | 4.2 | .... | 15 |
| M.-K.-T. of T. | 3 | 10.8 | 10.8 | 4 | 29 |
| M. P. | 36 | 471.8 | 569.9 | 235 | 968 |
| Mun. Br. St. Louis | 1 | 3.4 | 6.8 | 30 | 32 |
| N. C. & St. L. | 3 | 199.7 | 204.4 | 108 | 391 |
| N. Y. C. | 1 | 40.9 | 44.2 | 33 | 75 |
| B. & A. | 2 | 15.4 | 15.4 | 12 | 32 |
| P. & L. E. | 1 | 3.1 | 6.3 | 20 | 12 |
| N. Y. C. & St. L. | 6 | 100.5 | 105.5 | 46 | 151 |
| N. Y. O. & W. | 5 | 16.7 | 16.7 | 6 | 14 |
| N. Y. S. & W. | 1 | 1.5 | 1.5 | .... | 3 |
| N. & W. | 11 | 197.2 | 227.1 | 122 | 424 |
| N. P. | 2 | 6.9 | 7.8 | 2 | 6 |
| P. R. R. | 25 | 330.9 | 358.1 | 206 | 382 |
| P. & P. U. | 1 | 7.1 | 14.2 | 20 | 31 |
| P. M. | 6 | 84.4 | 84.4 | 12 | 89 |
| Reading | 1 | 1.4 | 2.7 | 3 | 6 |
| St. L.-S. F. | 4 | 121.9 | 128.6 | 44 | 222 |
| Bir. Belt | 1 | 1.1 | 1.1 | .... | 2 |
| St. L. S. W. | 2 | 48.3 | 63.4 | 17 | 84 |
| S. A. L. | 6 | 197.5 | 212.5 | 112 | 355 |
| S. P. (Pac. Lines) | 6 | 283.4 | 285.9 | 205 | 805 |
| T. & N. O. | 8 | 39.0 | 41.3 | 82 | 136 |
| T. & P. | 13 | 145.4 | 179.5 | 64 | 323 |
| U. P. | 4 | 332.5 | 332.5 | 160 | 670 |
| Virginian | 1 | 57.8 | 57.8 | 16 | 66 |
| Wabash | 2 | 42.3 | 47.6 | 39 | 90 |
| W. P. | 1 | 60.4 | 60.4 | 32 | 95 |
| Total, 57 railroads | 321 | 5,384.9 | 6,229.7 | 3,153 | 9,718 |

During 1945, 43 installations of C. T. C. totaling 1,657.7 road miles and 1,733.6 track miles were made.*

* *Railway Age,* January 5, 1946, p. 105.

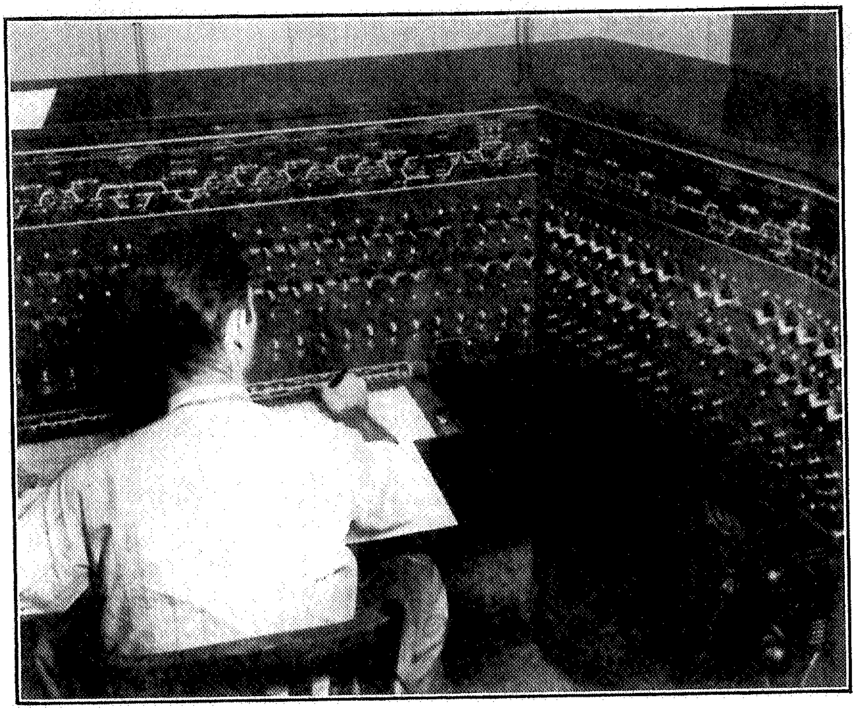
## TABLE XV

### Cost of Centralized Traffic Control

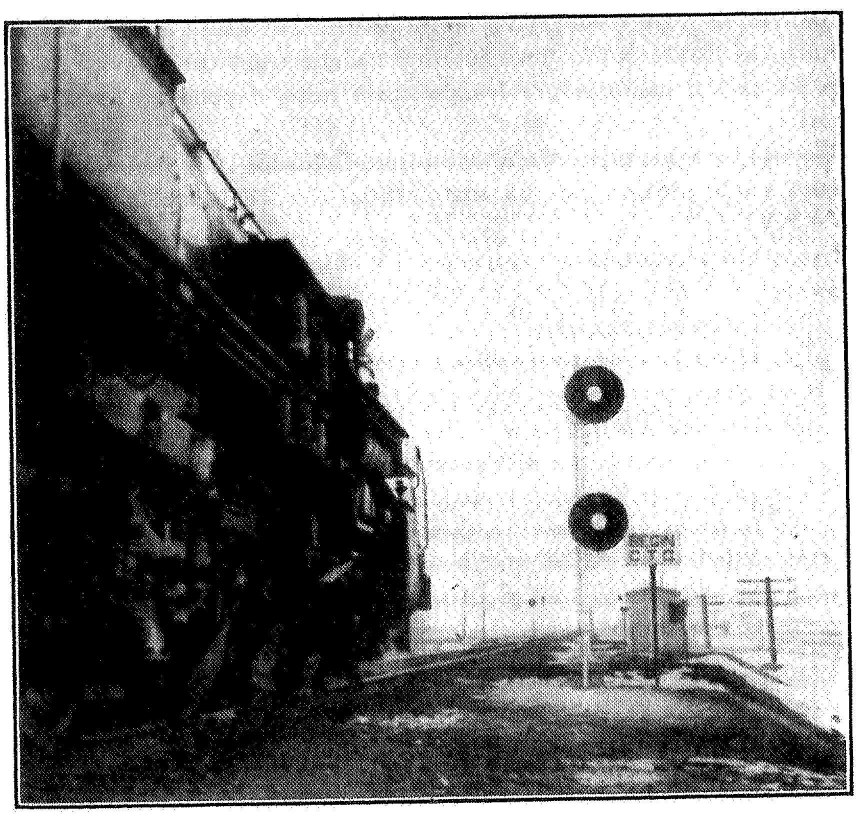
| Railroad | No. of installations | No. of C. T. C. switches | Miles of Road | Miles of Track | Total cost | Approximate Cost per mile of track | Remarks |
|---|---|---|---|---|---|---|---|
| B. & M. | 3 | 235 | 143.7 | 263.0 | $2,608,000 | $9,910 | Includes track changes. |
| C. P. | 1 | 2 | 9.0 | 9.0 | 57,600 | 6,400 | Replaced staff system. |
| C. B. & Q. | 4 | 41 | 53.0 | 75.0 | 214,810 | 2,865 | Existing automatic signals. |
| C. M. St. P. & P. | 1 | 5 | 60.0 | 60.0 | 159,126 | 2,650 | Replaced manual block. |
| D. & R. G. W. | 2 | 150 | 303.0 | 303.0 | 2,329,518 | 7,690 | Existing automatic signals. |
| G. T. W. | 1 | 0 | 5.2 | 5.2 | 5,000 | 960 | Replaced staff system. |
| I. C. | 1 | 10 | 11.5 | 23.0 | 35,000 | 1,520 | Existing signaling. |
| M. P. | 1 | 28 | 43.0 | 43.0 | 430,000 | 10,000 | Includes interlocking changes. |
| N. Y. C. & St. L. | 2 | 20 | 49.8 | 49.8 | 358,160 | 7,190 | Existing automatic signals. |
| N. Y. C. | 1 | 32 | 40.2 | 43.5 | 455,000 | 10,460 | Replaced manual block. |
| P. & I. | 1 | 13 | 15.0 | 15.0 | 130,000 | 8,660 | Replaced manual block. |
| P. R. R. | 1 | 12 | 33.0 | 36.0 | 178,750 | 4,960 | Replaced manual block. |
| P. & P. U. | 1 | 20 | 7.1 | 14.9 | 96,700 | 6,530 | Includes interlocking changes. |
| P. M. | 1 | 8 | 20.0 | 20.0 | 106,000 | 5,300 | Replaced manual block. |
| Wabash | 1 | 15 | 37.0 | 37.0 | 162,000 | 4,380 | Existing automatic signals. |
| Total | 22 | 591 | 830.5 | 997.4 | $7,325,664 | | |

Average per mile of track ........ $7,345

Average per C. T. C. switch controlled ........ $12,400



Centralized Traffic Control Machine on Union Pacific



Centralized Traffic Control Location on Chicago, Burlington & Quincy

The cost of centralized traffic control will vary, depending upon:

1. Previous method of directing trains.
2. Average spacing of sidings.
3. Changes in track facilities.
4. Changes in signaling.
5. Number of controlled signals and switches.
6. Number of switches in main track.
7. Traffic density.
8. Distribution of traffic in 24 hours.
9. Increased capacity desired.
10. Local conditions.

The cost of maintenance and operation of centralized traffic control on 5 installations on 3 railroads was reported* as follows:

| Railroad | Year | Track miles | Annual cost maintenance and operation | No. A.A.R. units | Per A.A.R. unit | Per track mile | Per cent of total cost |
|---|---|---|---|---|---|---|---|
| D. & R. G. W. | 1934 | 32 | $6,236 | 895 | $6.97 | $195 | 3.5 |
| M. P. | 1934 | 69 | 10,000 | 1,515 | 6.60 | 145 | 3.2 |
| M. P. | 1934 | 36 | 4,500 | 735 | 6.12 | 125 | 3.1 |
| M. P. | 1934 | 45 | 16,000 | 1,910 | 8.38 | 355 | 4.3 |
| Wabash | 1934 | 37 | 8,272 | 932 | 8.88 | 224 | 4.5 |
| Total | | 219 | $45,008 | 5,987 | | | |
| Average | | 43.8 | $9,002 | 1,197.4 | $7.52 | $206 | 3.8 |

The freight train time saving on 20 centralized traffic control installations is shown in Table XVI. The average freight train time saving has varied from 0.6 to 2.0 minutes per freight train mile, depending upon local conditions.

The improvements in train operation following the installation of centralized traffic control on 65 installations on 27 railroads are shown in Table XVII.

Among the advantages of centralized traffic control may be mentioned the following:

1. Increases capacity.
2. Reduces operating expenses due to the saving in locomotives, cars, train stops, train order offices and personnel, road freight train hours, and crew overtime.
3. Saves man hours and permits of a better utilization of manpower in train, locomotive and train dispatching service.
4. In many cases permits increased train loading due to power operation of siding switches.
5. Provides increased gross ton miles per train hour.
6. In some cases saves the necessity for additional main track.
7. In many cases reduces the number of sidings required for regular meets and passes.
8. The expedited train movements improve the competitive position of the railroad.

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* A.A.R. Signal Section 1936 Proceedings, Vol. XXXIV, pp. 24, 430.

9. The improved track and signaling provides increased capacity to meet sudden demands for increased traffic due to floods, detour movements, or other emergencies.

10. Increases safety of train operation.

For report on increased safety and intangible savings of centralized traffic control, see A.A.R. Signal Section 1933 Proceedings, Vol. XXXI, pp. 27 and 401.

The Signal Section, A.A.R., conclusion and findings on Centralized Traffic Control are as follows:

*Conclusion.*

Centralized traffic control for single or multiple-track operation is recommended as an economic means to be considered for postponing capital expenditure for additional trackage and reducing operating expenses by relieving congestion, increasing track capacity, improving train operation, eliminating written train orders, and providing facilities for instantly directing train movements as required.

*Findings.*

First cost, economy of installation and the return on the expenditure will vary with local conditions.

## TABLE XVI

### Freight Train Time Saving on Centralized Traffic Control

| Railroad | Location | Miles of Road | Miles of Track | Av. freight trains per day | Maximum trains per day | Av. freight train time saved per trip, mins. | Per cent time saved | Minutes saved per freight train mile |
|---|---|---|---|---|---|---|---|---|
| A. T. & S. F. | Holliday—Olathe, Kans. | 12.5 | 25.0 | 14.0 | 34 | 9.0 | 20.0 | 0.72 |
| A. T. & S. F. | Dodge City—Kinsley, Kans. | 35.8 | 43.8 | 10.0 | 42 | 41.0 | 26.0 | 1.14 |
| B. & O. | Gilkeson—Wheeling, W. Va. | 43.0 | 43.0 | 12.0 | 20 | 40.0 | 22.0 | 0.93 |
| B. & G. | Magna—Bingham, Utah | 17.0 | 17.0 | 36.0 | 46 | 20.0 | 25.0 | 1.18 |
| C. P. | Medicine Hat—Dunmore, Alta., Can. | 6.1 | 6.1 | 10.0 | 30 | 12.0 | 28.6 | 1.97 |
| C. & O. | Brighton—Cheviot, Ohio | 5.0 | 5.0 | 45.0 | 47 | 10.0 | 15.4 | 2.00 |
| C. B. & Q. | Red Oak—Balfour, Iowa | 25.3 | 27.8 | 11.6 | 45 | 19.4 | 17.2 | 0.77 |
| D. & R. G. W. | Provo—Midvale, Utah | 31.4 | 31.4 | 24.0 | 30 | 47.0 | 34.9 | 1.50 |
| G. T. W. | Sedley—Valparaiso, Ind. | 5.3 | 5.3 | 16.0 | 22 | 22.5 | 50.0 | 4.29 |
| M. P. | Edgewater Jct.—Atchison, Kans. | 42.0 | 42.0 | 24.0 | 60 | 59.4 | 32.2 | 1.41 |
| N. Y. C. | Stanley—Berwick, Ohio | 40.9 | 44.2 | 19.3 | 31 | 72.0 | 26.0 | 1.76 |
| P. & I. | Metropolis—Paducah, Ky. | 14.8 | 14.8 | 29.5 | 43 | 9.1 | 23.7 | 0.61 |
| P. R. R. | Ben Davis—Almeda, Ind. | 30.2 | 30.2 | 11.0 | 33 | 49.8 | 47.0 | 1.65 |
| P. R. R. | Machias—Jamison Road, N. Y. | 28.0 | 35.0 | 28.6 | 35 | 22.1 | 29.4 | 0.79 |
| P. R. R. | Hudson—Arlington, Ohio | 12.0 | 12.0 | 8.4 | 20 | 12.6 | 28.8 | 1.05 |
| P. R. R. | Norwood Heights—Glen, Ohio | 60.7 | 60.7 | 7.2 | 18 | 29.1 | 15.5 | 0.48 |
| P. M. | Mt. Morris—Bridgeport, Mich. | 19.8 | 24.0 | 16.5 | 28 | 12.2 | 20.8 | 0.63 |
| S. P. | Stockton—Brighton, Calif. | 39.7 | 42.0 | 18.7 | 46 | 68.5 | 39.8 | 1.73 |
| T. & P. | Dallas—Fort Worth, Tex. | 31.8 | 63.7 | 31.0 | 50 | 60.0 | 20.0 | 1.89 |
| Wabash | State Line—Lafayette, Ind. | 37.0 | 37.0 | 11.2 | 26 | 10.0 | 11.6 | 0.27 |
| Average of 20 installations | | | | | | 31.2 | 26.7 | 1.34 |

In addition to the time saving, there was an increase in tonnage on eight installations varying from 1 to 16 per cent, and increased gross ton miles per train hour.

## TABLE XVII

### Advantages of Centralized Traffic Control

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day | Per cent on investment | Pub. ref.* |
|---|---|---|---|---|---|---|---|
| Alton | South Joliet, Ill. | 1934 | 2.8 | 2.8 | 20 | .... | 198 |
| | Saved about 20 minutes for each westward freight and otherwise expedited train movements. | | | | | | |
| Alton | Plainview—Rinaker, Ill. | 1937 | 8.3 | 8.3 | 21 | .... | 264 |
| | Facilitated train movements, increased safety and reduced operating expenses. | | | | | | |
| A. T. & S. F. | Dodge City—Kinsley, Kans. | 1930 | 33.9 | 41.5 | 42 | .... | 96 |
| | Expedited freight trains and reduced delays and overtime. Forty-three per cent non-stop meets. | | | | | | |
| A. T. & S. F. | Holliday—Olathe, Kans. | 1931 | 12.2 | 24.4 | 34 | .... | 50 |
| | Either-direction signaling saved 9 minutes per freight train. Postponed third track. | | | | | | |
| B. & O. | Gilkeson—Wheeling, W. Va. | 1931 | 42.5 | 42.5 | 20 | .... | 97 |
| | Freight train time reduced 20 to 60 minutes, overtime reduced and increased capacity. | | | | | | |
| B. & O. | North Lima—Roachton, Ohio | 1931 | 54.7 | 54.7 | 45 | .... | 98 |
| | Saved 46,355 train stops per year, increased capacity and reduced operating expenses. | | | | | | |
| B. & O. | Fairpoint—Maynard, Ohio | 1931 | 5.4 | 8.3 | 14 | .... | 196 |
| | Eliminated interlocking and block station. Expedited traffic and saved $6,000 annually. | | | | | | |
| B. & G. | Arthur Jct.—Bingham, Utah | 1929 | 16.4 | 16.4 | 50 | .... | 99 |
| | Reduced delays to 5,400 ton trains on 2.5 per cent grade. Saved two block stations. | | | | | | |
| B. & M. | Dover, N. H.—Rigby, Me. | 1931 | 73.2 | 107.0 | 56 | .... | 100 |
| | Increased capacity and reduced operating expenses. | | | | | | |
| B. & M. | Hoosac Tunnel—E. Fitchburg, Mass. | 1931 | 73.2 | 155.5 | 36 | .... | 101 |
| | Expedited traffic, reduced delays, facilitated switching movements and increased capacity. | | | | | | |
| B. & M. | Lynn—Swampscott, Mass. | 1930 | 4.8 | 9.6 | 140 | .... | 102 |
| | Consolidated interlockings, reduced delays and expedited traffic at two junctions. | | | | | | |

* For publication references, see p. 88.

(Continued on next page)

TABLE XVII—Continued

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day | Per cent on investment | Pub. ref.* |
|---|---|---|---|---|---|---|---|
| B. & M. | North Chelmsford—Ayer, Mass. | 1929 | 13.2 | 27.3 | 57 | .... | 54 |
| | Reduced delays and yard interference and increased capacity. Saved $37,847 annually. | | | | | | |
| B. & M. | Winchester—Wilmington, Mass. | 1930 | 17.0 | 34.0 | 104 | .... | 103 |
| | Consolidated interlockings, faciliated train operation and increased capacity. | | | | | | |
| C. P. | Medicine Hat—Dunmore, Alberta, Can. | 1928 | 6.1 | 6.1 | 30 | 47.0 | 104 |
| | Expedited freights, provided quicker turn-around service and saved second track. | | | | | | |
| C. R. R. of N. J. | North Branch—White House, N. J. | 1930 | 4.4 | 17.6 | 50 | .... | 105 |
| | Consolidated interlockings, facilitated train operation and saved additional tracks. | | | | | | |
| C. & O. | Ronceverte, W. Va. | 1933 | 4.2 | 8.4 | 34 | .... | 197 |
| | Improved train operation and saved $8,150 annually. | | | | | | |
| C. & O. | "HY" Cabin—M. P. 282, Va. | 1935 | 2.0 | 2.0 | 40 | .... | 265 |
| | Expedited eastward freights entering classification yard and saved train stops on grade. | | | | | | |
| C. B. & Q. | Steward Jct.—Flag Center, Ill. | 1929 | 9.0 | 18.0 | 35 | 12.7 | 106 |
| | Consolidated interlockings and facilitated train operation. | | | | | | |
| C. B. & Q. | Red Oak—Balfour, Iowa | 1930 | 25.3 | 27.8 | 45 | 19.0 | 107 |
| | Expedited train operation and increased train tonnage. Saved second track. | | | | | | |
| C. B. & Q. | Waverly—Greenwood, Nebr. | 1929 | 5.4 | 5.4 | 40 | 20.0 | 108 |
| | Eliminated hand operation of switches at ends of two main tracks. Postponed second track. | | | | | | |
| C. B. & Q. | Shannon—Chariton, Iowa | 1934 | 6.5 | 10.0 | 22 | 24.0 | 199 |
| | Akron—Derby, Colo. | 1937 | 105.3 | 105.3 | 22 | .... | 266 |
| | Reduced delays, expedited train operation and increased capacity. | | | | | | |
| C. M. St. P. & P. | Lawson—Moseby, Mo. | 1931 | 11.6 | 11.6 | 40 | .... | 61 |
| | Beloit, Wis.—Rockton, Ill. | 1933 | 3.1 | 3.1 | 18 | 50.0 | 200 |
| | Austin—Ramsey, Minn. | 1934 | 2.2 | 2.2 | 24 | .... | 267 |
| | Reduced delays, expedited traffic and increased safety. | | | | | | |

(Continued on next page)

TABLE XVII—Continued

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day | Per cent on investment | Pub. ref.* |
|---|---|---|---|---|---|---|---|
| C. M. St. P. & P. | Manilla—Council Bluffs, Iowa | 1942 | 60.0 | 60.0 | 12 | 16 | 154 |
| | Saved 33.7 minutes per freight train. Saved train hours and train stops. | | | | | | |
| D. & H. | Lanesboro, Pa.—Center Village, N. Y. | 1930 | 12.7 | 18.3 | 34 | .... | 109 |
| | Interlockings consolidated, train stops eliminated, traffic expedited, and operating expenses reduced. | | | | | | |
| D. & H. | Watervliet Jct.—Albany, N. Y. | 1936 | 6.1 | 12.2 | 339 | .... | 268 |
| | Interlockings consolidated, delays reduced, train movements expedited with increased capacity. | | | | | | |
| D. & R. G. W. | Deen—Tennessee Pass, Colo. | 1928 | 7.0 | 9.5 | 44 | .... | 110 |
| | Trains expedited on 3 per cent grade and increased average train speed and GTM per train hour. | | | | | | |
| D. & R. G. W. | Provo—Midvale, Utah | 1929 | 31.4 | 31.4 | 30 | .... | 111 |
| | Expedited tonnage freight trains, reduced overtime and increased capacity. | | | | | | |
| D. & R. G. W. | Midvale—E. Roper, Utah | 1937 | 7.0 | 14.0 | 46 | .... | 269 |
| | Eliminated delays, facilitated train movements and saved stops on trains entering yard. | | | | | | |
| D. & R. G. W. | Grand Jct.—Palisade, Colo. | 1937 | 14.0 | 14.0 | 41 | .... | 270 |
| | Reduced delays and eliminated congestion. Expedited traffic and increased safety. | | | | | | |
| D. & R. G. W. | Agate—Helper, Utah | 1944 | 127.0 | 127.0 | 38 | 21 | 155 |
| | Train speeds increased from 18.2 to 21.6 m.p.h. GTM per train hour increased from 30,800 to 43,200. | | | | | | |
| D. & R. G. W. | Grand Jct., Colo.—Helper, Utah | 1945 | 176.0 | 176.0 | 60 | 26 | 156 |
| | Saved 157 minutes per through freight train and 14 minutes per passenger train. | | | | | | |
| Erie | Tusten—Lackawaxen, N. Y. | 1931 | 9.4 | 18.8 | 42 | .... | 65 |
| | Reduced delays, expedited preference trains and increased capacity. | | | | | | |
| G. T. W. | Sedley—Valparaiso, Ind. | 1933 | 5.2 | 5.2 | 25 | 120.0 | 201 |
| | Expedited some freight trains 15 to 30 minutes and increased capacity. | | | | | | |
| I. C. | Clinton—Kenney, Ill. | 1929 | 8.0 | 11.3 | 30 | 30.0 | 112 |
| | Expedited train operation and saved one telegraph office. | | | | | | |
| I. C. | Otto—Ashkum, Ill. | 1930 | 11.5 | 23.0 | 60 | 31.0 | 113 |
| | Consolidated interlockings, trains expedited and third main track postponed. | | | | | | |

* For publication references, see p. 88.

(Continued on next page)

TABLE XVII—Continued

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day | Per cent on investment | Pub. ref.* |
|---|---|---|---|---|---|---|---|
| M. P. | Edgewater Jct.—Atchison, Kans. | 1930 | 42.0 | 42.0 | 60 | 18.0 | 114 |
| | Freight train speed increased 47 per cent and GTM per train hour 57 per cent. Saved second main track. | | | | | | |
| M. P. | HD Jct.—Rose Hill, Mo. | 1931 | 35.4 | 67.3 | 30 | .... | 68 |
| | Facilitated train operation and eliminated train orders on two main tracks. | | | | | | |
| M. P. | Poplar Bluff, Mo.—Knobel, Ark. | 1937 | 34.0 | 42.0 | 43 | .... | 271 |
| | Reduced delays, increased average train speeds, relieved congestion and increased safety. | | | | | | |
| M. P. | Flinton—Raddle Jct., Ill. | 1938 | 28.9 | 30.5 | 60 | .... | 272 |
| | Facilitated train operation especially during peak periods. Increased capacity and safety. | | | | | | |
| N. Y. C. & St. L. | Maumee—Walbridge Jct., Ohio | 1933 | 5.2 | 10.2 | 36 | .... | 202 |
| | Interlockings consolidated, delays reduced and trains expedited. | | | | | | |
| N. Y. C. & St. L. | Kishmans—Kimball, Ohio | 1944 | 21.6 | 21.6 | 62 | 53 | 157 |
| | Saved 2,549 train hours, 6,903 car days and 6,205 train stops annually. | | | | | | |
| N. Y. C. & St. L. | Madison—Euclid, Ohio | 1944 | 28.2 | 28.2 | 41 | 62 | 158 |
| | Saved 4,807 train hours, 15,022 car days and 13,414 train stops annually. | | | | | | |
| N. Y. C. | Stanley—Berwick, Ohio | 1927 | 40.2 | 43.5 | 34 | 24.0 | 115 |
| | Freight train speed increased 36 per cent and GTM per train hour 39 per cent. Postponed second main track. | | | | | | |
| P. & I. | Metropolis, Ill.—Paducah, Ky. | 1929 | 14.8 | 14.8 | 64 | 24.2 | 116 |
| | Reduced delays, expedited trains and saved train stops at five junctions. | | | | | | |
| P. R. R. | Ben Davis—Almeda, Ind. | 1930 | 30.2 | 30.2 | 30 | 28.0 | 117 |
| | Freight train speed increased 87 per cent and GTM per train hour 89 per cent. Postponed second main track. | | | | | | |
| P. R. R. | Huntley—Sterling Run, Pa. | 1937 | 4.6 | 4.6 | 18 | .... | 273 |
| | Norwood Heights—Glen, Ohio | 1941 | 60.7 | 60.7 | 18 | .... | 145 |
| | Machias—Jamison Road, N. Y. | 1940 | 28.3 | 34.7 | 35 | .... | 76 |
| | Hudson—Arlington, Ohio | 1940 | 12.0 | 12.0 | 13 | .... | 76 |
| | Reduced delays and expedited trains in former manual block territory. | | | | | | |

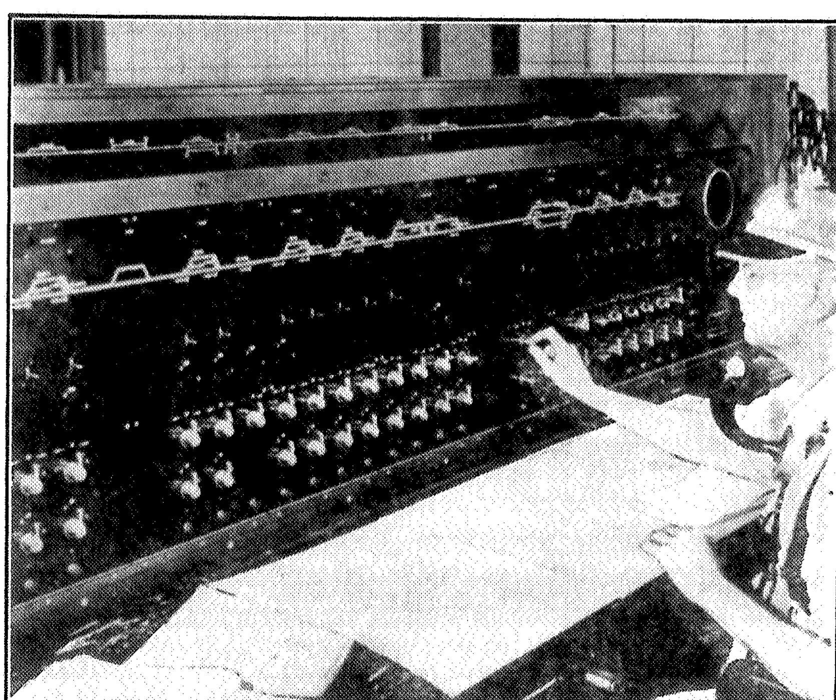
(Concluded on next page)

## TABLE XVII—Concluded

| Railroad | Location | In service | Miles of Road | Miles of Track | Trains per day | Per cent on investment | Pub. ref.* |
|---|---|---|---|---|---|---|---|
| P. & L. E. | Wampum—W. Pittsburgh, Pa. | 1935 | 3.1 | 6.3 | 65 | .... | 274 |
| | Reduced delays, facilitated train operation and reduced operating expenses. | | | | | | |
| P. & P. U. | Peoria—N. Pekin, Ill. | 1931 | 7.1 | 13.5 | 163 | 20 | 118 |
| | Interlockings consolidated, train operation facilitated and operating expenses reduced. | | | | | | |
| P. M. | Mt. Morris—Bridgeport, Mich. | 1928 | 19.8 | 19.8 | 28 | 22 | 119 |
| | Expedited train operation and increased capacity. Postponed second main track. | | | | | | |
| S. P. | Stockton—Brighton, Calif. | 1929 | 39.7 | 42.2 | 46 | .... | 120 |
| | Expedited train operation and increased capacity. Postponed second main track. | | | | | | |
| S. P. | San Jose—Lick, Calif. | 1938 | 4.9 | 5.4 | 35 | .... | 275 |
| | Reduced delays, expedited traffic and increased safety. | | | | | | |
| T. & N. O. | Beeville—Skidmore, Tex. | 1930 | 10.3 | 10.3 | 42 | .... | 121 |
| | Alpine—Paisano, Tex. | 1930 | 12.7 | 12.7 | 14 | .... | 203 |
| | Reduced delays and expedited train operation. | | | | | | |
| T. & P. | Addis—Edgards, La. | 1929 | 56.0 | 107.8 | 40 | .... | 122 |
| | Either-direction signaling saved additional sidings and reduced delays. | | | | | | |
| T. & P. | Ft. Worth—Dallas, Tex. | 1931 | 31.8 | 63.6 | 50 | .... | 204 |
| | Texarkana, Ark.—Springdale, Tex. | 1936 | 15.0 | 15.0 | 30 | .... | 276 |
| | Springdale—Atlanta, Tex. | 1937 | 9.0 | 9.0 | 24 | .... | 277 |
| | Marshall—Longview, Tex. | 1937 | 22.0 | 22.0 | 32 | .... | 277 |
| | Delays reduced and traffic expedited during peak periods. | | | | | | |
| Wabash | State Line—Lafayette, Ind. | 1931 | 37.0 | 37.0 | 19 | 18 | 123 |
| | Train stops and train hours reduced and second main track postponed. | | | | | | |

* For publication references, see p. 88.

Centralized Traffic Control Machine on New York Central



Centralized Traffic Control Machine on Louisville & Nashville

Originally all freight cars were classified in flat switching yards, but in order to reduce switch engine hours and speed up operation, hump or gravity yards were installed so that after a car was pushed over the top of the hump by the switch engine, it would accelerate down the hump by gravity to the classification tracks, each car or cut of cars being ridden by a car rider to control speed of car. Switchmen were used to operate the classification yard switches. The next move for effecting economies was the application of power-operated switches whereby one operator replaced a number of switchmen. The latest improvement at hump yards permits a few operators, controlling car retarders, to do the work formerly requiring a large number of car riders.

The car retarder is a braking device, usually power-operated, built into a railway track to reduce the speed of cars by means of brake shoes which, when set in braking position, press against the sides of the lower portions of the wheels. The car retarder system includes the retarders, the power-operated switches, control machines, power supply, and sometimes power-operated skate placing mechanisms at the hump end of each classification track for stopping cars in emergency. The number and location of car retarders and operating stations depends upon the track layout and profile at each yard. In general, however, the first retarder is near the summit of the hump; others are at intervals along the leads. The car retarder operators also operate the switches of the classification tracks, judge the speed of the cars, retard them when necessary by means of the car retarders, and, if necessary, operate the skate machines.

In 1945 there were 53 car retarder installations in service by 27 railroads or companies. The details of these installations are shown in Table XVIII.

The economies effected by the installation of car retarders depend upon the capacity of the yard, the number of cars handled and the distribution of cars throughout the day. A report* on 16 car retarder installations on 12 railroads showed a return of 7.72 per cent to 67.31 per cent on the capital investment. The average cost per car handled through the yard before the retarders were installed was $0.80, and after they were installed, $0.52, representing an average saving per car handled of $0.28. Four of the railroads reported that the installation of the retarders had resulted in eliminating switching at other points with savings of $15,000 to $192,000 per year. The operating advantages reported on 27 installations on 19 railroads are shown in Table XIX. In addition, there are other operating advantages and economies realized, such as:

1. Possibility of keeping a yard in operation under severe weather conditions.
2. Elimination of tracks, motor cars and concrete subways for returning riders to the hump or the utilization of such tracks for additional classification tracks.
3. Increases the capacity of the hump, as all delays caused by waiting for riders to return to the hump are removed.
4. Reduces damage to lading and equipment.
5. Practically eliminates personal injuries.

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* A.A.R. Signal Section 1933 Proceedings, Vol. XXXI, pp. 23, 400.

6. Permits faster freight schedules and better connections.

7. Permits clearing the receiving yard in a shorter time, resulting in an increased capacity of the yard, without providing additional receiving tracks.

8. Permits reduction in motive power.

9. Increases car miles per car day and reduces per diem.

10. Eliminates the problem of securing car riders.

11. Provides increased flexibility of operation for meeting varying traffic conditions.

12. Permits classifications at one central point rather than at several locations.

13. Has proven of economic advantage at low traffic density.

14. Reduces engine and crew hours.

The Signal Section, A.A.R., conclusion and findings on Car Retarders are as follows:

*Conclusion.*

Car retarders are recommended as an economic means to be considered for improving service to shippers and reducing operating expenses by reducing motive power expense, increasing car capacity, reducing delays and personal injuries, reducing damage to equipment and lading, and consolidating classification yards.

*Findings.*

First cost, economy of installation and the return on the expenditure will vary with local conditions.

## TABLE XVIII

### Details of Car Retarder Installations

| Railroad or company | No. of installations | In service | No. of tracks | Control stations | No. of retarders | Power switches | No. of skates | Track circuits |
|---|---|---|---|---|---|---|---|---|
| Atlas Cement Co. | 1 | 1938 | 1 | 0 | 2 | 0 | 0 | 0 |
| Belt Ry. of Chicago | 2 | 1938 | 80 | 6 | 44 | 95 | 0 | 95 |
| B. & M. | 3 | 1927 | 113 | 6 | 58 | 113 | 0 | 0 |
| Carnegie-Illinois Steel Corp. | 1 | 1929 | 1 | 0 | 1 | 0 | 0 | 0 |
| C. R. R. of N. J. | 1 | 1927 | 24 | 3 | 21 | 23 | 24 | 0 |
| C. & O. | 1 | 1929 | 21 | 3 | 21 | 25 | 21 | 23 |
| C. & N. W. | 1 | 1929 | 59 | 3 | 30 | 58 | 0 | 0 |
| C. B. & Q. | 3 | 1931–42–44 | 120 | 7 | 51 | 128 | 0 | 126 |
| C. C. C. & St. L. | 1 | 1929 | 30 | 2 | 24 | 31 | 0 | 31 |
| Commonwealth Edison Co. | 1 | 1926 | 4 | 0 | 1 | 0 | 0 | 0 |
| D. L. & W. | 1 | 1937 | 29 | 2 | 16 | 30 | 29 | 30 |
| Erie | 1 | 1931 | 24 | 2 | 17 | 24 | 0 | 24 |
| I. C. | 3 | 1926 | 137 | 13 | 251 | 143 | 135 | 0 |
| I. H. B. | 3 | 1924–26 | 90 | 12 | 170 | 95 | 0 | 0 |
| L. V. | 3 | 1928–30 | 70 | 5 | 45 | 68 | 70 | 68 |
| L. & N. | 1 | 1940 | 20 | 1 | 11 | 19 | 0 | 19 |
| M. C. | 1 | 1930 | 31 | 2 | 17 | 35 | 31 | 35 |
| N. Y. C. | 6 | 1928–29–30–31 | 172 | 16 | 125 | 172 | 111 | 172 |
| N. Y. N. H. & H. | 4 | 1926–29 | 145 | 10 | 106 | 146 | 24 | 122 |
| N. & W. | 4 | 1928–37–42 | 104 | 7 | 70 | 116 | 36 | 77 |
| P. & R. C. & I. Co. | 1 | 1932 | 1 | 0 | 1 | 0 | 0 | 1 |
| P. R. R. | 4 | 1929–37–39–44 | 107 | 9 | 68 | 115 | 100 | 115 |
| R. F. & P. | 2 | 1930–45 | 75 | 5 | 41 | 76 | 75 | 39 |
| State Line Gen. Co. | 1 | 1929 | 5 | 1 | 4 | 4 | 0 | 0 |
| T. & P. | 1 | 1928 | 32 | 2 | 21 | 38 | 32 | 0 |
| Waukegan Gen. Co. | 1 | 1931 | 2 | 1 | 1 | 1 | 0 | 0 |
| W. & L. E. | 1 | 1938 | 2 | 1 | 2 | 0 | 0 | 0 |
| Total | 53 | | 1,499 | 119 | 1,219 | 1,555 | 688 | 977 |

## TABLE XIX

### Advantages of Car Retarder Installations

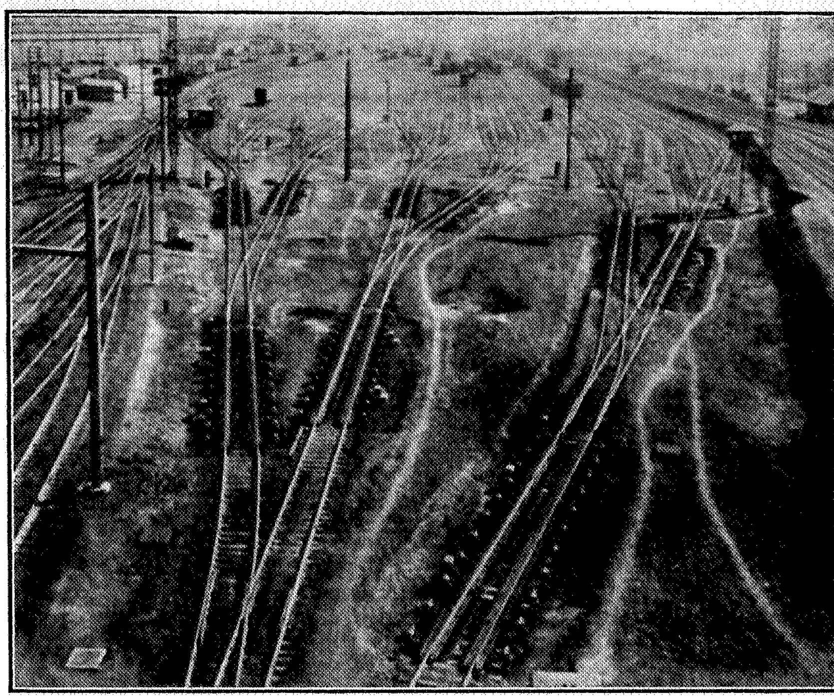
| Railroad | Location | In service | Cars per day | Pub. ref.* |
|---|---|---|---|---|
| Belt Ry. of Chicago | E. B.-W. B. Clearing, Chicago, Ill. | 1938 | 6,000 | 278 |
| | Reduced delays and expedited peak car movements during rush hours. | | | |
| B. & M. | Mechanicville, N. Y. | 1927 | 1,200 | 124 |
| | Reduced time of cars in yard 50 per cent and saved over 50 per cent on investment. | | | |
| B. & M. | Mystic Yards, Boston, Mass. | 1927 | 2,150 | 125 |
| | Effected a large saving in switching costs. | | | |
| C. R. R. of N. J. | Allentown, Pa. | 1927 | 1,000 | 126 |
| | Saved approximately 40 cents per car. | | | |
| C. & O. | Russell, Ky. | 1929 | 2,750 | 127 |
| | Saved 25 cents per car and about 40 per cent on investment. | | | |
| C. & N. W. | Proviso, Ill. | 1929 | 2,500 | 128 |
| | Materially expedited traffic at busy Chicago Terminal. | | | |
| C. B. & Q. | Galesburg, Ill. | 1931 | 3,500 | 129 |
| | Saved 29 cents per car and reduced switching at other yards. | | | |
| C. B. & Q. | Lincoln, Nebr. | 1944 | 4,400 | 162 |
| | Reduced delays and speeds cars with substantial savings. | | | |
| C. C. C. & St. L. | Sharonville, Ohio | 1929 | 1,150 | 130 |
| | Saved 25 cents per car and about 40 per cent on investment. | | | |
| D. L. & W. | Hampton Yard, Scranton, Pa. | 1937 | 600 | 279 |
| | Classifications expedited and expenses materially reduced. | | | |
| Erie | Marion, Ohio | 1931 | 1,400 | 131 |
| | Saved 40 cents per car and about 30 per cent on investment. | | | |
| I. C. | Markham Yard, Ill. | 1926 | 2,500 | 132 |
| | Saved 24.8 per cent on investment and expedited cars. | | | |
| I. C. | E. St. Louis, Ill. | 1926 | 1,500 | 133 |
| | Reduced yard cost 27.5 per cent. | | | |

(Concluded on next page)

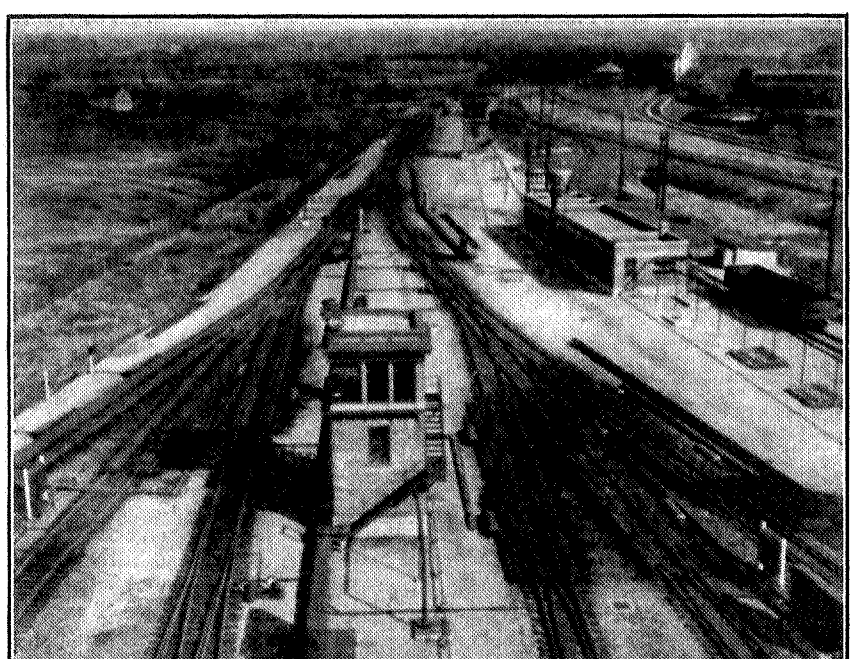
TABLE XIX—Concluded

| Railroad | Location | In service | Cars per day | Pub. ref.* |
|---|---|---|---|---|
| I. H. B. | Gibson, Ind. | 1924 | 1,600 | 134 |
| | Saved 33 cents per car in first year of operation. | | | |
| I. H. B. | Blue Island, Ill. | 1926 | 2,760 | 135 |
| | Reduced cost of yard operation and increased capacity for peak business. | | | |
| L. & N. | DeCoursey Yard, Ky. | 1940 | 1,500 | 163 |
| | Increased capacity, facilitating classifications, and reduced expenses. | | | |
| M. C. | W. Detroit, Mich. | 1930 | 1,125 | 136 |
| | Saved $145,000 annually. Increased cars humped per hour by 14 per cent. | | | |
| N. Y. C. | Selkirk, N. Y. | 1928 | 1,800 | 137 |
| | Capacity of yard increased 50 per cent. | | | |
| N. Y. C. | Stanley, Ohio | 1931 | 1,000 | 138 |
| | New yard designed to handle northward lake coal traffic. | | | |
| N. Y. C. | Toledo, Ohio | 1929 | 500 | 139 |
| | Coal dock installation facilitated operation and reduced expenses. | | | |
| N. Y. N. H. & H. | Hartford, Conn. | 1926 | 1,350 | 140 |
| | Saved 13 cents per car in direct costs of classification, | | | |
| N. & W. | Portsmouth, Ohio | 1928 | 1,800 | 141 |
| | Saved 10 cents per car and reduced damage to cars and lading 40 per cent. | | | |
| N. & W. | Roanoke, Va. | 1942 | 2,200 | 164 |
| | New yard increased efficiency and expedited traffic. | | | |
| P. R. R. | Pitcairn, Pa. | 1929 | 1,400 | 142 |
| | Saved $153,000 annually. Increased capacity and reduced tricks. | | | |
| P. R. R. | E. B. Enola Yard, Harrisburg, Pa. | 1937 | 2,600 | 280 |
| | Classifications expedited and yard capacity increased. | | | |
| R. F. & P. | Potomac Yard, Va. | 1930 | 1,300 | 143 |
| | Saved 11 cents per car and expedited perishable freight. | | | |
| T. & P. | Fort Worth, Tex. | 1928 | 1,500 | 144 |
| | New yard increased efficiency with reduced switching at other yards. | | | |

* For publication references, see p. 88.



Car Retarder Installation on Pennsylvania



Car Retarder Installation on New York Central

Prior to the advent of the automobile, the protection of highway grade crossings with railroads was generally confined to the installation of warning signs indicating the location of the crossings except at the more heavily traveled crossings where watchmen, gates, or bells were installed to indicate the approach of trains. However, the rapid development of improved highways and the increasing automobile registration has introduced new problems. The greater automobile traffic at night and in the early morning hours has greatly increased the cost of watchmen and gatemen for continuous service and resulted in excessive costs of operation and maintenance. The rapid increase in the number of highway crossings where it has become necessary to provide warning of the approach of trains and the necessity for economy led to the development of automatic crossing protection devices which have a low yearly maintenance cost as compared with the previous types of protection. These devices can be more widely used than more expensive means of protection, thereby reducing the hazards of accidents at the maximum number of crossings.

The recommended standards and practices for new installations of railroad highway grade crossing signs, signals and automatic gates, are shown in A.A.R. Joint Committee on Grade Crossing Protection Bulletin No. 3, dated October 1942.

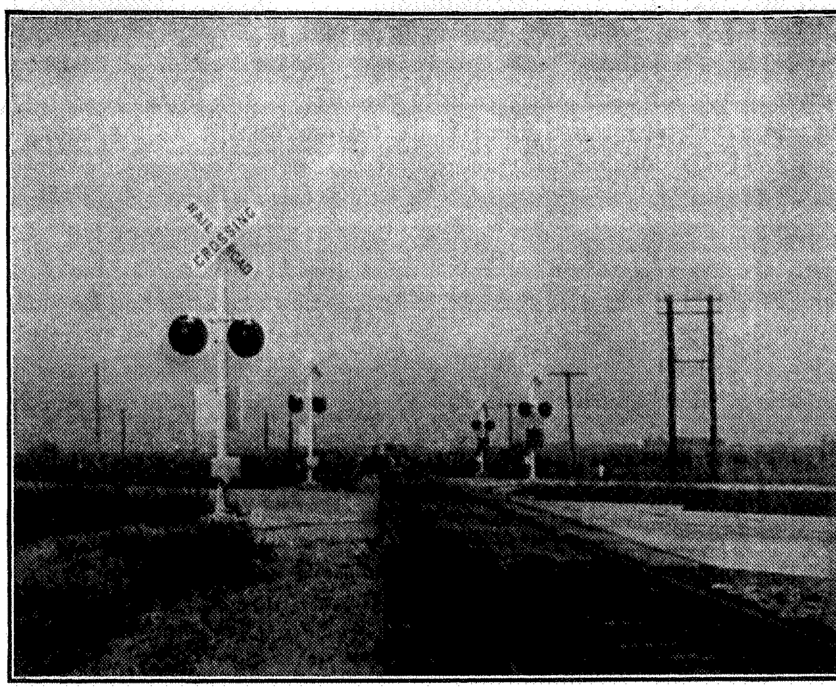
A summarized statement of the various types of protection at railroad highway grade crossings on Class I steam railroads in the United States for 8 years is shown in Table XX.

Of the 33,124 protected crossings in 1943, about 14.6 per cent of the total number of crossings, the number equipped with gates, watchmen and signals is shown in Table XXI.

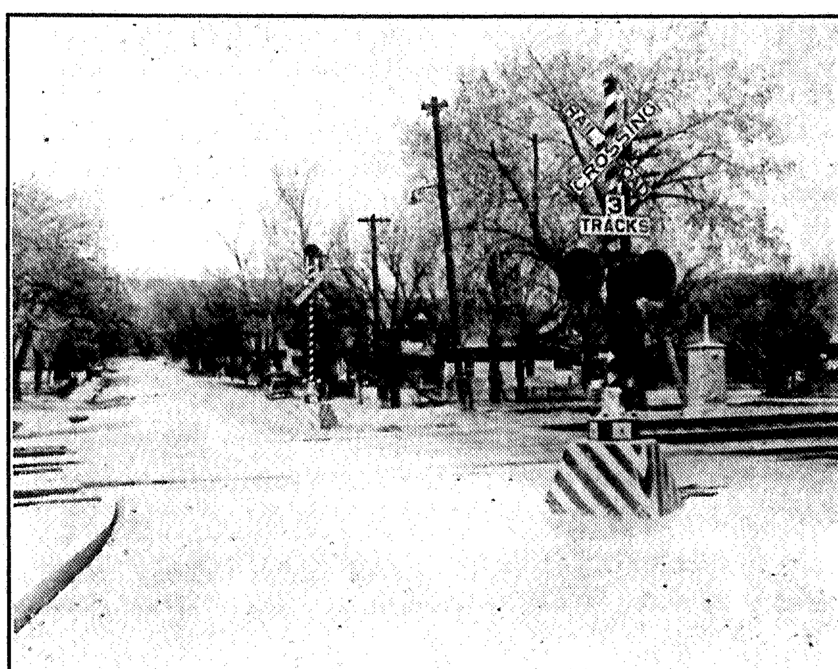
In addition to providing more economical protection, automatic railroad highway grade crossing signals provide more efficient protection than the type replaced, and provides 24-hour protection whereas, in many cases, the protection replaced was only for a portion of the day. In certain cases automanually controlled signals have been used and in other cases manual control has made it possible to make substantial saving in operating expenses.

Table XXII shows the relative costs of maintaining various types of railroad highway grade crossing protection and indicates that the annual cost of protecting one crossing with watchmen or gates manually controlled would be sufficient to maintain about seven crossings with automatic devices.

In considering the economics of railroad highway grade crossing protection, no attempt is made to evaluate the safety features in dollars. The relative advantages of one type of protection over another in dollar costs is considered rather than the question as to whether protection is required. The railroad does not in all cases have the final word as to the type of protection to be installed but in many cases can choose between several alternatives. It is, of course, to the interest of the public and the railroad to provide the most economical solution to the highway traffic problem. Ordinarily, however, it will be found that the use of automatic crossing signals will provide the most desirable protection even at points where traffic conditions are unusual.



Highway Grade Crossing Signal Installation on Chesapeake & Ohio




Highway Grade Crossing Signal Installation on Denver & Rio Grande Western

## TABLE XX

### Types of Protection at Railroad Highway Grade Crossings*, December 31 of Each Year

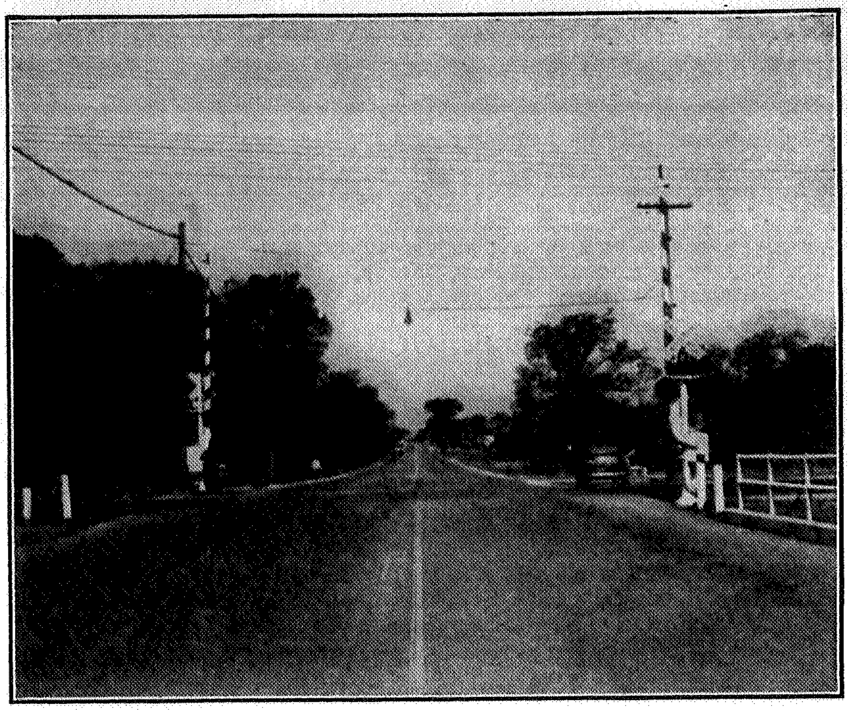
| Type of protection | 1925 | 1935 | 1938 | 1939 | 1940 | 1941 | 1942 | 1943 |
|---|---|---|---|---|---|---|---|---|
| Gates | 6,320 | 4,314 | 4,047 | 4,005 | 4,032 | 4,077 | 4,049 | 4,074 |
| Watchmen | 7,907 | 5,528 | 5,211 | 5,092 | 4,950 | 4,882 | 4,805 | 4,811 |
| Signals | 13,014 | 20,358 | 22,190 | 22,678 | 23,439 | 23,900 | 24,221 | 24,239 |
| Total protected crossings | 27,241 | 30,200 | 31,448 | 31,775 | 32,421 | 32,859 | 33,075 | 33,124 |
| Fixed signs | 202,324 | 197,340 | 191,340 | 190,487 | 188,930 | 187,958 | 185,660 | 184,961 |
| Otherwise unprotected | 4,068 | 6,691 | 8,612 | 8,842 | 8,934 | 8,905 | 8,761 | 8,853 |
| Grand total | 233,633 | 234,231 | 231,400 | 231,104 | 230,285 | 229,722 | 227,496 | 226,938 |

* I. C. C. "Statistics of Railways in the United States."

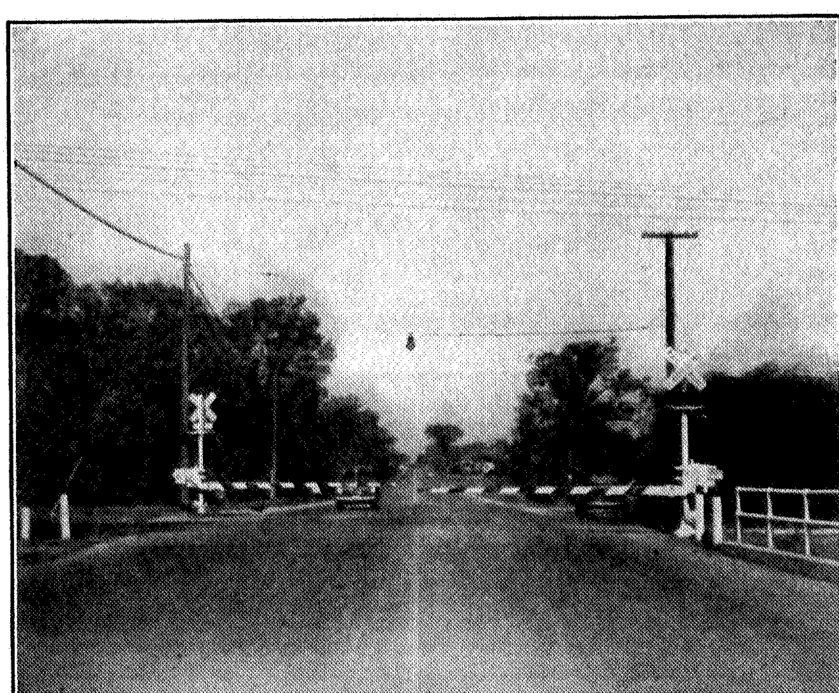
## TABLE XXI

Crossings Equipped with Gates, Watchmen and Signals
December 31, 1943

| Type | Number | Total |
|---|---|---|
| Gates, with or without other protection operated 24 hours per day | 2,895 | |
| Gates, with or without other protection operated less than 24 hours per day | 1,179 | 4,074 |
| Watchmen, alone or with protection other than gates, on duty 24 hours per day | 1,337 | |
| Watchmen, alone or with protection other than gates, on duty less than 24 hours per day | 3,474 | 4,811 |
| Both audible and visible signals, without other protection | 12,232 | |
| Audible signals only | 2,783 | |
| Visible signals only | 9,224 | 24,239 |
| Total protected crossings | | 33,124 |



Automatic Crossing Gates on Chicago, Milwaukee, St. Paul & Pacific



Automatic Crossing Gates on Chicago, Milwaukee, St. Paul & Pacific

## TABLE XXII

Cost of Railroad Highway Grade Crossing Protection*

| Type of protection | No. of railroads reporting | Annual Depre- ciation | Annual Interest 5.5% | Annual maintenance and operation | Total annual cost | Annual cost capitalized at 5.5% |
|---|---|---|---|---|---|---|
| Watchmen | 8 | $8.24 | $9.54 | $2,851.23 | $2,869.01 | $52,000.00 |
| Gates | 11 | 86.59 | 95.10 | 3,069.65 | 3,251.34 | 59,000.00 |
| Flashing lights | 10 | 93.09 | 105.27 | 256.30 | 454.66 | 8,300.00 |
| Wig-wags | 7 | 90.32 | 106.96 | 245.20 | 442.48 | 8,000.00 |
| Special fixed signs | 4 | 1.71 | 1.53 | 9.44 | 12.68 | 250.00 |

Table XXIII shows the economies effected by 246 signal installations replacing more expensive types of protection. Some are operated automatically, some auto-manually and others manually from one or more centralized points.

Most of the installations shown in Table XXIII have provided increased protection for the complete 24 hour period instead of a portion of the day. The saving shown is not on the basis of what it would cost to provide equivalent protection under the old method for 24 hours each day at each crossing, but represents only the difference between the cost of the protection furnished during the period previous to the installation, and the cost during a like period subsequent to the installation.

The Signal Section, A.A.R., conclusion and findings on Highway Grade Crossing Protection are as follows:

*Conclusion.*

Replacing manual by automatic, auto manual, or centralized control highway grade crossing protection is recommended as an economic means for reducing operating expenses.

*Findings.*

First cost, economy of installation and the return on the expenditure will vary with local conditions.

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* A.R.E.A. Proceedings, Vol. 30, p. 503.

## TABLE XXIII

### Economy of Railroad Highway Grade Crossing Protection

| Railroad | Location | No. of crossings | Type of protection* Before | Type of protection* After | Saving Per year | Saving Per cent | Pub. ref.** |
|---|---|---|---|---|---|---|---|
| A. R. A. Signal Section report | | 42 | W | Sigs. | $71,058 | 99.8 | 153 |
| B. & L. E. | Greenville, Pa. | 5 | G | G-Sigs. | 3,000 | 15.6 | 146 |
| B. & M. | Hudson, Mass. | 9 | G-W | Sigs. | 4,255 | 27.0 | 205 |
| C. P. | Renfrew, Ont., Can. | 1 | G | Sigs. | 3,500 | 77.8 | 206 |
| C. P. | Chatham, Ont., Can. | 13 | G-Sigs. | G-Sigs. | 1,970 | 10.1 | 281 |
| C. & A. | Pekin, Ill. | 4 | W | Sigs. | 2,020 | 38.8 | 207 |
| C. & N. W. | Elgin, Ill. | 25 | G-W | Sigs. | 9,213 | 72.8 | 147 |
| C. B. & Q. | Rockford, Ill. | 3 | G | A. G.-Sigs. | 4,100 | 40.4 | 282 |
| C. B. & Q. | Macomb, Ill. | 15 | G-W | Sigs. | 4,645 | 29.2 | 208 |
| C. G. W. | Waterloo, Iowa | 14 | G-W | W-Sigs. | 12,784 | 58.7 | 209 |
| C. M. St. P. & P. | Oconomowoc, Wis. | 6 | G-W | W-Sigs. | 4,758 | 33.4 | 148 |
| C. M. St. P. & P. | Bensenville, Ill. | 5 | G-W | W-Sigs. | 3,745 | 43.2 | 210 |
| C. R. I. & P. | 95th St., Chicago, Ill. | 1 | G | A. G.-Sigs. | 2,716 | 34.3 | 283 |
| Detroit Term. | Detroit, Mich. | 1 | G-W | Sigs. | 5,250 | 175.0 | 211 |
| I. U. T. | Indianapolis, Ind. | 23 | G-W | Sigs. | 15,984 | 33.3 | 149 |
| L. & N. | E. St. Louis, Ill. | 6 | G | Sigs. | 10,187 | 113.3 | 150 |
| M. C. | Kalamazoo, Mich. | 20 | G-W-Sigs. | Sigs. | 15,165 | 30.8 | 284 |
| M. K. T. | Clinton, Mo. | 11 | W | Sigs. | 3,300 | 28.7 | 151 |
| P. R. R. | Kokomo, Ind. | 13 | W | Sigs. | 10,000 | 31.7 | 147 |
| P. R. R. | Erie, Pa. | 8 | G-W | Sigs. | 7,284 | 36.2 | 285 |
| T. & N. O. | El Paso, Tex. | 8 | G-W | Sigs. | 4,000 | 18.3 | 212 |
| Wabash | Wabash, Ind. | 13 | G-W | Sigs. | 7,800 | 40.0 | 152 |
| Total | | 246 | | | $206,734 | 46.9 | |

* Abbreviations: G=Manually operated gates A. G.=Automatic gates W=Watchmen

** For publication references, see p. 88.

## TABLE XXIV

Summary of Economic Results

| Type | No. of installations | Cost | Saving | |
|---|---|---|---|---|
| | | | Per year | Per cent |
| Automatic block signals | 6 | $2,452,186 | $417,895 | 17.0 |
| Interlockings: | | | | |
| (a) Manually operated | 7 | 253,467 | 150,618 | 59.4 |
| (b) Consolidation of interlockings | 24 | 1,133,460 | 246,271 | 21.7 |
| (c) Automatic | 73 | 524,036 | 334,357 | 63.8 |
| Train operation by signal indication | 3 | 138,000 | 52,701 | 38.2 |
| Remote control | 37 | 726,678 | 231,631 | 31.8 |
| Centralized traffic control | 20 | 4,424,525 | 1,127,721 | 25.5 |
| Car retarders | 16 | 8,850,000 | 3,470,603 | 39.2 |
| Railroad highway grade crossing protection | 246 | 440,434 | 206,734 | 46.9 |
| Grand total | 432 | $18,942,786 | $6,238,531 | 32.9 |

## *Methods for Determining the Economic Value of Railroad Signaling*

*General.*

The principal economic advantages of signaling systems and devices will result from expedited train movements, train miles saved due to increased tonnage, train stops and slow downs eliminated, locomotive and car saving due to expedited equipment, train order offices eliminated, personnel relieved for other duties, signaling and track facilities eliminated, prevention of accidents, etc.

These factors generally produce savings in the cost of maintenance and operation which can be determined by comparing train operations on representative days under existing conditions with the improvement in the operations under the proposed signaling.

The general procedure in determining the estimated time saving, in train hours per day, of a proposed C.T.C. installation for example, is as follows:

1. Select period in past performance which will approximate expected train density.
2. Select consecutive test days of varying number of trains per day.
3. Pick out 1, 3, 7, 15 or 30 days, depending upon the accuracy required and time available for the study.
4. Chart the trains, from the train sheets, to determine the actual total number of train hours required by all trains for the selected test days.
5. Redispatch the same traffic by days to show the probable performance in train hours with the new signaling.
6. Translate the average daily saving to an annual basis to show the estimated saving per year.
7. The procedure will vary on different types of signaling projects depending on the local conditions on each railroad.

After determining the estimated train hours, etc., saved by the proposed signaling, the results should be translated to a dollar basis by using the unit values applicable to the particular installation.

*Savings.*

*Saving due to expedited train movements.*

Include under this heading the train hour saving of freight trains based on straight time without crew wages, overtime wages, 16-hour tie-ups, railroad retirement taxes, and train mile saving.

*Saving due to stops and slow downs eliminated.*

Compute the saving in stops and slow downs eliminated by the improved signaling for each train on the test days and translate to an annual basis. If different types of trains are involved, list each type separately.

*Saving due to expedited equipment.*

Estimate the saving in locomotives and cars from the following formulae:

Locomotive saving*

$$\frac{A}{B} = \text{Freight locomotives saved}$$

Where A = Freight locomotive hours saved per day
B = Locomotive hours per trip or cycle

Car day saving**

$$\frac{C \times D}{24} \times 365 = \text{Car days saved per year}$$

Where C = Freight train hours saved per day
D = Average number of per diem cars per train
24 = Hours per day

*Saving due to eliminating train order offices.*

Estimate the saving in tricks and offices by the proposed signaling. Include vacation and relief allowance, railroad retirement taxes, expenses, and maintenance and operation of the offices.

*Saving due to facilities displaced.*

Estimate the saving due to signaling, track and other facilities displaced by the proposed signaling. These items usually include train order, automatic block and other signals, switches, switch lamps and siding maintenance, water station changes, etc. All factors entering into a particular project should be included.

*Saving due to reduced cost of accidents.*

This item is included only when involved in a project where the proposed signaling definitely increases safety of train operation. If records over at least a 5-year period are available, the average yearly saving should be included.

*Non-productive time saved.*

Where a signal installation increases the productive time of men on work trains and track cars, etc., the saving should be included.

*Deductions.*

After the annual savings have been totaled, a deduction should be made for the increased cost of signal and track maintenance, etc., and the net reduction in annual operating expenses calculated for use in the economic statement.

*Unit values.*

In making economic studies of signal installations there are several factors upon which a unit value must be placed in order to determine the annual per cent return upon the proposed expenditure.

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* A.A.R. Signal Section 1943 Proceedings, Vol. XLI, p. 17 and A.A.R. Signal Section 1944 Proceedings, Vol. XLII, p. 24-A.

** A.A.R. Signal Section 1943 Proceedings, Vol. XLI, p. 19.

*Train hour value.*

The train hour value, THV, has been a subject of several reports*, in which it was concluded that in determining the total THV the following items should be considered:

1. Wages, train and enginemen
2. Train fuel
3. Water for train locomotives
4. Lubricants for train locomotives
5. Other supplies for train locomotives
6. Enginehouse expenses—train
7. Train supplies and expenses
8. Locomotive repairs
9. Locomotive depreciation
12. Payroll taxes

An analysis was then made of the annual reports of 82 railroads in various regions and data published for Items 1, 2 to 8, 9 and 12 with a total for Items 2 to 8, 9 and 12 for each of the railroads for the year 1942.

For Railroad 34, for example, the respective figures for these 10 items, for the year 1942, were as follows:

| | THV |
|---|---|
| 1. Wages, train and enginemen | $ 9.03 |
| 2. Train fuel | 5.60 |
| 3. Water for train locomotives | 0.36 |
| 4. Lubricants for train locomotives | 0.22 |
| 5. Other supplies for train locomotives | 0.07 |
| 6. Enginehouse expenses—train | 1.22 |
| 7. Train supplies and expenses | 1.72 |
| 8. Locomotive repairs | 7.31 |
| 9. Locomotive depreciation | 1.36 |
| 12. Payroll taxes | 0.38 |
| Total, including wages | $27.27 |
| Total, excluding wages | $18.24 |

The averages by regions in 1942 varied from $8.42 to $10.80 for Item 1 and $14.00 to $21.69 for Items 2 to 9 plus 12. Each railroad should use the values which it considers applicable on any particular project which may be under consideration.

*Train mile value.*

Where a signal installation improves the train performance so that increased tonnage may be handled and a reduction can be made in the number of train miles required to move a given traffic, the train mile saving should be included in the economic statement. The train mile cost for the operating territory should be used and has varied from $1.25 to $1.72 per train mile in several economic reports in 1945.

* A.A.R. Signal Section 1941 Proceedings, Vol. XXXIX, p. 15; A.A.R. Signal Section 1942 Proceedings, Vol. XL, p. 25-A, and A.A.R. Signal Section 1943 Proceedings, Vol. XLI, p. 21.

*Train stop value.*

The value of a train stop* eliminated is predicated upon and will vary according to the characteristics and inherent differences of various classes of locomotives, the resistance to traction met under various conditions, such as grade resistance, curvature (equated to grade resistance), frictional resistance of various weight cars, number of cars in train, tonnage of train including locomotive, braking distance, cost of fuel, crew wages, straight time or overtime, and delay time resulting from stop.

As early as 1905 a report** was presented to the Railway Signal Association in which it was stated that the cost of stopping and starting a 2,000 ton freight train from and to a speed of 35 m.p.h. was estimated at $1.00. This estimated figure by a check made from recent charts and calculations for a similar weight train is satisfactory, although a little underestimated. However, such figure cannot be applied to all trains. Calculations have shown that each train and class of locomotive must be considered separately if the train stop value is to be arrived at with any resulting degree of accuracy, definitely establishing that no blanket figure is applicable to all train stops and the train stop value must be calculated giving consideration to all factors governing in each stop.

There are many intangibles which may or may not enter into the train stop value, such as wear and tear on brake equipment, damage to lading, damage to car equipment, etc., as pertain to each stop.

The time lost is an important item in stopping, and also in slowing down by increasing the train stop value, that is in cost, not worth. Stops and slow downs, when frequent, very materially reduce the scheduled speed of a train and have a direct bearing in reducing the earning capacity of a road.

The major portion of the train stop value is represented in the fuel and water wasted. Therefore, given the characteristics of the locomotive, the B.t.u. value and unit cost of fuel and unit cost of water, the cost of power dissipated in making a stop from any speed and the cost of power required to regain that speed may be determined as against the power required to run through at that speed without stop, and by subtraction the cost of making the stop may be determined.

Reference is made to four charts†, A.A.R. Sig. Sec. 7059, 7060, 7061 and 7062, which offer a method for arriving at the cost of fuel and water wasted in stopping various weight trains on level tangent track. The curves depicted in these charts are the result of calculations for the acceleration of trains from a start and at various intermediate speeds with allowance for time, distance and power required, and for time and power running through at constant speed. The diagram of stop cycle†† upon

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* A.A.R. Signal Section 1938 Proceedings, Vol. XXXVI, pp. 6, 235; A.A.R. Signal Section 1939 Proceedings, Vol. XXXVII, pp. 6-19, 548-550; A.A.R. Signal Section 1941 Proceedings, Vol. XXXIX, p. 6, and A.A.R. Signal Section 1944 Proceedings, Vol. XLII, p. 7-A.

** R.S.A. Digest of Proceedings, Vol. I, p. 282.

† A.A.R. Signal Section 1938 Proceedings, Vol. XXXVI, pp. 11, 13, 15 and 17.

†† A.A.R. Signal Section 1938 Proceedings, Vol. XXXVI, p. 7.

which these charts are based, is recommended for consideration for a better understanding of the charts referred to before applying them in determination of the train stop value.

The type of locomotive referred to in the title shown on each of these charts is representative of a group of locomotives and should be observed in applying charts to any specific problem. This also applies to the weight of cars shown.

Having in mind that these typical charts apply to train stops on level tangent track only, it is obvious that stops on plus or minus track grade will affect the train stop value. These plus and minus grades may be considered as also including any curves which may be equated to grade as previously mentioned.

Chart A.A.R. Sig. Sec. 7063* shows a method for arriving at the cost of fuel and water wasted stopping a 4,400 ton gross weight train of 45-ton double truck cars hauled by a 2-8-4 locomotive on various plus and minus grades.

Application of the aforementioned chart to a 4,400 ton gross weight train of 45-ton cars stopped from 35 m.p.h. on a plus 0.1 per cent grade shows the train stop value of fuel and water wasted as $1.134. The same train stopped from the same speed on a minus 0.1 per cent grade shows the train stop value of fuel and water wasted as $1.267. Observe the stop on the minus 0.1 per cent grade costs more in value of fuel and water wasted than the stop on the plus 0.1 per cent grade.

Mention is again made, however, that the fuel and water wasted in stopping does not constitute the complete train stop value. Costs other than fuel and water wasted are involved such as intangibles and time lost and these items cannot be neglected in determining the value of any train stop.

In every stop time is lost to a greater or lesser degree and must be considered in every case as it involves consideration of the freight train delay hour constituting part of the train stop value. Overtime of train crews, investment in equipment and delay to other trains are included in this item.

In some instances it may be essential to give consideration to the cost of regaining lost time where possible by running at higher speed and the inclusion of this in train stop value.†

Train stop values of $0.50 to $1.00 for passenger trains and $1.00 to $4.00 for freight trains have been used in economic reports in 1945.

*Maintenance and operation.*

The cost of maintenance and operation varies, depending upon local conditions on each railroad. The cost may be lower where additional signal maintenance labor is not involved and may vary from 1 to 4 per cent of the total cost of the new signaling. Where possible, the actual labor and material costs should be estimated for the signal installation.

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* A.A.R. Signal Section 1939 Proceedings, Vol. XXXVII, p. 9.

† A.A.R. Signal Section 1939 Proceedings, Vol. XXXVII, p. 14.

*Depreciation.*

Where depreciation is involved, it should be given consideration.

*Railroad retirement taxes.*

Railroad retirement taxes, unemployment insurance and injury to persons insurance should be included in wages, the rate in 1945 being 6¼ per cent.

*Interest.*

Interest should be computed at the current rate and will vary with different railroads. A 4 per cent rate was used in economic reports in 1945.

*Conclusion.*

The conclusions of the economic study should be briefly stated in the first part of the report.

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| A.C. Primary Battery Track Circuits | 1944 | XLII | 16-A |
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