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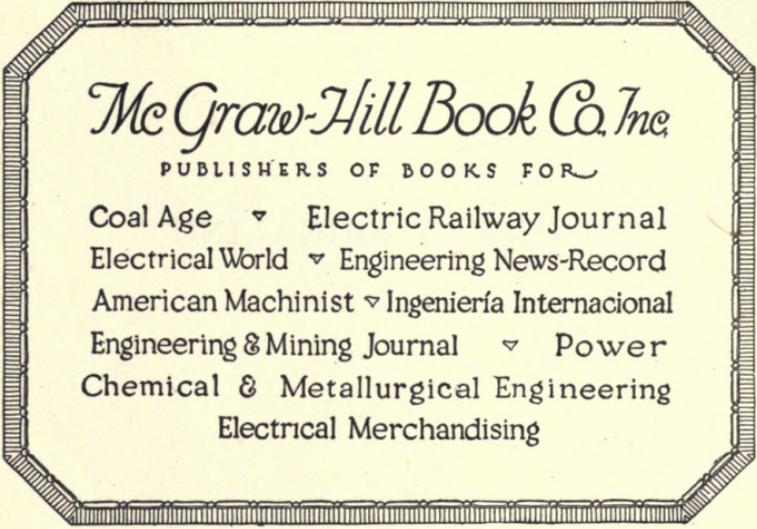








**RAILWAY SIGNALING**



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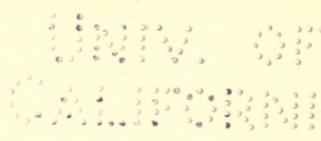
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# RAILWAY SIGNALING

BY

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## PREFACE

It is the purpose of this book to collect from various sources that which is already in use in common practice in the field of railway signaling and to present it in text-book form suitable for the beginner in his study of this subject. Much of the descriptive material and many of the drawings were furnished by the various signal and supply companies specially for this book. Other descriptions and drawings were taken from catalogues and descriptive literature issued by these companies. I have not included any thing concerning specifications for the construction, installation and maintenance of materials. This is a voluminous subject in itself; besides, specifications for practically every item of equipment that enters into railway signaling are provided for in the Manual of the American Railway Association, Signal Section.

In a few cases, I have quoted from the Proceedings of the American Railway Engineering Association, from the Signal Dictionary and from the Railway Signal Engineer. As I have drawn so largely from the Proceedings of the Railway Signal Association, it might be pertinent to state briefly that in its early days the organization was known as the Railway Signaling Club. Later it changed its name to the Railway Signal Association; and recently during the time when the railways were under the supervision of the Director General of Railroads, United States Railroad Administration, the organization amalgamated with the American Railway Association and took the name which it still retains, the American Railway Association, Signal Section. I might state in this connection, also, that the Manual and all the Proceedings of the organization under both the old and new regimes may be obtained from the Secretary, Mr. H. S. Balliet, 75 Church St., New York.

I want to express my appreciation for the help received from all sources, for the material furnished, for the suggestions offered and for the corrections made in the preparation of the manuscript. I am especially indebted to the Union Switch and Signal Company, the General Railway Signal Company, The Federal Signal Company, and the Hall Switch and Signal Company for

the photographs and drawings that I have selected and used for general illustrations. I am equally indebted to all the companies that have furnished photographs and drawings that illustrate their particular line of equipment. I am likewise indebted to the Board of Directors of the American Railway Association, Signal Section, for permitting me to use the many cuts and quotations that I have included in the text. I appreciate very much the assistance given by Mr. G. A. Blackmore of the Union Switch and Signal Company, by Mr. A. G. Moore of the General Railway Signal Company, and Mr. S. J. Turreff of the Federal Signal Company. I am especially grateful to Mr. Balliet for suggestions and corrections that he has offered in the preparation of the manuscript, and to Mr. S. E. Gillespie for his kindness in preparing some of the material for the original manuscript and for his valuable suggestions while reviewing and proof-reading the major portion of the remainder of it.

E. E. KING.

URBANA, ILL.  
*September, 1921.*

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# RAILWAY SIGNALING

## CHAPTER 1

### PRELIMINARY

**1. Introductory.**—Practically the only purpose a railroad has is to give train service to the public and its industries; and whatever will facilitate and expedite train movements to the best advantage to serve this purpose with a reasonable expenditure of capital will work to the best interests of the public generally. As the number of trains increases and their speed, weight, and length grow greater in the effort to handle the continually increasing volume of traffic, the demands for safe and efficient methods of train operation become more urgent. A great many factors enter into the success of railroad transportation, among which are the motive power and train equipment, the track and roadway, the signal systems and methods of despatching trains, and the personnel of the employees from the office boy to the manager. This text deals only with signaling; and the reader should bear in mind that signaling is a means to an end and not the end itself.

**2. History.**—An early history of railway signaling in America written by Mr. J. A. Anderson and published in the March 5, 1909 issue of the *Railway Age Gazette* and reprinted in the 1909 Volume of the *Proceedings* of the Railway Signal Association, gave 1870 as the date for the first interlocking plant and 1863 as the date for the first block system. The interlocking plant was installed at Trenton, N. J., on the line of the United New Jersey Canal and Railroad Companies, afterwards leased by the Pennsylvania Railroad Company. The machine was built by Saxby and Farmer of London after the same pattern as those they had built and installed on lines in England. It was built principally as an experiment, and from this humble beginning the interlocking plant has been installed wherever important railroad crossings and terminals have been established.

The block system was introduced by the same company on the line between New Brunswick and Philadelphia. A form of block signaling had been proposed in England as early as 1842, but its adoption in that country generally was very limited for a number of years afterwards. The system established in America gave positive indications by means of signals, and went a long way in eliminating many of the difficulties involved in the older foreign systems.

In the early days practically all of the signal appliances were of a mechanical type, more or less simple in construction, and did not require men especially trained for their maintenance and operation. Improvements were made from time to time to keep pace with the demands of transportation. The public saw in signaling possibilities for greater safety; the railroads saw opportunities for both safety and efficiency in operation. Later, electricity was applied to solve the signal problems, and it became a potent factor in the growth of the signal industry. More and more was it utilized to replace the human element in signal operation. As the systems grew, organizations grew with them. As the equipment became more complicated, there came the demand for specialists, men who were better trained, and who could give all their time and attention to this particular kind of work. Power interlocking was introduced and the track circuit became well established. Gradually a reliable system has thus been developed to meet the needs of the situation. Interlocking appliances have been made better and automatic block systems perfected until accidents rarely occur on account of signal failures. The service has been so improved that many roads have been able largely to eliminate the train order as a factor in despatching trains.

**3. Organization.**—The field of signal engineering is a distinct one and embraces construction, installation, operation and maintenance of railway signals. The equipment is practically all made by signal manufacturers and is bought by the railroads at a unit price or on a contract basis. The companies that make the equipment may also install it, or the railroad may take the equipment when it is delivered and install it with its own construction forces. In nearly all cases the maintenance is handled by railroad forces.

The general type of organization that prevails on a road will determine, in a measure at least, the particular organization of

the signal department. In the departmental system, the signal engineer reports to the chief engineer and has charge of all the work of the signal department. He makes requisitions for new equipment, has charge of all materials and supplies on hand and directs the work of the organization. In the divisional system, the signal engineer reports to the chief engineer as before and has immediate charge of standards and construction. The divisional maintenance is in charge of the signal supervisor who reports directly to the division superintendent or division engineer. In this connection he is assisted in an advisory way by the signal engineer. The following article written by Mr. A. G. Shaver and published in the September, 1917, issue of the *Signal Engineer* states some of the requirements for success as a signal engineer and outlines a typical signal department organization:<sup>1</sup>

“Four qualifications are indispensable in every man that he may be a good signal engineer; he must have had experience in railway signaling; he must have a technical education; he must be a good executive, and he must have a general knowledge of railroading. Any signal engineer who does not have an intimate knowledge of signaling, such as one gets from actual service as laborer, skilled workman, foreman or maintainer, is not only greatly handicapped, but is more or less inefficient to his company. The technical education need not be that acquired by a course in college, though that is an advantage; it must include a very complete knowledge of the general principles of electricity, an understanding of mechanics and a familiarity with those features of civil engineering concerned in railroad construction. Since the job of signal engineer on most railroads carries with it a command over men, executive ability is necessary for effective results. In railroading a knowledge of construction, maintenance and operation is needed. The construction of the railroad and the signaling must harmonize and be maintained and operated together; it is particularly necessary to know how trains are run and what the facilities must be for trains to be operated to the best advantage.

“Signal departments vary considerably in make-up and jurisdiction, having often been gradually built up from some old arbitrarily established basis and having to meet conditions peculiar to the railroad itself. There are, doubtless, few signal department organizations entirely satisfactory to the signal engineer in charge.

“An example of a suitable signal department organization for a large road is shown by the diagram Fig. 1. The assistant signal engineer, the general inspector, the superintendent of signal construction, the chief

<sup>1</sup> Page 276.

draftsman and the chief clerk all report to the signal engineer. The assistant signal engineer is in authority next to the signal engineer and has charge of all matters pertaining to maintenance and operation and the preparation of standards and specifications. The general signal inspector has supervision over all inspections, investigations, tests, experiments, educational matters and the signal shop. The superintendent of signal construction has charge of all work of construction, reconstruction and changes. The chief draftsman has the preparation of estimates and drawings, the designing of circuits and apparatus and, under the assistant signal engineer, the making of standards and specifications. The chief clerk has authority over the force and business of the office, including accounts, statistics, reports, payrolls, etc. The

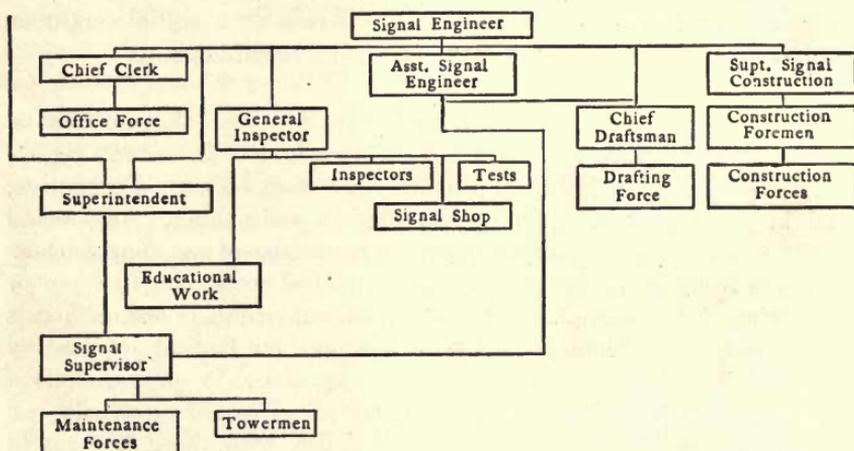


FIG. 1.—A typical signal department organization. (*Railway Signal Engineer.*)

signal supervisor reports to the superintendent in all matters pertaining to the maintenance and operation of signals and to the assistant signal engineer on technical matters, special reports, special requisitions and those things not covered by standards and approved practices; he is appointed by the superintendent on approval of the signal engineer. The signal engineer gives to the superintendent general and special instructions concerning maintenance and operation of signals, confers with him regarding new construction proposed and authorized and assists to get efficient results from the signaling in service.

“On a small railroad this organization may be varied to suit conditions. Ordinarily the signal engineer would have direct authority over the maintenance and operation of signals as well as construction and other matters, and his organization might be curtailed as to the number and assignment of subordinates. Indeed, a railroad may be so small, as to the amount of signaling it has, as not to need a signal department

at all. The care of its signal work could be given over to some existing department having work of a like nature and expert service hired as required."

**4. Rules for Signal Supervisors and Signal Foremen.**—In order to establish a high grade of uniform practice among signal supervisors and their foremen, the following rules were prepared and written in the Manual of the American Railway Engineering Association:<sup>1</sup>

#### RULES GOVERNING SIGNAL SUPERVISORS

1. Signal Supervisors shall report to and receive instructions from the \_\_\_\_\_  
(Title)
2. They shall be responsible for the safe condition and proper maintenance of signals and interlocking plants. They must make temporary repairs of such defects as may endanger or delay the movement of trains, and promptly report defective conditions to the \_\_\_\_\_  
(Title)
3. They must make frequent inspections of signals and interlocking plants and have necessary repairs made as promptly as conditions require. They must see that all failures of signals and interlocking plants are promptly investigated and report made on Form No. . . . .
4. They shall, as necessary, employ men for carrying out the duties for which they are responsible.
5. They must know that foremen are familiar with the operating rules in regard to train signals and flagging, and that they fully understand and comply with them.
6. They must, in case of damage to signals or interlocking, promptly assemble forces, tools and materials, and make necessary repairs.
7. They shall investigate and report on accidents which may be attributable to defects in, or result in damage to, the signal apparatus.
8. They shall conform to the prescribed standards and plans in the execution of work under their charge.
9. They must know that foremen are supplied with tools and materials necessary for the efficient performance of their duties, and see that these are properly used and cared for.
10. They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.
11. They shall keep themselves informed in regard to all work performed in their districts by contractors, or others who do not come under their charge, see that nothing is done by them that will interfere with the safe operation of signals, and report promptly to the \_\_\_\_\_  
(Title)  
if the work is not done in accordance with the prescribed standards.
12. They shall have immediate supervision of work-train service for the maintenance of signals and interlocking plants in their districts, and employ such service only when authorized by the \_\_\_\_\_  
(Title)

<sup>1</sup> Page 430, 1915 edition.

13. They must know that foremen are provided with the rules, circulars, forms, special instructions and safety regulations pertaining to their duties, and that they fully understand and comply with them.

#### RULES GOVERNING SIGNAL FOREMEN

1. Signal Foremen shall report to and receive instructions from the  
(Title)
2. They shall be responsible for the proper inspection and safe condition of signals and interlocking plants under their charge, and shall do no work thereon that will interfere with the safe passage of trains, except under proper protection.
3. They must make such inspection of the signals and interlocking plants in their districts as the \_\_\_\_\_ (Title) \_\_\_\_\_ may direct, and report all defects found on Form No. \_\_\_\_\_
4. They shall employ men as the \_\_\_\_\_ (Title) \_\_\_\_\_ directs. They must treat employees with consideration, and see that they properly perform their duties. They must discharge men who are incompetent or neglect their duties, but in no case shall they discharge men without cause. They must keep the required records of the time of their men and of the materials used.
5. They must each have a copy of the current timetable, and be thoroughly familiar with the rules and regulations therein, and with the time of trains over their districts. They must carefully observe signals displayed by all trains, and assure themselves, before obstructing track, that all trains and sections due have passed. No notice will be given of extra trains, and employees must protect themselves as prescribed by the rules. Foremen must provide themselves with reliable watches, and, when possible, verify time daily with a standard clock or with the watches of other employees who are required to have the standard time.
6. They must, in case of damage to signal or interlocking apparatus in their districts, promptly proceed to the place with the men, tools and materials at their command and do all in their power to make necessary repairs.
7. They shall investigate and report on accidents which may be attributable to defects in, or result in damage to, the signal apparatus.
8. They shall conform to the prescribed standards, plans and specifications in the execution of the work under their charge.
9. They shall be responsible for the proper care and use of tools and materials necessary for the efficient performance of their duties, and shall make requisition to the \_\_\_\_\_ (Title) \_\_\_\_\_ from time to time as additional supply becomes necessary.
10. They must not, except by proper authority, permit experimental trials of appliances or devices, nor give out information of the results of any trial.
11. They must not make nor permit any permanent rearrangement or change in the signals or interlocking plants without proper authority.
12. They must thoroughly understand the rules, circulars, forms, special instructions and safety regulations pertaining to their duties, and see that they are complied with.

**5. Commissions.**—The Interstate Commerce Commission and State Railroad or Public Utilities Commissions are vitally interested in railway signaling, but their interest lies wholly on the side of safety. In its early days the Interstate Commerce Commission gave attention to investigations concerning safety in signal systems, and in 1907 it established a Block Signal and Train Control Board. This Board was charged with a number of duties, among which were those of making investigations in regard to block signals, automatic stops and cab signals, and other devices that were produced with the idea of promoting safety in railroad operation. As block signals had been in service for a sufficient period to be made successful in operation, the Board gave a large share of its attention to automatic stops and cab signals. For a number of years automatic stops have been used on subway, elevated and other electric lines, but their application has not yet been extended generally to steam roads. The Block Signal and Train Control Board passed out of existence in 1912, and their work was then handled by the Division of Safety of the Interstate Commerce Commission. In 1917 the name of the organization was changed to Bureau of Safety of the Interstate Commerce Commission.

Many of the state commissions have formulated rules governing the installation and operation of interlocking plants, block signal systems and other appliances, and have a corps of inspectors to see that their requirements are fulfilled. One of the important problems that the state commissions have to face is the question of adequate protection for vehicles where the highways cross the railways at grade. This has become especially serious in recent years on account of the heavy increase in automobile traffic over transcontinental and other high-speed routes.

## CHAPTER II

### SIGNAL INDICATIONS

Signals are used to convey certain information to trainmen and others interested in railway operation that they may be able to act intelligently with safety and promptness concerning train movements. Practically all of the information given by signals is intended for enginemen, and is generally conveyed by visual indications. "Railway Signaling" is, then, that branch of railway service that is engaged in installing and operating such equipment and appliances adjacent to the track as will indicate to an engineman whether he should advance his train or stop it.

#### 6. Two- and Three-position Semaphore Signal Indications.—

The day indications are given by different positions of semaphore arms, by colored and uncolored lights, or by discs; while night indications are given entirely by colored and uncolored lights. Signal indications may be either two-position or three-position. Two-position signals require a home and distant signal. The home signal gives final authority to the enginemen while the distant signal merely repeats the indications of the home signal; and its function is purely cautionary.

In two-position semaphore signaling the home blade is made with a square end for interlocking and with either a square end or a pointed end for block signaling. The front of it is usually painted red with a white stripe near its outer end and the back of it white with a black stripe near the end. The distant blade is made with a V-shape or fish-tail end. The front of it is generally painted yellow with a black stripe parallel to the end of the blade, or green with a white or red stripe. The back of the blade is painted white with a black stripe. A few roads that do not use this notation, paint the front of all blades yellow with a black stripe and the back black with or without a white stripe.

Three-position blades are made with square ends for interlocking purposes and with either square or pointed ends for block signaling. Where both square and pointed blades are used, the square end blades indicate stop and stay when the signal indicates stop; while the pointed end blades indicate stop and proceed at

low speed when the signal indicates stop. Stop and stay is always the stop indication at interlocking plants.

The front side of three-position blades is painted red with a white stripe parallel to the end or yellow with a black stripe. The back side is painted white with a black stripe, or black with or without a white stripe.

Signal blade indications are given in either the lower or upper quadrant. Two-position signals built as such generally operate the blade from the horizontal into the lower quadrant. In the case of the home signal, the horizontal position means stop; the inclined position, which varies from 45 to 75 degrees below the horizontal, with an average of 60 degrees, means proceed. In the case of the distant signal, the horizontal position means caution

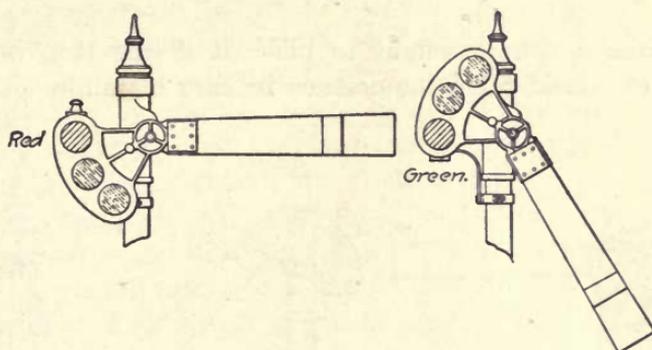


FIG. 2.—Two-position home signal.

and indicates that the home signal is in the stop position; the inclined position means proceed and indicates that the home signal is in the proceed position. An engineman may pass a distant signal set at caution, but he must be prepared to stop at the home signal set at stop. In the case of interlocking, he must stop and stay, while in some cases in block signaling he may proceed after the stop. Figures 2 and 3 show the ordinary two-position home and distant semaphore signals.

Three-position signals may operate the blade in either the lower or upper quadrant. The horizontal position means stop; inclined up or down 45 degrees from the horizontal means caution, the first signal ahead is at the stop indication; up or down 90 degrees from the horizontal means proceed. Figure 4 shows three-position lower and upper quadrant semaphore signals.

The upper quadrant signal is the latest development of blade

indications and possesses some advantages over lower quadrant movements, chief among which is the fact that the arm does

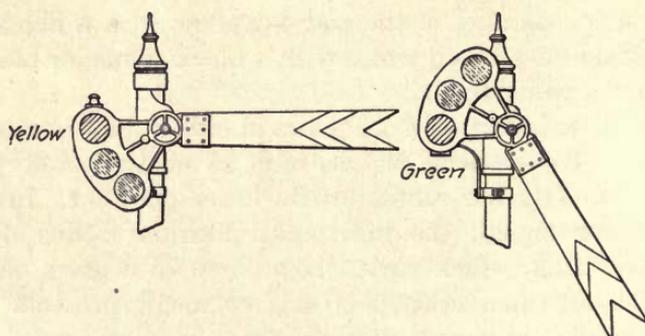


FIG. 3.—Two-position distant signal.

not require a counterweight to place it in the stop position. This is of considerable importance in case of failure of signal

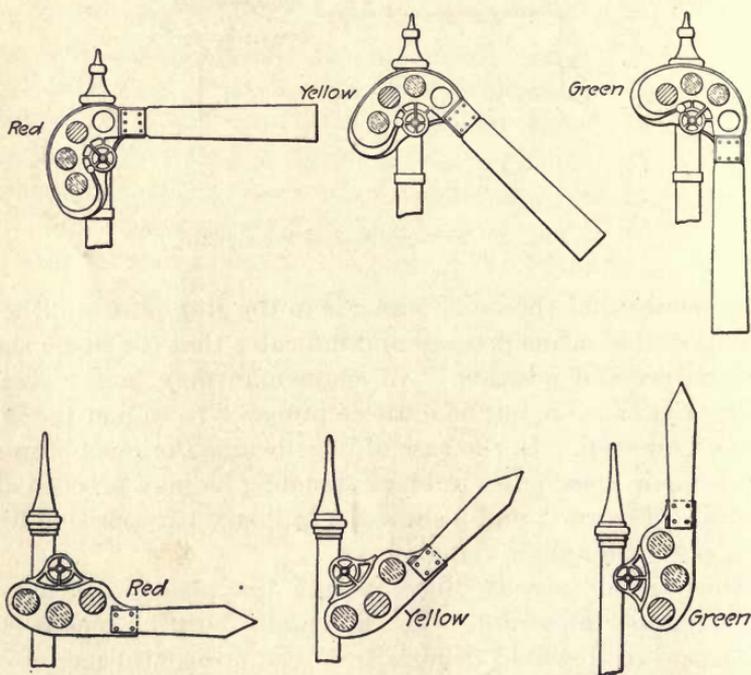


FIG. 4.—Three-position lower and upper quadrant signals.

operating mechanisms. Should sleet collect on the blade it would tend to pull the upper quadrant signal to the stop position and

to hold the lower quadrant signal in the proceed position. There is little doubt, too, but that the blade giving the proceed indication in the upper quadrant can be seen farther by engineers than one giving the same indication in the lower quadrant.

Signal light indications in the case of two-position signals are given by two colors in the home and two in the distant signal. A red light in the home signal means stop, a green light means proceed, as indicated by Fig. 2. A yellow light in the distant signal means caution, a green light means proceed, as shown by Fig. 3. Some roads use the combination red and white, and green and white, for the indications. The objections raised against the white light are that it might be confused with some other light or might be the result of a broken roundel. In the case of three-position signals a red light means stop, a yellow light caution, a green light clear, as indicated in Fig. 4. Some roads use the combination red, green, and white, but the same objections hold against the white light. Where three-position signals are used at interlocking plants, not in block signal territory, the home and distant signals are wired to indicate only in the 0 and 90-degree positions, upper and lower quadrants. When used where automatic block signals are in operation, the home and distant signals indicate also in the 45-degree position, a caution indication for block signaling, but proceed for interlocking.

The casting in the two-position signal is generally made with three spectacles in which the upper two glasses, called roundels, are the same color. The object of having the two glasses with the same color is to give a continuous stop or caution indication until the signal reaches the proceed position. The three-position lower quadrant signal frequently has four spectacles, the extra one being made to provide for two possible positions of the signal lamp. Usually the lamp is on the side of the post, but occasionally it stands on top.

**7. Color Lights for Day Indications.**—Within recent years it has become the practice on many electric lines and even on some steam roads to use lights for giving both day and night indications. Where large and powerful lenses are used in connection with reflectors and deep hoods, as shown in Fig. 5, the lights can be seen for a considerable distance, even in bright sunlight. For three-position signaling with colored lights each signal will have three lenses, red, yellow, and green, placed vertically with the usual arrangement of having the red at the bottom, the yellow

in the middle, and the green at the top. The range of vision varies from a few hundred feet for subway and tunnel signaling to 3,000 ft. for outdoor signaling where the light must be distinctly seen in bright sunlight by high-speed trains. There must be enough spread to the light so that a train crew can readily see it as they approach it on a curve.

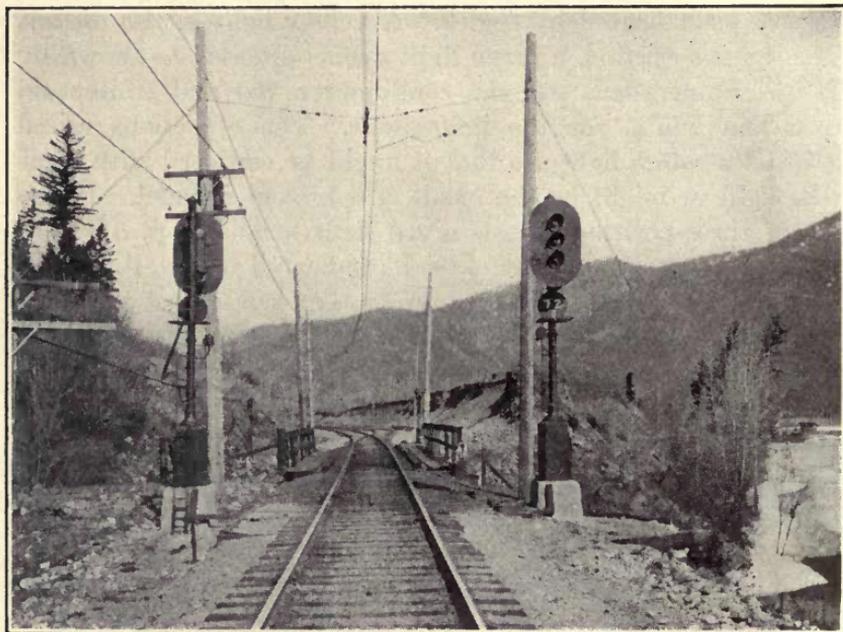


FIG. 5.—Color-light signal.

**8. Position-light Signals.**—The position-light signals first came into use in 1915 at the time the Pennsylvania Railroad electrified its line between Philadelphia and Paoli. The signal is a modification of the semaphore to the extent that the indications are given by electric lamps placed in rows to represent the positions of the blade in upper quadrant signaling. Both two- and three-position signals are used for high-speed lines with four lights in each row spaced 18 in. apart to represent the different positions of the signal blade. Yellow-tinted lenses are used with the advantage of having a longer range of vision. The lamps for high signals are provided with deep hoods and with metal backgrounds. The dwarfs are provided with two lunar-white lamps in each row constructed for a comparatively short range of vision.

Light signals require a greater current than semaphore signals

for continuous normal clear indications, for it requires a comparatively small amount of energy to hold semaphores to the proceed indication; but if lights could be wired to give their indications only on the approach of trains, they would use a very small amount of current and extend the life of the lamp in proportion. There is more justification for using lights to give day indications on roads that use alternating current for signaling or propulsion than on those that use the battery for signaling. As the current is already available in those cases, practically no additional expense is necessary for wiring.

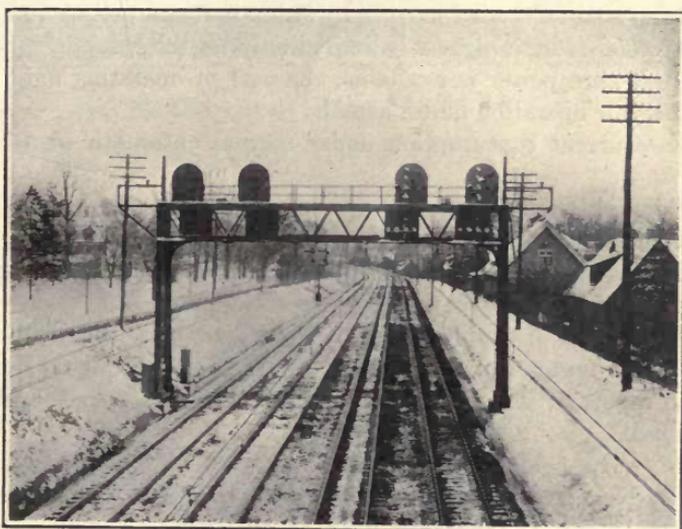


FIG. 6.—Position-light signal.

As there are no complicated mechanisms nor moving parts as there are in the case of the semaphore signal, the chances for failure are materially reduced. By having standard light indications for both day and night signaling instead of two distinct types, the semaphore for position by day and the light for color by night, the system becomes much simplified. The lights have another advantage that there are no exposed parts, such as the disc or blade to collect sleet and ice, thereby tending to obscure the indication. The following conclusions concerning the use of light signals are given in the 1917 volume of the *Proceedings* of the Railway Signal Association:<sup>1</sup>

<sup>1</sup> Page 10.

*First.*—Colored and position-light signals, for day and night use, by elimination of all moving parts except the control relays, reduce the number of failures.

*Second.*—Light signal aspects have greater visibility and range under adverse weather and background conditions than the semaphore, while the close indications compare favorably.

*Third.*—Light signals give uniform indications at all times. Other types of signals give the indication by position in daylight, by color at night, and by both during transition periods. The various aspects of the position-light signal are equal in intensity, range and visibility.

*Fourth.*—In general practice, the number of aspects of any one arm of a semaphore is limited to three. With the position-light signal, four distinctive positions may be used, while the number of indications given by colored-light signals is limited only by the colors available.

*Fifth.*—Where power is available, the cost of operating light signals is less than for operating motor signals.

*Sixth.*—Current consumption under normal automatic signal conditions:

Position-light signals: Four 5-watt lamps—20 watts.

One colored light: 35 to 50 watts.

For interlocking signals, consumption is increased depending upon the number of lights displayed, but the ratio holds.

*Seventh.*—Cost of maintenance of light signals is considerably less than that of motor signals, and, as the colored-light signal has fewer lights to renew, it has an advantage in this respect over the position-light signal.

*Eighth.*—The field for the economical use of light signals is limited, as noted above, to points where power is available. In this field, the light signals have advantages over other types. The position-light signal can be installed at any location where clearance will permit the present standard semaphore to be erected. The colored-light signal can be used in more restricted clearances.

**9. Disc Signals.**—A few roads are using the disc signal for automatic block signaling purposes. It operates as a two-position signal, although in an entirely different manner from the semaphore type. The day indications are given by colored discs, a red disc for the home signal and a yellow or green one for the distant signal. Each disc operates in an enclosed case mounted on top of a post that stands in the same relative position to the track as does the semaphore signal, as shown in Fig. 7. To give the stop or caution indication, the disc swings into full view entirely covering the opening in the front of the banjo-shaped case, as shown by (a) and (b) of Fig. 8. To give the proceed

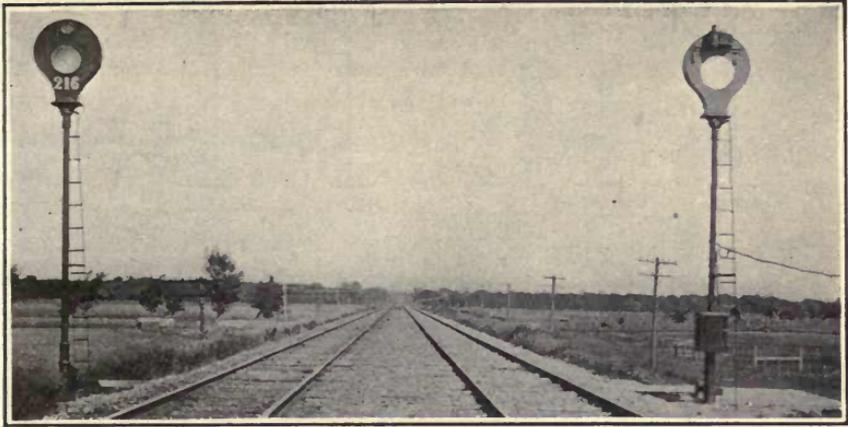


FIG. 7.—Disc signals arranged for left-hand running.

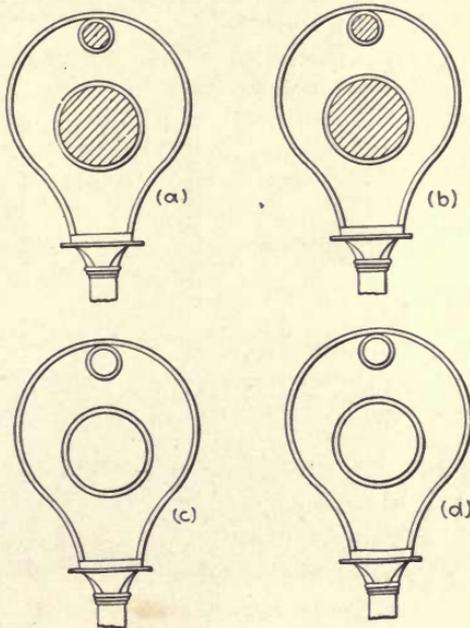


FIG. 8.—Disc signals.

- |  |   |
|--|---|
| (a). Home Signal,<br>Stop Indication,<br>Red Disc,<br>Red Light.     | (b). Distant Signal,<br>Caution Indication,<br>Yellow or Green Disc,<br>Green Light |
| (c). Home Signal,<br>Proceed Indication,<br>No Disc,<br>White Light. | (d). Distant Signal,<br>Proceed Indication,<br>No Disc,<br>White Light.             |

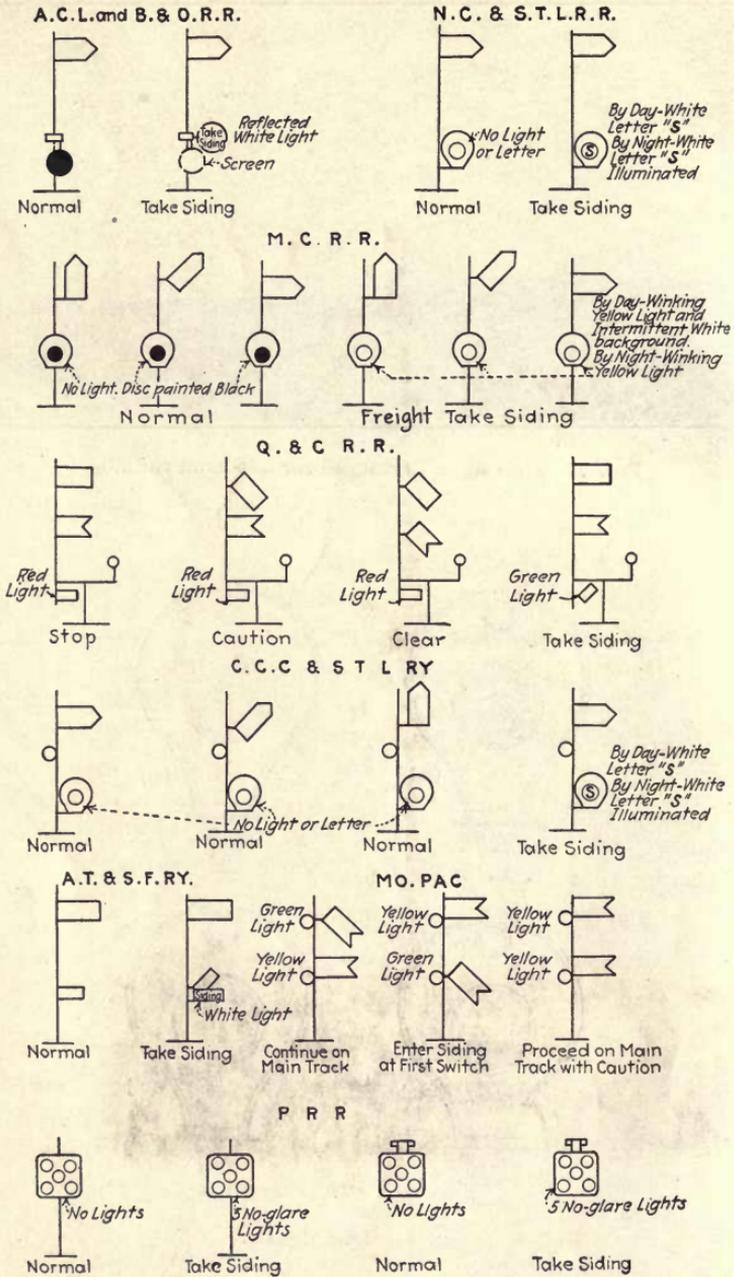


FIG. 9.—Take siding indicators. (Pro. R. S. A. 1918, pages 276-277.)

indication it swings almost, if not entirely, clear of the opening as indicated by (c) and (d) of Fig. 8. Just above each disc is a light for the night indications that are given by the following colors: (a) red; (b) green; (c) white; and (d) white. Where two discs appear on one mast, the upper one is generally the home signal and the lower one the distant signal.

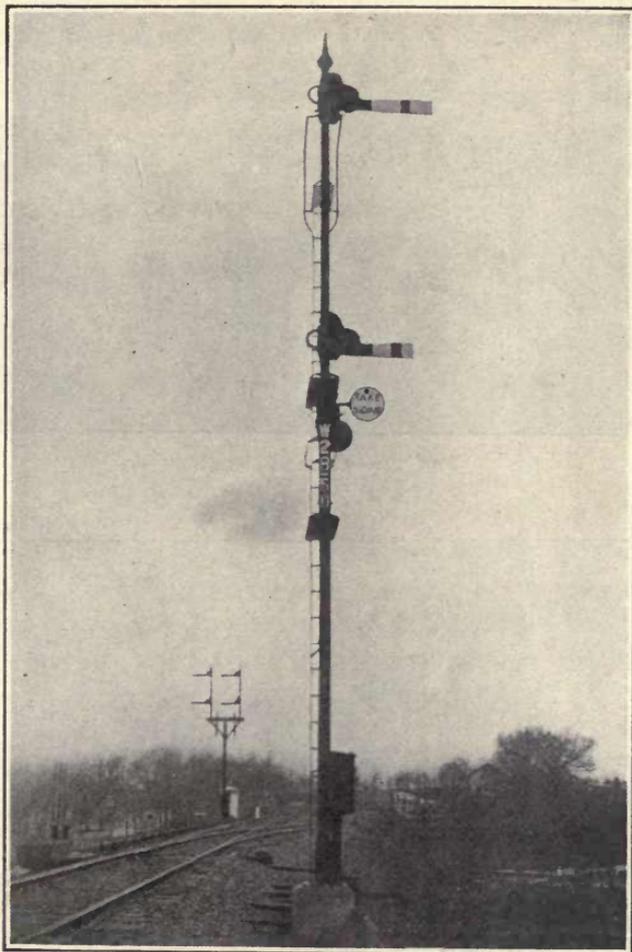


FIG. 10.—R. S. A. take siding signal.

**10. Take Siding Signal.**—The take siding signal in one form or another is used by a few roads to notify trainmen without the use of train orders to take siding at non-interlocked switches, especially located at some distance from the operating towers. The different types include both semaphore arms and discs. One of the forms in service is a two-arm signal in which the lower arm is

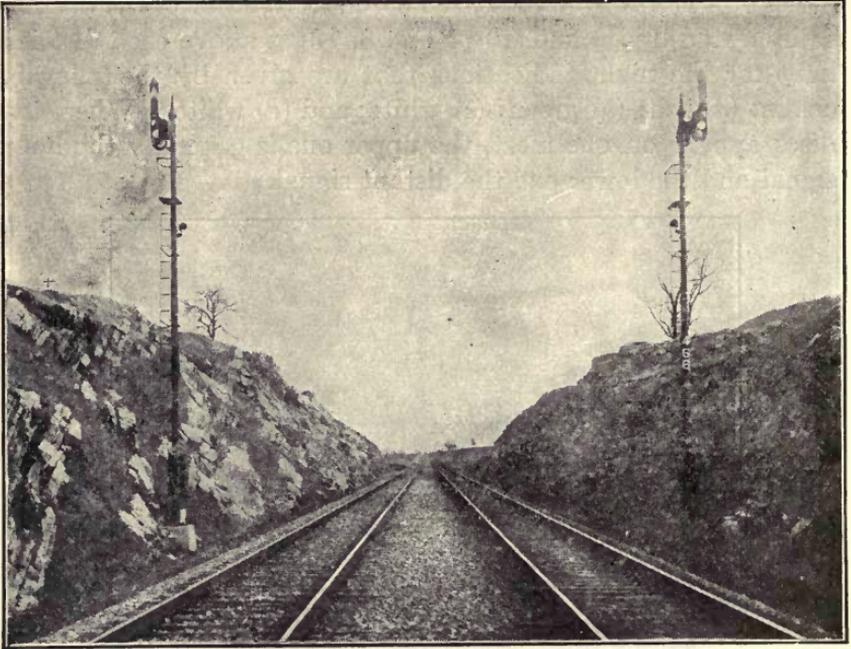


FIG. 11.—Ground signals.

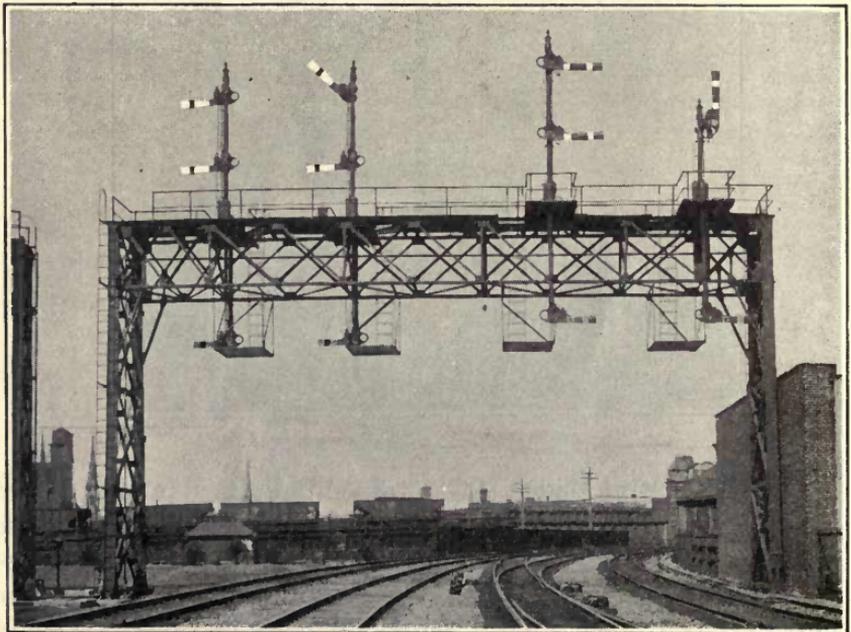


FIG. 12.—Signal bridge.

operated to the 45-degree position in the upper quadrant and is marked with the words "Take Siding" illuminated at night. One road employs a disc case that displays a swinging disc for day indications and a blinking light for night indications. Two roads use a disc bearing a white letter "S" illuminated at night, and two use a yellow disc bearing the words "Take Siding" properly illuminated at night. Another road employs five no-glare lights arranged in the form of an X for both day and night

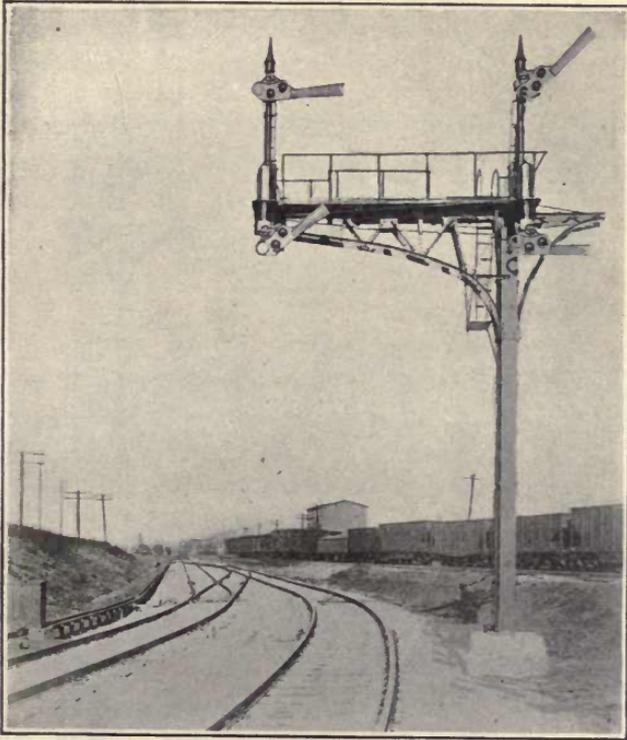


FIG. 13.—Bracket signal.

indications. The signal is located in the rear of the switch, so that the engineman must pass it before he takes the siding. It is controlled from the nearest tower or from the train dispatcher's office, and is usually operated by means of the ordinary electric signal mechanism.

**11. Relative Location of Signals and Tracks.**—There must be a set of signals to govern the movements of trains in each direction. In railway practice in America, ground signals are nearly always located on the right-hand side of the track they govern, as indi-

cated by Fig. 11. On one or two double-track roads where left-hand running is the custom, they are located on the left-hand side. In the case of semaphore signals, on steam roads, the blade extends to the right of the post while on electric railways, the blade may extend either to the right or to the left, depending upon local conditions. Where there are several parallel tracks or where there is not sufficient room at the side for semaphores, the signals are usually mounted on signal bridges. In this case,



FIG. 14.—Bracket signal and doll post.

they are mounted on short poles, supported above or suspended below the bridge directly over the tracks they govern, as shown in Fig. 12.

Where there are two high-speed tracks for traffic in the same direction, as in the case of the four-track line, the bracket signal may be used as shown in Fig. 13. The inside signal governs the inside track of the two and the outside signal the outside track. If the outside track is a freight line where trains are run

at a somewhat lower speed, the outside pole may be a little shorter than the inside one.

In case there is a siding between the high signal and the track it governs, the bracket type of semaphore may be used as before. A bracket post signal will govern the inside track and a short doll pole without a signal blade will represent the outside track. This arrangement is simply to indicate that there is one track between the signal and the track it protects as shown in Fig. 14. A purple light is used on the doll pole at night. If there are two tracks between the signal and the track it governs, two such doll poles will be used on a bracket post.

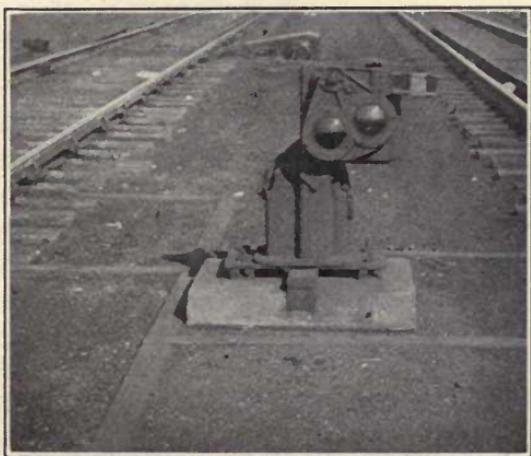


FIG. 15.—Upper quadrant two-position dwarf signal.

Dwarf signals are used as home signals to give interlocking indications in practically the same manner as high signals except that they are used only where the movements of trains are slow. The dwarf is not used at all for block signaling purposes, neither is it used as a distant signal. An upper quadrant two-position dwarf signal is shown in Fig. 15. It is the practice on many roads to use the purple instead of the red light for dwarf indications. This is distinctive; and, although of short range, it is possible to use the purple since the train movements that it governs are necessarily slow.

## CHAPTER III

### INTERLOCKING

**12. Definition.**—The subject of signaling naturally divides itself into two phases, interlocking and block signaling. As discussed here, interlocking is the operation of an assemblage of equipment and appliances used to govern the movements of trains over conflicting routes; while block signaling is the operation of equipment and appliances used to govern the movements of following or opposing trains over the same route.

Where movements of trains on one track may conflict with those on another, such movements are usually governed by visible signals operated by an interlocking mechanism so constructed and arranged that there can be no conflict of signal indications. This not only provides safety for train operation, but also expedites train movements. Such "an arrangement of switches, lock and signal appliances, so interconnected or interlocked that one movement must succeed another in a predetermined order," is defined by the American Railroad Association as an interlocking plant.

**13. Object.**—The plant is so constructed that the control of all the ground functions is located at one point. This provides for a much more expeditious operation than if each function had to be manipulated by a lever on the ground. The control equipment usually is placed in the second story of the tower, which is so located and constructed as to permit the operator to see the entire yard. Concentrating the controlling apparatus all at one point provides an opportunity for interlocking that would be almost impossible if each function were handled as a separate unit.

Up to 1919 there had been installed approximately 5,300 interlocking plants on American roads. The motives that prompted expenditures for such equipment were based on the idea of expediting train movements while assuring their safety. At a railroad crossing where no interlocking plant is installed, all trains in most states are obliged by law to come to a full stop before they attempt to pass the crossing. The purpose of such regulation is to require train crews to ascertain that the way is

clear in order to prevent collision, and even then there is a strong possibility of trains colliding. If there should be a number of such crossings in succession in regions of dense traffic, the time lost in stopping and starting would tend to intensify the congestion that might arise from other sources. Where interlocking plants are installed at crossings, however, trains are not ordinarily required to stop. This affects a saving not only in the time element involved, but also in the expense of operation in stopping and starting the trains. In 1905, Mr. J. A. Peabody, Signal Engineer for the Chicago and North Western Railway Company, obtained some analyses of the cost of starting and stopping trains; and from the data then available he determined that a road could economically install an interlocking plant where there were between 16 and 20 trains a day.<sup>1</sup> While the first cost of construction and the expense of operation of such plants have increased since that time, the expense of train service and equipment has increased in proportion so that the conclusions drawn probably still hold true.

In the case of four-track lines where two tracks are ordinarily given to passenger service and two to freight, the capacity of the road may be considerably increased if the crossovers between tracks having traffic in the same direction are interlocked. This arrangement would permit a fast freight, for instance, safely to take the passenger track between two points in order to pass a slower freight without the necessity of the slower train taking siding and waiting.

**14. General Plan.**—The first step in installing an interlocking plant is to make, or otherwise secure, a plan of the tracks affected. This should be drawn to suitable scale and should show all tracks, switches, and railroad crossings, and all street crossings, buildings, tanks and water-cranes that may influence the details of the plant. The size of the scale will depend upon the complications and local conditions, and will usually be 100 ft. to the inch. Fifty feet to the inch may be chosen if greater detail is necessary. The tower, signals, derails, and other parts of the interlocking plant are then located on the map using for this purpose the symbols adopted and recommended by the Railway Signal Association, and which are shown in Appendix B. It will be noted that a signal is laid flat on the map with the top in advance of the base as the train it governs approaches it.

<sup>1</sup> *Proceedings* Railway Signal Association, Volume I.

Two sets of signals are required for an interlocking plant, a home signal and a distant signal. The home signal stands just in the rear of the derail or switch that it governs; while the distant signal stands from 1,200 to 6,000 ft. in the rear of the home signal. The distance between the two signals depends upon the length of track required to stop a train and the kind of power used to operate the distant signal. The home signal is the controlling one and must not be passed by a train until the proper indication is given. The distant signal is a purely cautionary function and serves to warn enginemen of the indication that its home signal is showing at that particular time.

On account of the heavier train equipment and the high speed found necessary to maintain schedules, many roads that formerly operated their distant signals mechanically with a wire have moved them farther away from the home signal and are operating them by electric power. This increased distance affords greater safety in train operation with but little, if any, more expense for maintenance. From a questionnaire sent out by the Railway Signal Association in 1906 it was found that for 15 roads, approximately one-third of the mileage in the United States, the average distance from the distant signal to the home signal was 3,745 ft. and to the interlocking tower was 4,025 ft. In 1901 the average distance from the distant signal to the home signal was 1,444 ft. and to the tower was 1,750 ft.

In addition to signals, derails also form a very necessary part of the interlocking equipment at railroad crossings and junctions. A derail is a device for throwing an engine or car from the track; and the presence of such equipment in the plant is to guarantee that the train shall stop before it reaches the crossing should the route not be lined up for it to proceed. The derail is generally located about 500 ft. from the crossing, while the home signal is placed about 58 ft. in the rear of the derail, as shown in Fig. 16. By placing the derail this distance from the crossing there is practically no chance for the derailed train to continue on the ties and reach the crossing.

All signals and derails at an interlocked crossing stand normally at danger to stop traffic. When they are set against movement of traffic, they are said to be "normal;" when they are in position for movement of traffic, they are said to be "reversed." The levers corresponding to these positions are also normal and reversed. Usually one lever is assigned to operate each function.

**15. General Order of Locking Signals and Derails.**—When a movement over a crossing is desired, the towerman first closes the two derails on the track, then he clears the home signal on the side from which the train is approaching, and finally he clears the distant signal on that side. When a derail on one track of a crossing is reversed, it locks the derails of the conflicting tracks at normal. When the derails are reversed the home signal may then be reversed, and this movement locks the derails reversed. The distant signal is then unlocked and may be reversed, locking the home signal clear or reversed. The levers in the tower must

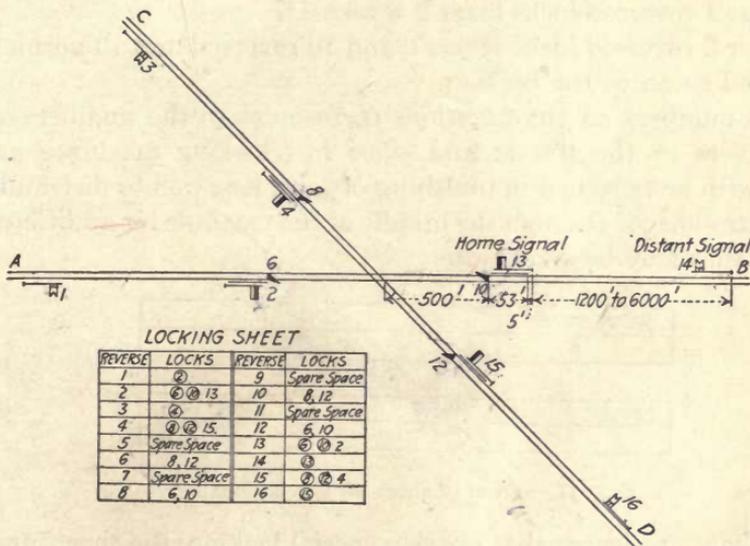


Fig. 16.—Single track crossing a single track.

be operated in this order, for the construction of the plant will permit no other. To put the plant normal the functions must be operated in the opposite order.

To have a train pass from A to B in Fig. 16, the towerman clears derails 6 and 10. This locks derails 8 and 12 open. He then clears the home signal 2, which locks 6 and 10 closed, and 13 normal. He finally clears distant signal 1, which locks 2 clear. To set the track to normal again the towerman sets distant signal 1 to caution, then home signal 2 to the stop position, and finally opens derails 6 and 10.

In order to line up a route through an interlocking plant, therefore, all the derails on the route must be reversed, locking those

on conflicting routes normal. Clearing the home signal then locks all the derails in the route reversed and all opposing direction signals normal. Finally, clearing the distant signal locks the home signal reversed.

**16. Locking Sheet.**—A locking sheet is a tabulated statement of the order in which the levers of any particular plant interlock one another. In the locking sheet shown in connection with Fig. 16, the levers in the first column are all understood to be reversed. Those in the second column that are reversed are shown as such by drawing a circle around them; otherwise they are understood to be normal. The chart reads:

Lever 1 reversed locks lever 2 reversed;

Lever 2 reversed locks levers 6 and 10 reversed and 13 normal:  
and so on to the bottom.

The numbers on the functions correspond to the numbers on the levers in the tower; and since interlocking machines are built with lever spaces in multiples of four, it is well to distribute the extra spaces through the middle of the machine for additional levers that may be added later.

REVERSED	LOCKS	
5	④	W ⑦

LEVER	WHEN	LOCKS
5	⑦	④

FIG. 17.—Form of sheet for special locking.

If there are levers that operate special locking, the sheet must include them also. The usual form of expressing such locking is as shown in one of the forms in Fig. 17, which in each case reads lever 5 reversed locks 4 reversed when 7 is reversed.

When facing point locks, designated *F.P.L.*, are used to lock the derails and switches, the two locks on the same route at a crossing are generally thrown by one lever and the two derails by another. In the case of switch and lock movements, designated *S.L.M.*, one lever in a mechanical plant is generally assigned to each derail or switch, although two may be assigned where power is used.

If facing point locks were used in Fig. 16, the numbering and locking would be as shown in Fig. 18. A single track crossing a double track where switch and lock movements are used, has a locking sheet as shown in Fig. 19. Back-up movements, or

those that run counterwise to the normal direction of traffic, are governed by dwarf signals. Otherwise the installation is the

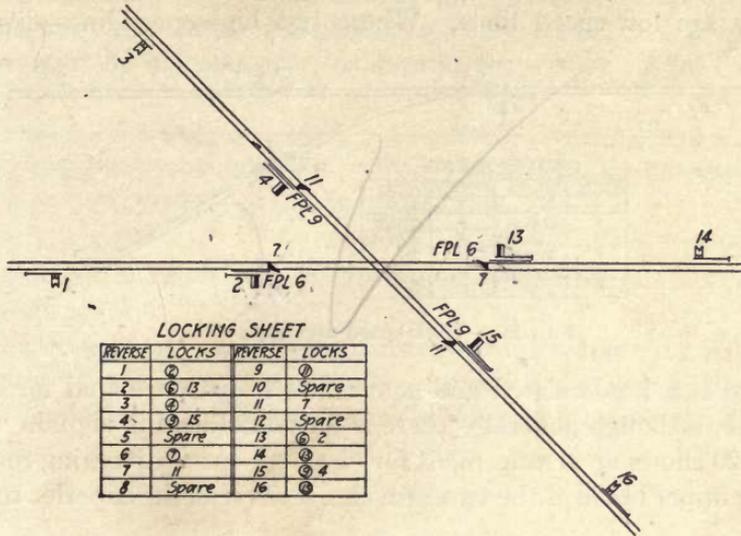


FIG. 18.—Facing point locks.

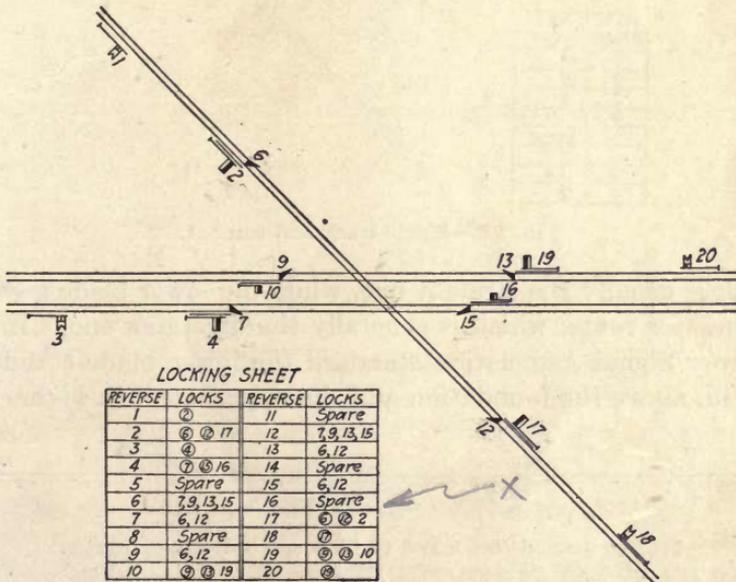


FIG. 19.—Single track crossing a double track.

same as for a single-track crossing. The details for the dwarf signals are generally located about 250 to 300 ft. from the crossing.

17. **Diverging Routes.**—There are many cases of diverging routes that require more than one signal on a post. In some instances the diverging routes are high-speed lines and in others they are low-speed lines. Where two high-speed lines diverge

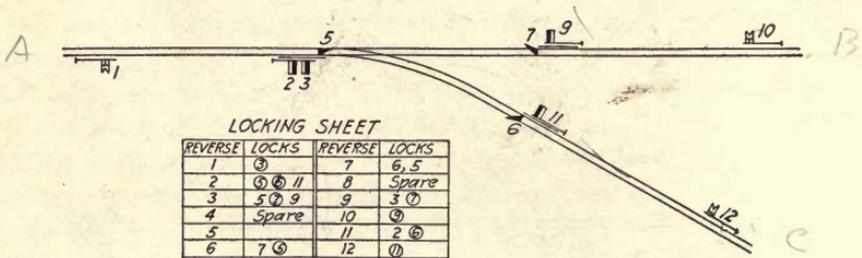


FIG. 20.—High speed diverging routes.

there is a home signal and sometimes a distant signal for each route, although generally there is only one distant signal. Figure 20 shows an arrangement for two high-speed diverging routes. The upper blade of the two-arm signal governs the superior route,

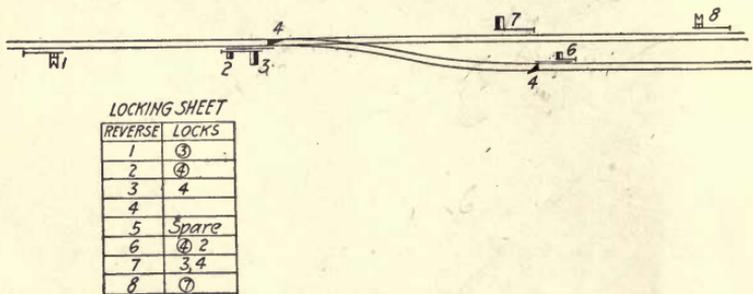


FIG. 21.—Single track and turnout.

which is usually the straight one, while the lower blade governs the inferior route, which is generally the diverging one. In the Railway Signal Association standard the lower blade stands 22 ft. 6 in. above the foundation and the upper one 7 ft. higher.

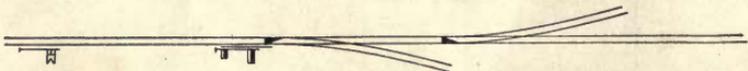


FIG. 22.—Single track and two low speed diverging routes.

Whenever a very low-speed route diverges from a main line, the high-speed route may be governed by a high signal, while the inferior route may be governed by a dwarf signal placed either on the lower portion of the high signal post or on the ground at the

base of the post. Figure 21 shows an arrangement where the two blades are on the same post. When the dwarf signal is cleared, the high-speed home and distant signals are respectively in the stop and caution positions. The inferior or low-speed route may be a cross-over, a transfer, or a spur. The dwarf

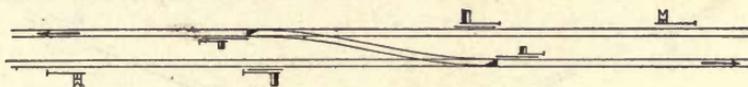


FIG. 23.—Trailing point crossover.

signal on the siding is to govern trains moving from the siding to the main track.

Where there are two or more inferior routes diverging within a comparatively short distance, the common practice is to have a set of high signals to govern the main line and a dwarf all of the

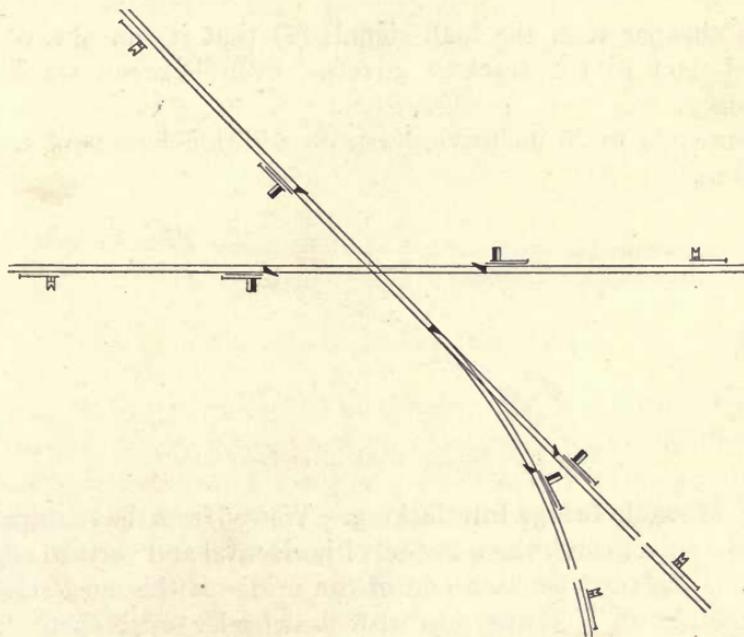


FIG. 24.—Single track crossing and high speed diverging route.

others. In Fig. 22 the dwarf may govern either of the diverging routes. It will show a clear indication when any of the diverging routes is lined up.

As the dwarf signal is low, the engineman can see it only a short distance ahead and therefore he is required to reduce his

speed and to keep his locomotive under control as he approaches the turnout. On the other hand, the blade must be high in the case of high-speed routes in order that the engineman may see it at a distance. Besides requiring the engineman to check his speed, the dwarf signal has two other advantages: (1) that it is

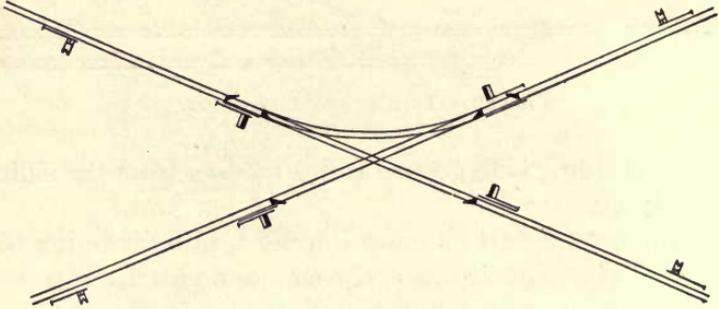


FIG. 25.—Single track crossing and transfer track.

much cheaper than the high signal; (2) that it can always be placed next to the track it governs, even between tracks if necessary.

Figures 23 to 26 inclusive illustrate additional cases of route signaling.

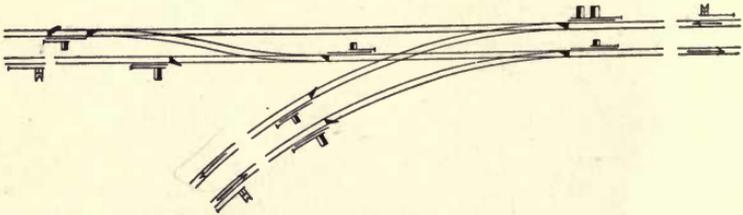


FIG. 26.—Double track diverging routes.

**18. Movable Bridge Interlocking.**—Viewed from the standpoint of train movements, the question of horizontal and vertical alignment of the track at each end of the bridge is the most serious that comes up in connection with drawbridge operation. The bridge when properly closed not only must be so placed that the track centers are continuous, but also it must be so seated that the top of the rail is continuous. For this purpose end lifts are required for horizontal swing bridges to place the rails to the proper surface and locks to secure them in this position and also in proper alignment. Locks are necessary also for lift bridges in order to secure the continuity of the track.

The rail ends may be cut either mitered or square. In case of mitered joints the full thickness of the web of the rail should continue to the end of the point. The point should be placed in a trailing position at each end of the bridge on double track and in a trailing position towards the center of the bridge on single track. Some sort of provision should be made, as for instance the addition of an easer rail on the outside of the joints, to support the train wheels across the gap between the bridge rails and the approach rails.

Signals are used to protect movable bridges in practically the same manner as railway crossings. The interlocking machine is frequently placed on the bridge itself. The interlocking should be so constructed that the bridge should be locked in alignment for traffic before the signals can be cleared; and conversely, the

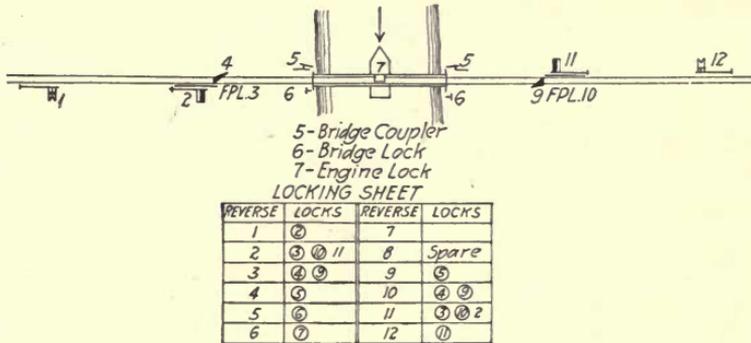


FIG. 27.—Drawbridge interlocking.

signals should all be locked at the stop position when the bridge is open. Where mechanical interlocking is employed the connections between the pipes on the bridge and those on the roadbed are made by means of couplers. The order in which the towerman operates the functions to close a bridge and line up the route for trains is: motor, bridge locks, couplers, derails, facing point locks, home signal, and distant signal. Each one reversed locks all those in front of it reversed. There is, then, no possibility of opening the bridge until every signal and derail is set at the stop indication. In order to open the bridge the levers must be placed normal in exactly the reverse order. Figure 27 gives a plan of the signal and derail arrangement together with a locking sheet for a single-track swing bridge. The derails are placed at least 500 ft. from the bridge so that the derailed trains cannot

run into the stream. Usually each derail and facing point lock has its own lever to guarantee safety in operation. In the case of double-track lines the derails for back-up movements should be not less than 300 ft. from the bridge.

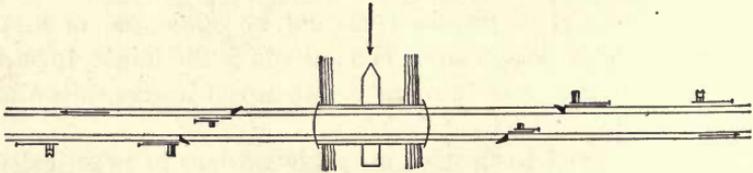


FIG. 28.—Drawbridge interlocking.

**19. Requirements for the protection of traffic at movable bridges** as defined in the *Proceedings* of the Railway Signal Association in 1916:

The protective appliances at drawbridges consist in devices for insuring that the bridge is in proper position, and the track in condition for the passage of trains over draw, or for reduction to a minimum of the damage in case of trains not stopping when track is not in condition for passage of same over draw; also the usual devices for protection against damage in case of derailment.

The protective devices may be classified under the headings:

- (a) Interlocking power and bridge devices.
- (b) Bridge surfacing, aligning and fastening devices.
- (c) Rail-end connections.
- (d) Signaling and interlocking.
- (e) Guard rails.

(a) *Interlocking Power and Bridge Devices.*—Interlocking the drawbridge devices so that their movements must follow in a predetermined order to protect the drawbridge machinery.

(b) *Bridge Surfacing, Aligning and Fastening Devices.*—Drawbridges should be equipped with proper mechanism to surface and align them accurately and fasten them securely in position. This condition can be secured by the use of efficient end lifts in case of swing bridges, and by proper end locks in case of lift bridges.

(c) *Rail-end Connections.*—Rail ends may be mitered or cut square. Mitered rails where lapped should retain the full thickness of the web to the points. The points should be trailing to normal traffic where possible; on single-track bridges the points should be trailing to traffic entering the movable span.

Where rail ends are cut square or mitered and not lapped, they should be connected by sliding sleeve or joint bar or by easer rails to carry the wheels over the opening between the end of bridge and approach rails.

(d) *Signaling and Interlocking.*—If trains are to proceed over drawbridges which are in service, without first stopping, interlocking should be installed which will provide that the drawspan, tracks and switches within the limits of the plant are locked in the proper position.

This will require:

1. Locking drawbridge devices.
2. Locking providing for the proper order of operation of signaling devices, such as signals, switches and derails.

This interlocking will require the following order of operation:

BEFORE OPENING A DRAWBRIDGE      BEFORE OPERATING TRAINS OVER  
DRAWBRIDGE

- |                                    |                                  |
|------------------------------------|----------------------------------|
| 1. Display stop signals.           | 1. Lock bridge and rail devices. |
| 2. Unlock rail and bridge devices. | 2. Display clear signals.        |

Since there are various types and designs of drawbridges and various drawbridge devices for each of the types, and also various designs and types of signaling devices, as well as various locations, from which they all may be interlocked and operated, a typical example only of the detail order of operations is given; *viz.*, a swingbridge with all its devices operated from one location on the drawspan, having home and distant signals, derails, etc.

TO OPEN DRAWBRIDGE

TO PASS TRAINS OVER DRAWBRIDGE

- |  |  |
|--|--|
| 1. Display stop signals.   | 1. Close bridge.   |
| 2. Unlock derails.   | 2. Insert bridge surfacing, aligning and fastening devices.  |
| 3. Open derails.   | 3. Insert rail-end connections.  |
| 4. Uncouple interlocking connections.  | 4. Operate power-controlling device to position preventing application of power to bridge machinery. |
| 5. Unlock rail-end connections.  | 5. Lock bridge surfacing, aligning and fastening devices.  |
| 6. Unlock bridge surfacing, aligning and fastening devices.  | 6. Lock rail-end connections.  |
| 7. Operate power-controlling device to position permitting application of power to bridge machinery. | 7. Couple interlocking connections.  |
| 8. Withdraw rail-end connections.  | 8. Close derails.  |
| 9. Withdraw bridge surfacing, aligning and fastening devices.  | 9. Lock derails.   |
| 10. Open bridge.   | 10. Display clear signals.   |



struction to derailed wheels which are guided by the guard rails should be reduced to a minimum.

(f) *Rail Attachments*.—The rails and attachments should be separated from the metallic structure so track circuits may be successfully operated the entire length of the bridge.

(g) *Bridge Devices*.—The various bridge devices should be so designed that Railway Signal Association interlocking apparatus may be used.

(h) *Locking*.—Electric and time locking are regarded as adjuncts.

**20. Track Diagram and Manipulation Chart.**—A track diagram and a manipulation chart are usually placed in each tower for the benefit of the signalmen. The track diagram is a plan of the track layout showing the relative positions of the switches, derails, and signals with the number assigned to each that corresponds to the lever that operates it; the manipulation chart shows the order in which these functions must be operated to line up a certain route. The diagram and chart are made on rather a large scale and are hung on the front wall of the tower so that the signalmen can see them as they stand to manipulate the levers. A typical track diagram and manipulation chart are illustrated in Fig. 29.

## CHAPTER IV

### MECHANICAL INTERLOCKING

#### INTERLOCKING MACHINES

**21. General.**—Two kinds of interlocking plants are built—mechanical and power. In the mechanical plant, the levers are operated by hand; and the movements are transmitted by hand power to the switches, signals, and derails by means of pipes, wires and other mechanical appliances. In the other type the levers are operated by hand, but they are so constructed as to bring into action some kind of power to operate the switches, signals, and derails. The power most commonly used is air or electricity, or a combination of the two; and such plants are known as pneumatic, electric, or electro-pneumatic.

The levers of an interlocking plant are arranged in a row across the second floor of an interlocking tower parallel to one set of tracks in the plan. The front of the interlocking machine is the side on which the towerman stands while he operates the levers. The levers are numbered from the left to the right of the towerman as he stands in position to operate his machine. The location of the levers in the machine should correspond somewhat to the respective locations of the functions on the ground. In the case of the railroad crossing, those signal levers that stand nearest together on the ground should be grouped nearest together in the machine. Usually the signal levers are on the ends and the switches and derails between. The arrangement of the levers should be such as to cause the signalman to walk back and forth as little as possible to manipulate them.

The mechanical machines may have either horizontal or vertical locking. The horizontal type is known as Saxby and Farmer; the vertical has three similar designs, Standard or Style A, Johnson, and National. Most of the vertical locking plants in use have Style A machines.

**22. Horizontal Locking.**—Figure 30 illustrates an eight-lever Saxby and Farmer interlocking machine, while Fig. 31 shows it more in detail. The figures used in the explanation of the system

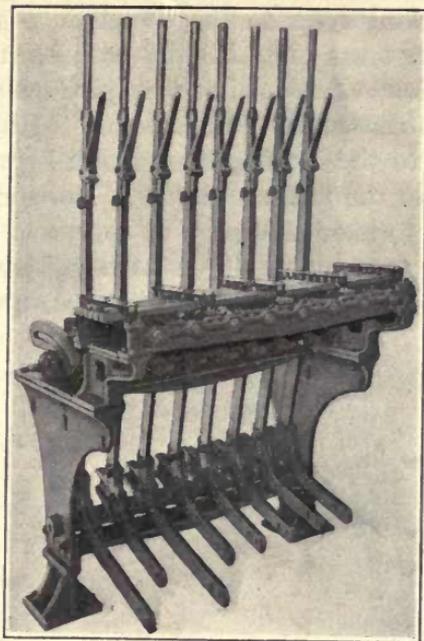


FIG. 30.—Saxby and Farmer interlocking machine.

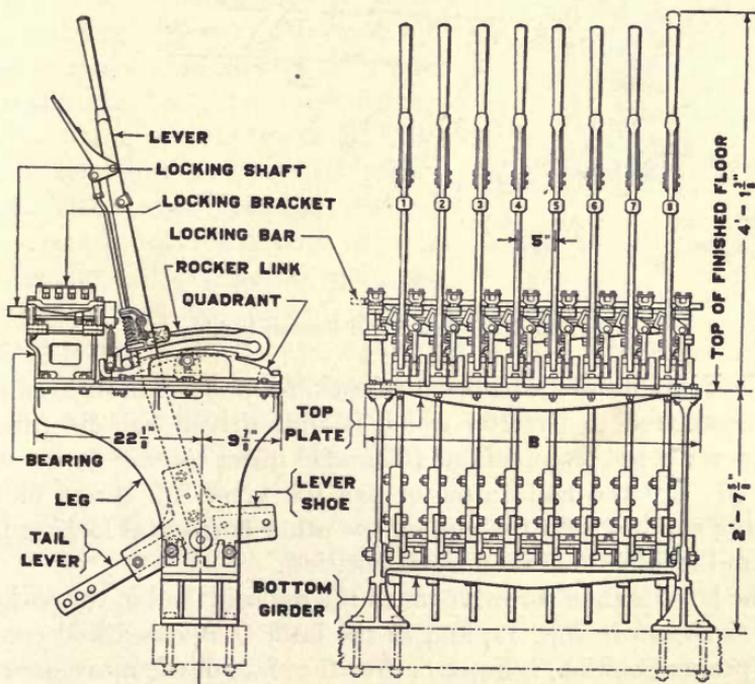


FIG. 31.—Saxby and Farmer interlocking machine.

of horizontal locking refer to the sketch in Fig. 32. Lever 1 is pivoted near its lower end at 3 and is shown in the sketch in its normal position. Rocker-link 5 is pivoted at its center 4. The back end of this rocker-link is connected by means of the universal link 6 to the locking shaft crank 7, which in turn is rigidly fastened to the locking shaft 9. Horizontal locking bar 10a is connected to locking shaft 9 by means of the locking bar driver 8. As the towerman pulls on latch 2 of lever 1, he lifts for

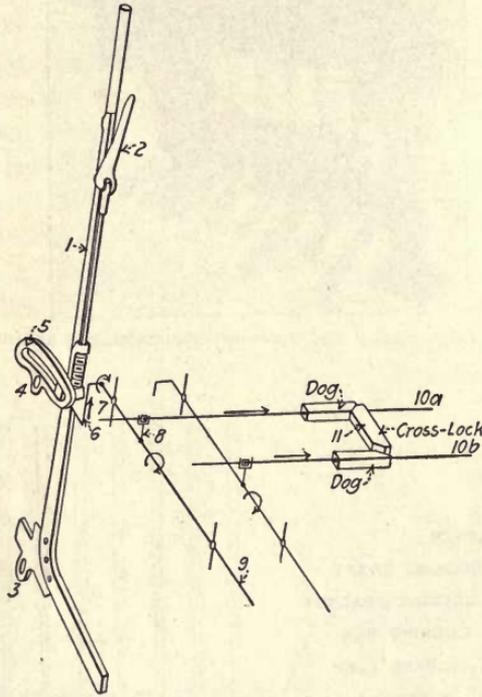


FIG. 32.—Saxby and Farmer locking.

one-half its throw, the back end of rocker-link 5. This movement is transmitted to bar 10a which is thus driven half its throw. The dog riveted on top of bar 10a makes miter contact with cross-lock 11, and the half throw of bar 10a gives full throw to 11, making contact with the dog on the other horizontal locking bar 10b and locking it in its normal position.

The lever is then thrown over to the opposite end of the rocker-link as shown in Fig. 33; and as the latch is released and comes into proper position, it imparts the other half of the movement to the horizontal locking bar. While the movements of the signals

and switches are made by the lever, the movements of the locking are all made by the latch. This is known as preliminary or latch locking, and is very fundamental in the construction and operation of the machine. This insures that not only must the lever be placed in its full normal or reverse position, but that it also must be locked in this position before any other levers can be unlocked. Furthermore, with this arrangement the signalman can apply only a comparatively small amount of pressure against the locking bed; whereas, if the lever, itself, were connected directly to the locking he might be able to apply enough force to cause the locking to break or fail.

The locking shafts, locking bars, dogs, cross-locks, and brackets assembled in working order constitute what is called the locking bed. The locking bars are  $\frac{1}{2}$  by  $\frac{3}{4}$  in. in section and are arranged in pairs. The pairs have  $\frac{5}{8}$  in. clear space between them. Most of the machines are constructed with half as many brackets as levers and they are spaced to come between the locking shafts and not directly above them. The cross-locks may extend between two locking bars or entirely across the bed depending upon the particular locking construction. The cross-locks are  $\frac{3}{4}$  in. square in section and have a throw of  $\frac{3}{8}$  in. When the lever is normal, the locking bar stands as far to the right as it is possible to go; when the lever is reversed, the bar stands as far to the left as it is possible to go, moving from one position to another through a distance of  $1\frac{3}{4}$  in.

**23. Special Locking.**—Special locking is applied to the Saxby and Farmer machine by having a long crooked dog fastened to the locking bar in such a manner as to permit it to swing about one end. This is called a swing dog or "when" dog. The cross-lock is made in two pieces, one on each side of the swing dog. The dog on one locking bar will drive the cross-lock to engage another

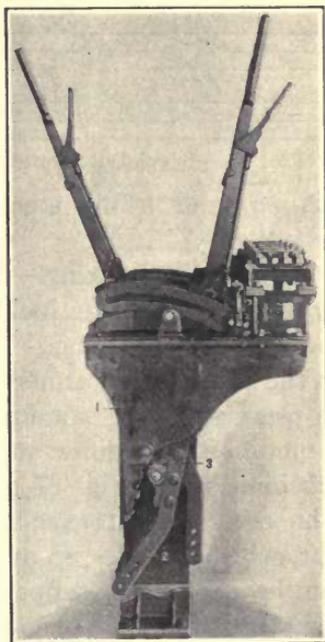


FIG. 33.—Saxby and Farmer interlocking machine.

when the swing dog is in place between the two sections of the cross-lock. That is, dog 1 reversed will lock 2 normal when swing dog 4 is reversed. When 4 is reversed it makes the cross-lock practically continuous, for 4 can swing about its pivot *P*, Fig. 34. If 4 is not reversed, reversing 1 will have no effect on 2. Figure 35 shows the different forms of dogs used in the Saxby and

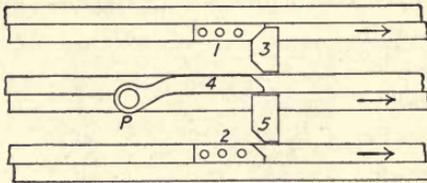


FIG. 34.—Special horizontal locking.

Farmer machines. Numbers 1 to 13 inclusive are locking dogs; 14, 16, and 18 are left-hand swing dogs; 15, 17, and 19 are right-hand swing dogs; 20 is a swing dog trunnion; 21 is a locking bar driver; 32, 33, and 34 are stock pieces for making locking bars and cross-locks.

**24. Vertical Locking.**—In the case of machines with the vertical type of locking, the locking bed stands vertically; whence the name, vertical locking. The levers are substantially the same as in the Saxby and Farmer machines and they operate rocker-links in practically the same manner, but the remainder of the construction is very different. Figure 36 shows a view of the Style A machine, while Fig. 37 gives more details of the construction. The end of the rocker-link is connected by a link to a tappet bar, which it slides up and down through a distance of  $1\frac{1}{16}$  in. On the sides of the tappet are V-shaped notches and on the front are tappet pieces that engage dogs fastened to small locking bars which slide horizontally through locking guides. Two or more dogs are fastened to each bar, and as the tappet is pushed or pulled it impinges the dog by miter contact. If the bar is free to move, the lever may be thrown. The sliding of the bar will cause one or more dogs on it to engage the notches of other tappets, locking them in either the normal or reverse position. The locking bars are  $\frac{3}{8}$  in. in section and have a throw of  $\frac{7}{16}$  in. Lifting the latch in the vertical machine gives the rocker-link and the tappet one-half their throw, and releasing it at the other end of the quadrant completes the locking.

Vertical machines are ordinarily built with not more than four locking plates, which are numbered from the top down, 1, 2, 3, and 4. The plates are made to contain both back and front locking bars. Three bars may be placed side by side in the back of each locking plate and five in front, giving a maximum of eight

bars to each plate. The back locking dogs operate in the same plane as the tappet bars. If it should become necessary at any time to install more locking bars, additional locking plates may be

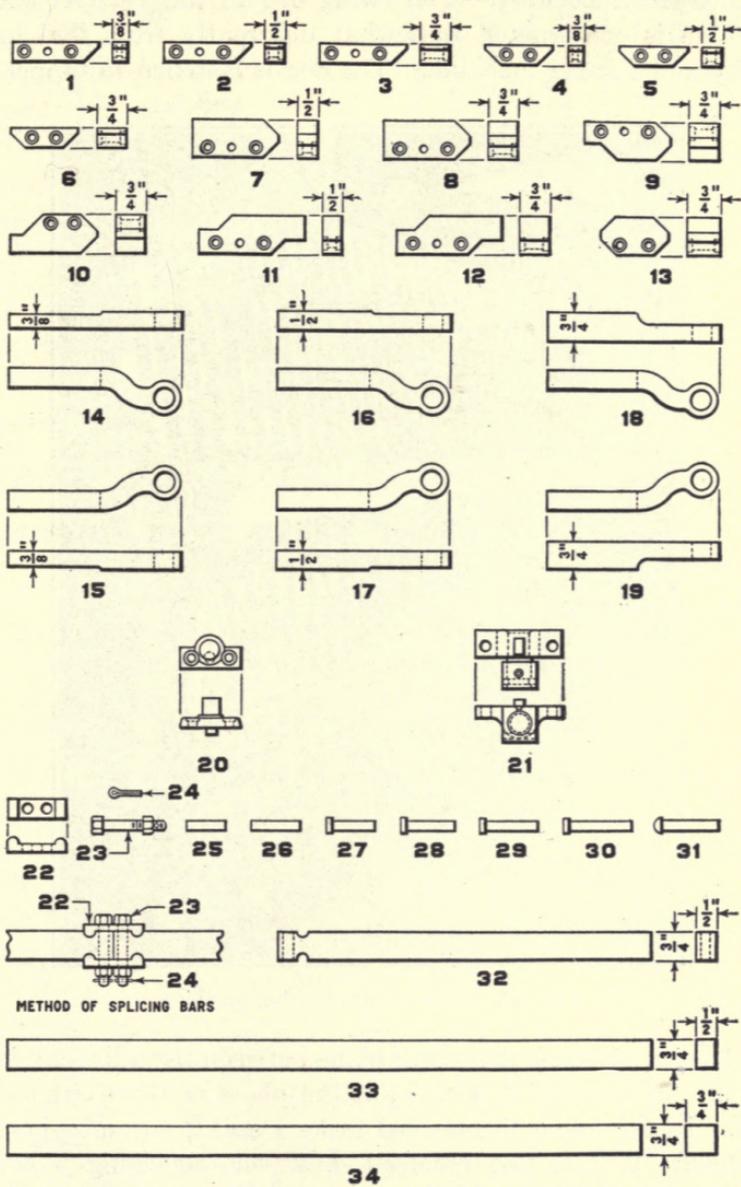


FIG. 35.—Locking details of Saxby and Farmer interlocking machine.

provided by using extension legs for the machine. In making up a dog chart, the back locking for each space is shown above

the front locking of that space. Figure 38 illustrates an example of back locking. 1 and 2 are tappet bars so arranged that 1 reversed locks 2 normal.

**25. Special Locking.**—The swing dog in the vertical locking machine is constructed somewhat differently from that in the Saxby and Farmer machine. The dog is fastened to tappet 4 in

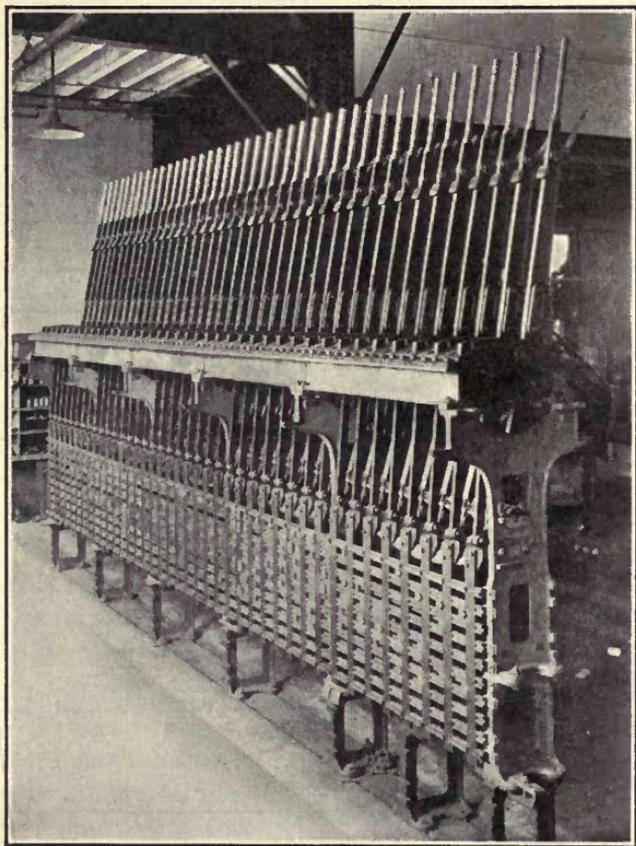


FIG. 36.—Style A interlocking machine.

Fig. 39 and swings in a vertical plane between the adjacent dogs *a* and *b*. The special locking is in the plane of the front locking bars. In the figure, 5 reversed locks 1 and 2 normal when 4 is reversed. If 4 is not reversed, however, reversing 5 has no effect on 1 and 2.

In Fig. 40, the numbers 1 to 36 inclusive represent front locking dogs; 37 to 39 are front couplings; 40 to 42 are front carriers; 43 is a special swing dog; 44 to 49 are tappet pieces;

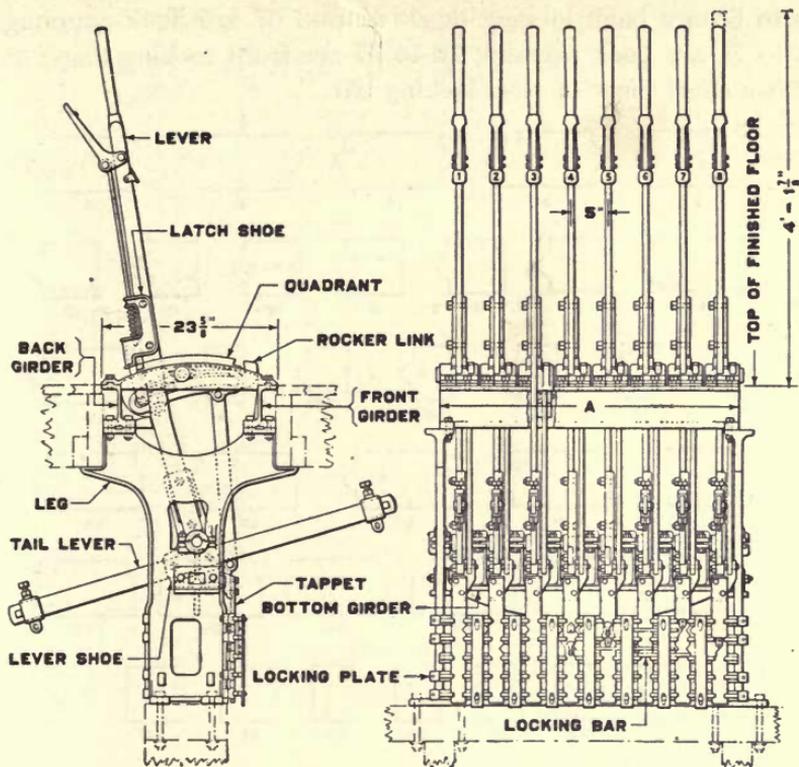


FIG. 37.—Style A interlocking machine.

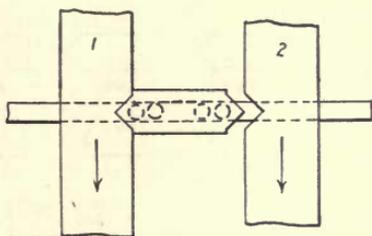


FIG. 38.—Back locking.

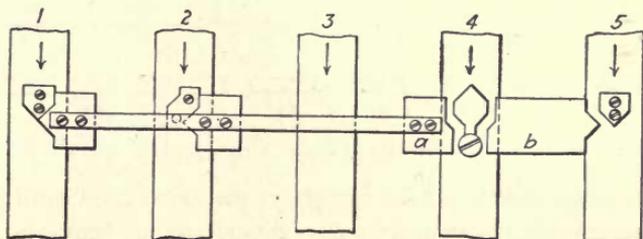


FIG. 39.—Special vertical locking.

50 to 65 are back locking dogs; 66 and 67 are back couplings; 68 to 71 are back carriers; 72 to 77 are front locking dogs; and 83 is a short piece of steel locking bar.

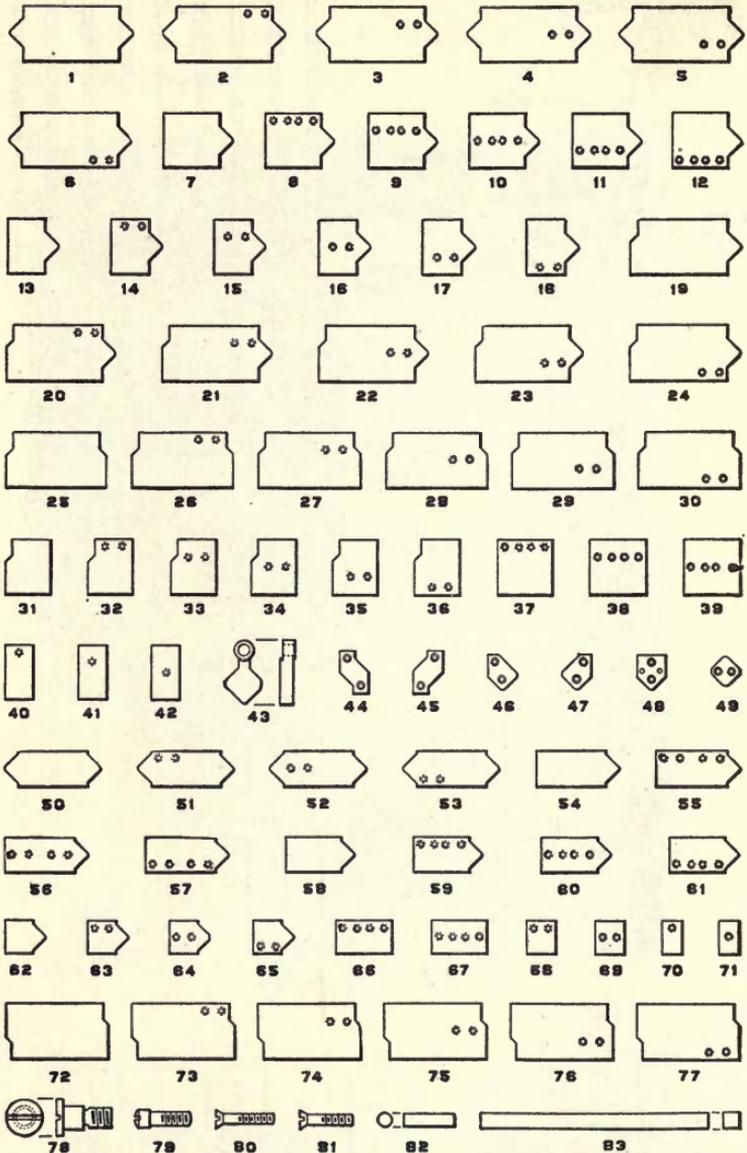
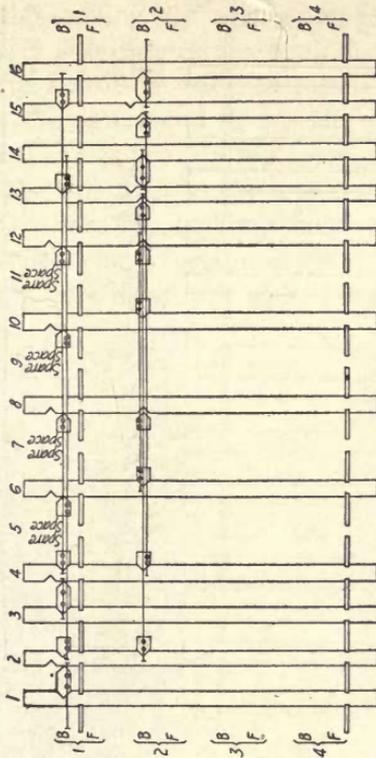


FIG. 40.—Locking details of style A interlocking machine.

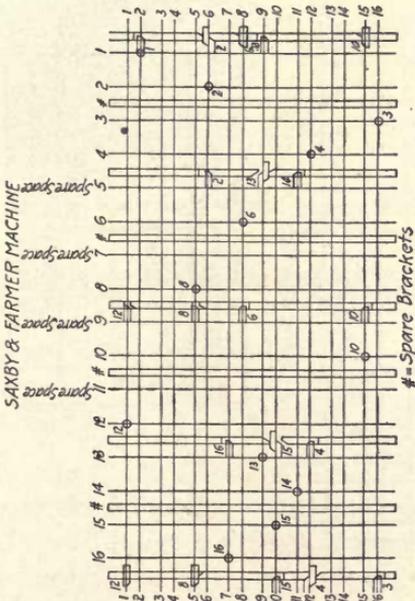
**26. The Dog Chart.**—The dog chart is a plan showing the locking arrangement of any particular interlocking machine. The dog chart for the Saxby and Farmer machine is made up with the

STYLE "A" MACHINE



NOTE:  
 B - Bar in Back of Tappet  
 F - Bar in Front of Tappet

SAXBY & FARMER MACHINE



Locking Sheet	
Level	Level
1	9 Spare Space
2	10 12
3	11 Spare Space
4	12
5	13
6	14
7	15
8	16

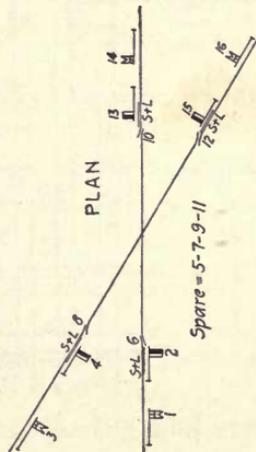
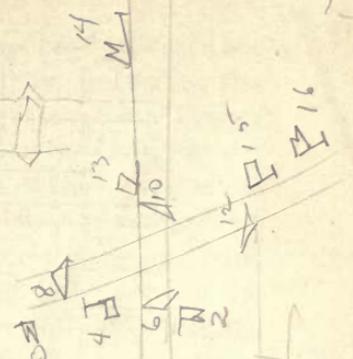
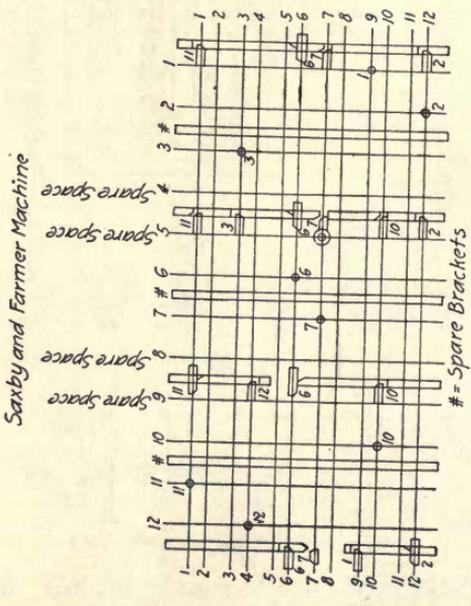
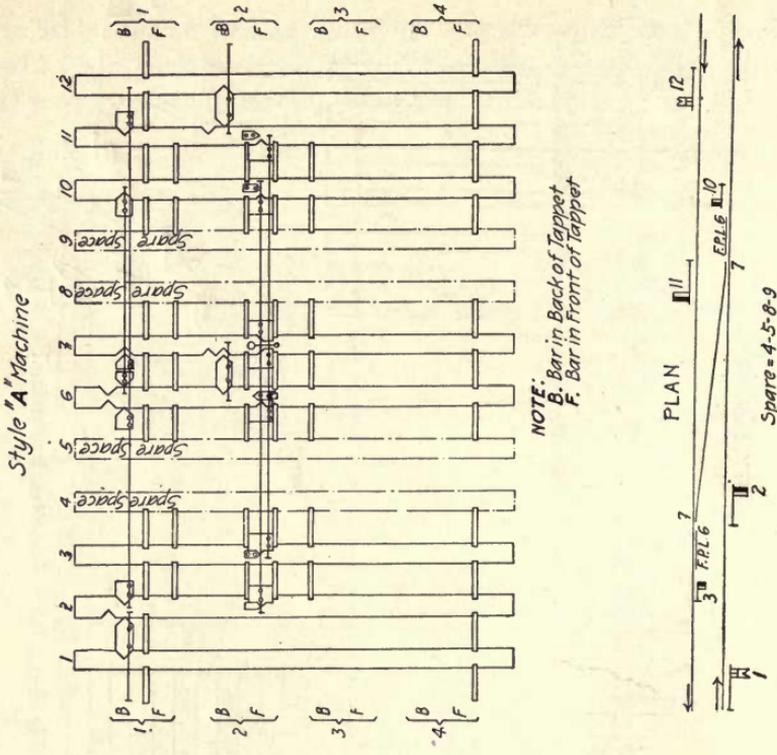


Fig. 41.—Locking sheet and dog charts for a single track crossing.



1	2	3	4	5
9	10	11	12	13
14	15	16	17	18



Locking Sheet			
Lever/When	Locks	Lever/When	Locks
1	②	6	7 ⑦
2	7-⑤-10	7	-
3	⑥-11	8	Spare Space
	⑦ 10	9	Spare Space
4	Spare Space	10	⑥
5	Spare Space	11	7-⑥
		12	⑦

FIG. 42.—Locking sheet and dog charts for a trailing point crossover between the main tracks of a double-track line.

front of the locking bed at the top just as an observer would see it if he were standing at the back of the machine and facing the operator in position to manipulate the levers. This throws lever 1 to the right-hand side on the drawing, as shown in Fig. 41. The figures across the top represent numbers of the levers, while those on the side refer to the locking bars. The circles represent the points where the locking shafts connect to the locking bars.

On the dog chart for the Style A machine, illustrated in the same figure, the back locking is shown above the front locking.

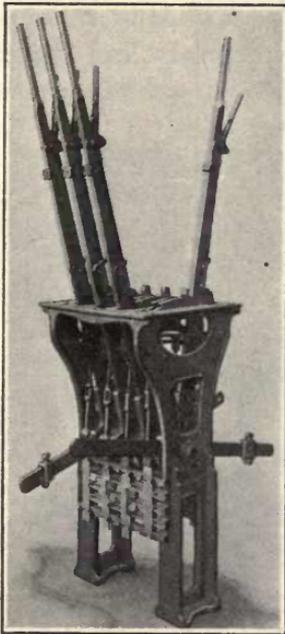


FIG. 43.—The National interlocking machine.

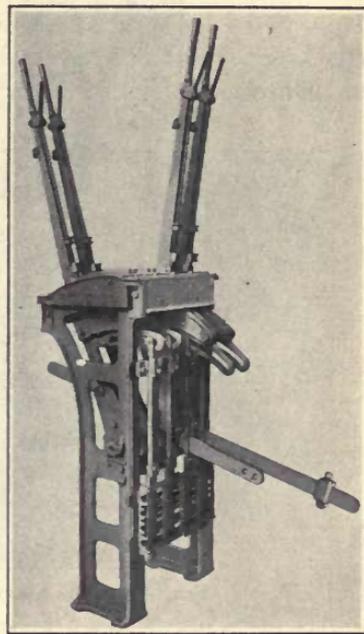


FIG. 44.—The Johnson interlocking machine.

$\left. \begin{matrix} B \\ F \end{matrix} \right\} 1$  are back and front locking spaces of the first or top plate;  
 $\left. \begin{matrix} B \\ F \end{matrix} \right\} 2$  are back and front locking spaces of the second locking plate; and so on to  $\left. \begin{matrix} B \\ F \end{matrix} \right\} 4$ . The position of lever 1 is at the left on the sheet.

Figure 42 shows dog charts for Saxby and Farmer and Style A machines to operate a trailing point crossover between double-track lines.

Figure 43 represents a National interlocking machine while Fig. 44 represents a Johnson.

The vertical locking plant requires less room than the horizontal, but has more wear between the dogs and the notches in the tappets. In the case of the vertical locking plant the locking is below the floor, while in the case of the horizontal locking, it is above the floor. Lying below the floor, often in a dark room, the vertical locking frequently does not get the attention and care it should have.

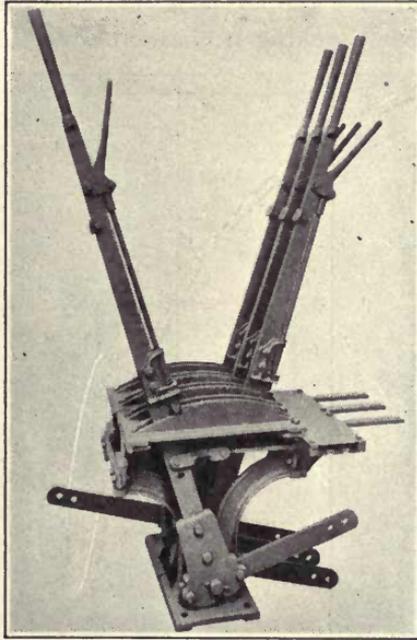


FIG. 45.—The Stevens interlocking machine.

**27. Stevens Interlocking Machine.**—A dwarf type of interlocking machine constructed with lever instead of latch locking is known as the Stevens. It operates with a vertical type of locking placed in a horizontal bed, but the stroke of the tappet is much longer than is the case with the Style A machine. It is used principally where a number of yard switches can be controlled from a central point or where it is desired to install some form of temporary interlocking.

CHAPTER V  
MECHANICAL INTERLOCKING

OTHER EQUIPMENT

28. **Leadouts.**—The equipment that transfers the motion from the levers in the tower to the horizontal pipes and wires on the ground is called the leadout. It includes all of the vertical pipes and wires within the tower and all the rocking shafts, cranks, and

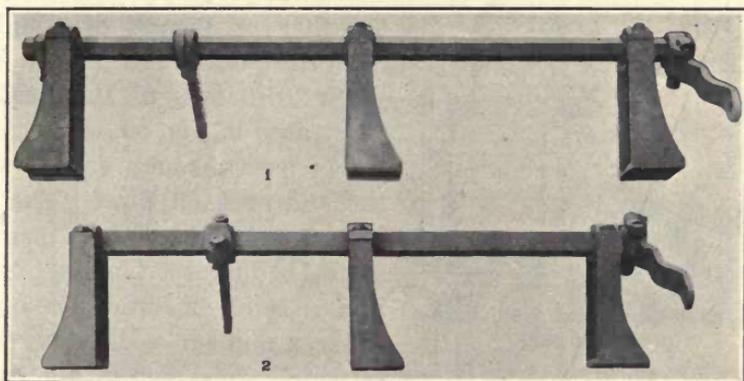


FIG. 46.—Rocking shafts for leadouts.

deflecting bars in the case of pipes, and wheels and chains in the case of wires that connect the pipes and wires inside with those outside the building. In the case of the rocking shaft, shown in Fig. 46, the vertical pipe connects with the outside arm and the horizontal pipe with the adjustable inside arm. The shaft itself may be either square or hexagonal, as the figure illustrates, the square ones being most commonly found in practice.

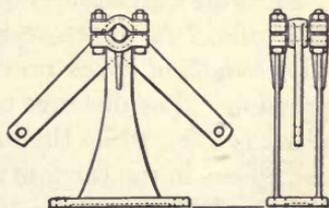


FIG. 47.—R. S. A. vertical crank.

Figure 47 represents a vertical crank and Fig. 48 a horizontal and a vertical deflecting bar. The horizontal crank is illustrated

in Fig. 60. In the case of the deflecting bar, the curved bar slides between two sets of rollers supported by the frame. Figure 49 shows the use of both rocking shafts and deflecting bars in a leadout.

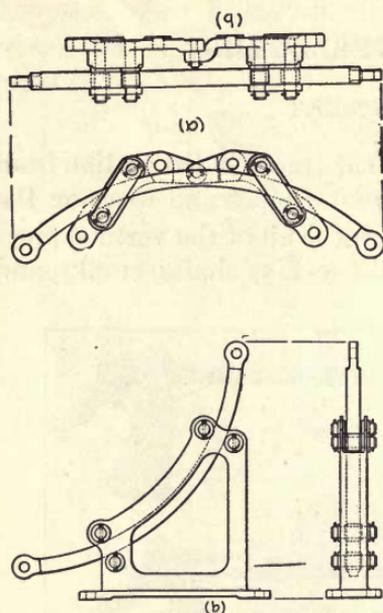


FIG. 48.—Horizontal and vertical deflecting bars.

**29. Pipes and Couplings.**—The movements of the levers in a mechanical plant are transmitted to the derails, home signals, and switches by means of 1-in. iron pipes, and to distant signals by means of No. 8 or 9 steel wire. Home signals and dwarf signals are sometimes operated by wires. The ends of the pipes are fastened together by means of couplings over the outside and  $3\frac{1}{32}$ -in. steel plugs 10 in. long on the inside, as illustrated in Fig. 50. Two  $\frac{1}{4}$ -in. rivets pass through each plug at the end of each pipe. The pipe is fastened to a crank by means of a steel rod with a tang on one end and a solid or screw jaw on the other, a number of different forms of which are shown in Fig. 51.

**30. Stuffing Box.**—It very often becomes necessary to carry pipe lines under a street, in which case the pipes are placed inside of larger pipes enclosed at the ends by stuffing boxes, as illustrated in Fig. 52. The outer pipes are filled with oil to preserve the materials and to eliminate the friction.

**31. Pipe Carriers.**—Pipes are supported on pipe carriers placed, as a rule, 7 ft. apart on straight lines and 6 ft. apart on curves. This length of space prevents buckling when the pipe is in compression. The distance center to center of levers in a mechanical plant is 5 in., while the distance center to center of pipes as they are placed in the carriers is  $2\frac{3}{4}$  in. The two rollers in the carrier, the one below and the other above the pipe, tend to reduce the amount of friction during the movement of the pipe line. Where there is only one set of rollers in the frame it is called a one-way carrier; where there are two, a two-way carrier; and so on. The pipe carrier is fastened to its foundation by means of a pipe

carrier base. The transverse carriers, represented by Fig. 54, rest on two track ties and carry the pipes under the rails at right angles to the track.

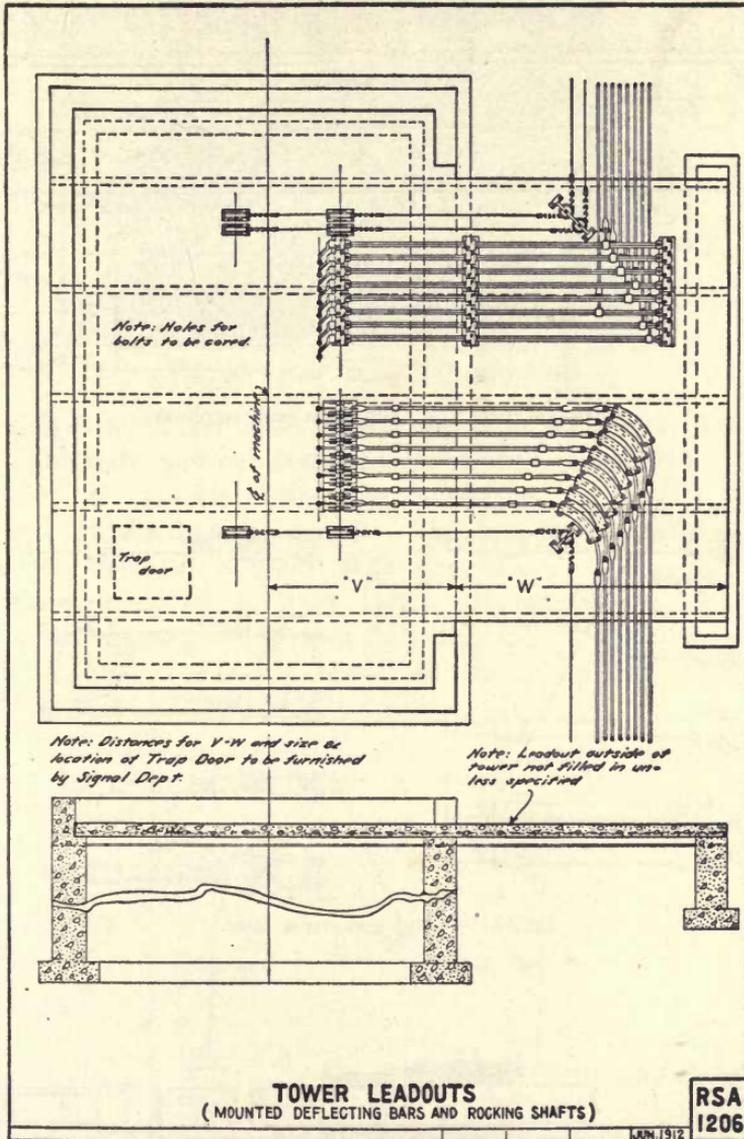


FIG. 49.—R. S. A. tower leadout.

**32. Compensators.**—Compensators are inserted at the proper places in pipe and wire lines to provide automatically for changes in length, due to expansion or contraction caused by differences

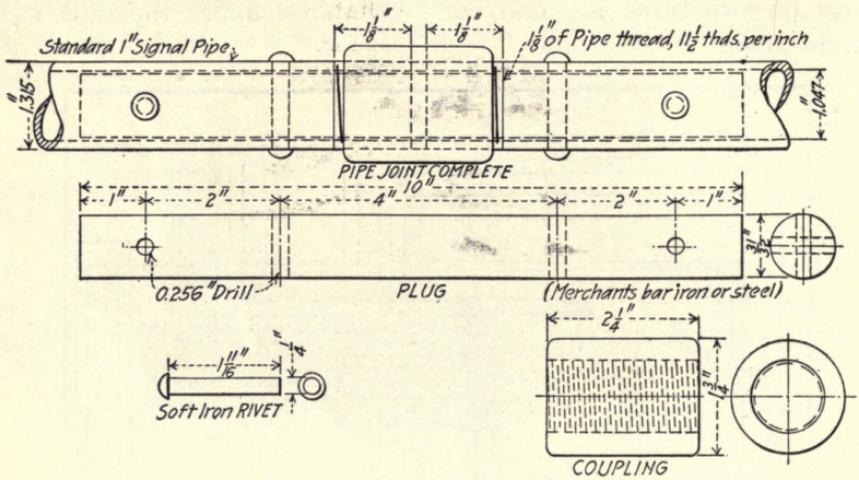


FIG. 50.—R. S. A. 1-in. pipe and coupling.

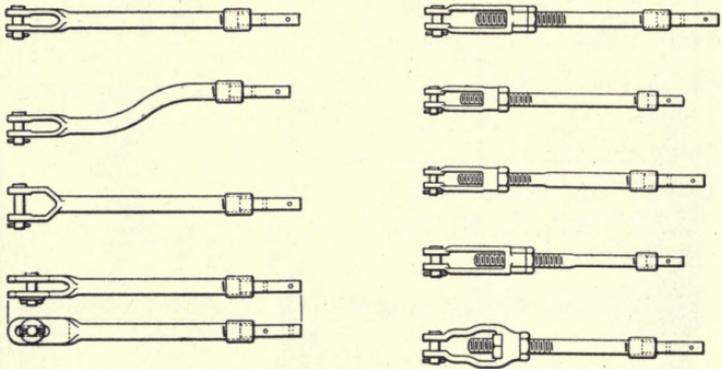


FIG. 51.—Solid and screw jaws.

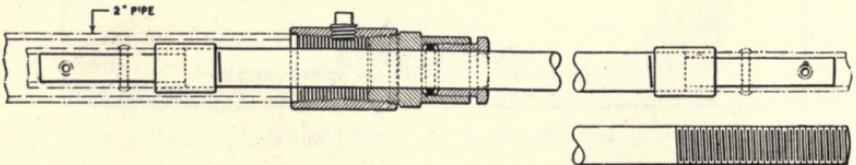


FIG. 52.—R. S. A. standard stuffing box.

in temperature. In the case of a pipe line, the compensator reverses the direction of motion so that the change in length on

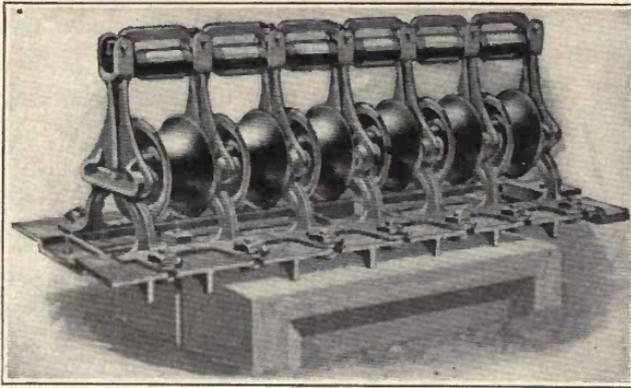


FIG. 53.—Pipe carrier. Universal base.

one side of it will just offset the change on the other side. Where a line is straight and one compensator is used, it should be in the middle. If two are used, they should be located at the quarter points. The compensator used in straight pipe line construction is called a "lazy jack." It is made of two angles, 60 and 120 degrees, with a link connecting them, as shown in Fig. 55. One



FIG. 54.—R. S. A. two-way transverse pipe carrier.

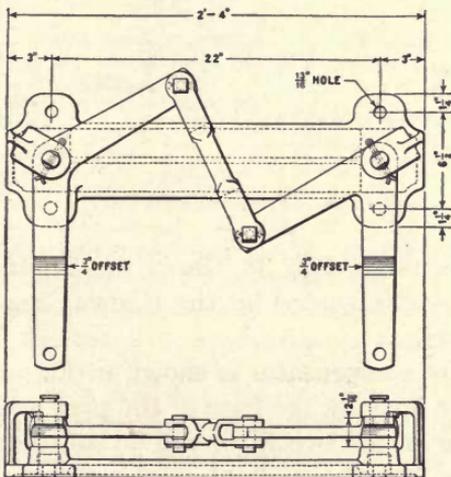


FIG. 55.—R. S. A. "lazy jack" pipe compensator.

compensator is used for a pipe 50 to 650 ft. long and two for a line between 650 and 1,300 ft. In the case of a 90-degree change

in the direction of a line, a crank if properly placed may be used as a compensator. Figure 56 illustrates a straight arm compensator.

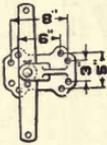


FIG. 56.—R. S. A. straight arm compensator.

The following example will serve to illustrate the principle of applying compensation to a pipe line: A pipe as a part of an interlocking plant is used to throw switches 1 and 2 of a main-line crossover. The switches are normally lined up for the main tracks clear. The dimensions of the track layout are given in the sketch, Fig. 57.

The motion from the leadout is a push, which causes a pull beyond the first compensator. Since the motion to be given to the switch 1 is a push, the angle crank at *A* should be a compensator. The direction of motion beyond the second compensator is a push; and since the motion to be given switch 2 is a pull, the crank at *B* should also be a compensator. The calculated locations of the "lazy jacks" are shown in the figure.

Should a compensator figure to come where a pipe carrier is located, the compensator should be placed at the middle of the adjoining span.

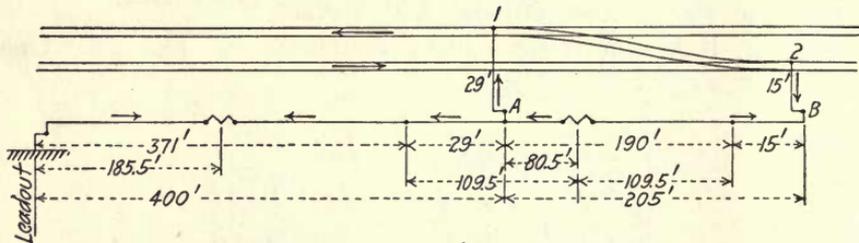
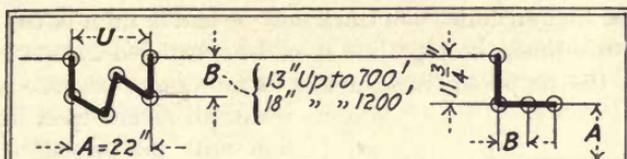


FIG. 57.—Compensation.

The following table, Fig. 58, shows the lengths and positions of crank arms recommended by the Railway Signal Association for compensation.

A type of wire compensator is shown in Fig. 59. It operates by means of the lever at the base of the post and is so arranged that the tension on the two wires will be constant. On one arm of the lever are two chain wheels and on the other is a rather heavy counterweight. When the wires shorten, the counterweight rises; when they lengthen, the counterweight drops, adjusting the length automatically.

33. Field construction of pipe lines as recommended by Committee II of the Railway Signal Association in Volume XIV, 1917, of the *Proceedings*:<sup>1</sup>



Values of "U" are based on 0.08 of an inch as coefficient of expansion for an increase of 10° F. for each 100' of line and the nearest  $\frac{1}{16}$ " is given.

Values of spacing "U" for giving temp. and length of lines compensated and table of equivalent lengths to be used in compensating pipe lines when crank arms are of unequal lengths.

Temp F.	Lengths of Lines Compensated in Feet										
	100'	200'	300'	400'	500'	600'	700'	800'	900'	1000'	1100'
110°	21 $\frac{3}{8}$ "	21"	20 $\frac{3}{4}$ "	20"	19 $\frac{1}{2}$ "	19"	18 $\frac{1}{2}$ "	18"	17 $\frac{1}{2}$ "	17"	16 $\frac{1}{2}$ "
90°	21 $\frac{1}{16}$ "	21 $\frac{3}{8}$ "	21"	20 $\frac{11}{16}$ "	20 $\frac{3}{8}$ "	20"	19 $\frac{11}{16}$ "	19 $\frac{3}{8}$ "	19"	18 $\frac{11}{16}$ "	18 $\frac{3}{8}$ "
70°	21 $\frac{1}{16}$ "	21 $\frac{1}{8}$ "	21 $\frac{1}{8}$ "	21 $\frac{1}{8}$ "	21 $\frac{1}{8}$ "	21"	20 $\frac{7}{16}$ "	20 $\frac{1}{2}$ "	20 $\frac{1}{2}$ "	20 $\frac{1}{2}$ "	20 $\frac{1}{4}$ "
50°	Mean Temperature U = 22°										
30°	22 $\frac{3}{16}$ "	22 $\frac{1}{8}$ "	22 $\frac{1}{8}$ "	22 $\frac{1}{8}$ "	22 $\frac{1}{8}$ "	23"	23 $\frac{1}{16}$ "	23 $\frac{1}{8}$ "	23 $\frac{1}{8}$ "	23 $\frac{1}{8}$ "	23 $\frac{1}{8}$ "
10°	22 $\frac{5}{16}$ "	22 $\frac{3}{8}$ "	23"	23 $\frac{1}{8}$ "	23 $\frac{1}{8}$ "	23 $\frac{1}{8}$ "	24 $\frac{1}{16}$ "	24 $\frac{1}{8}$ "	24 $\frac{1}{8}$ "	25 $\frac{1}{16}$ "	25 $\frac{1}{8}$ "
0°	22 $\frac{7}{16}$ "	22 $\frac{1}{2}$ "	23 $\frac{1}{4}$ "	23 $\frac{3}{8}$ "	24 $\frac{1}{16}$ "	24 $\frac{1}{8}$ "	24 $\frac{1}{8}$ "	25 $\frac{1}{4}$ "	25 $\frac{1}{8}$ "	26 $\frac{1}{16}$ "	26 $\frac{1}{8}$ "
-10°	22 $\frac{7}{16}$ "	23"	23 $\frac{1}{2}$ "	24"	24 $\frac{1}{2}$ "	25"	25 $\frac{1}{2}$ "	26"	26 $\frac{1}{2}$ "	27"	27 $\frac{1}{2}$ "
"A"	Equivalent for "A" for various lengths of "B"										
Length in ft.	B=7"	B=7 $\frac{1}{2}$ "	B=8"	B=8 $\frac{1}{2}$ "	B=9"	B=9 $\frac{1}{2}$ "	B=10"				
25	42	39	37	35	33	31	29				
50	84	78	73	69	65	62	59				
75	126	117	110	104	98	93	88				
100	168	157	147	138	130	124	117				
150	252	235	220	207	196	185	176				
200	336	313	294	276	261	247	235				
250	419	391	367	345	326	309	294				
300	503	470	441	415	391	371	352				

NOTE: Since the mean temp. varies, it must be taken for the latitude where the work is done.

Fig. 58.—R. S. A. compensation table.

1. When laying out a pipe line, the selection of a place as free as possible from fixed obstructions, such as buildings, bridge girders, abutments, etc., should be given first consideration. The alignment of the pipe line should be straight when practicable. Often by slightly changing the distance the pipe line is located from the rail, some fixed obstruction can be avoided and the line kept straight. Where the pipe line

<sup>1</sup> Page 395.

follows a turnout, the curve in the pipe line should be gradual instead of following the rather sharp curve of the turnout, and the maximum curvature should not exceed (10) degrees.

2. Where the interlocking station building is set back far enough from the tracks so that an additional track may be laid in front of the building at some future time, the pipe line should be installed the standard distance from the proposed track, unless extraordinary expense would be incurred, rather than install the line near the present track and later move it when the proposed track is laid.

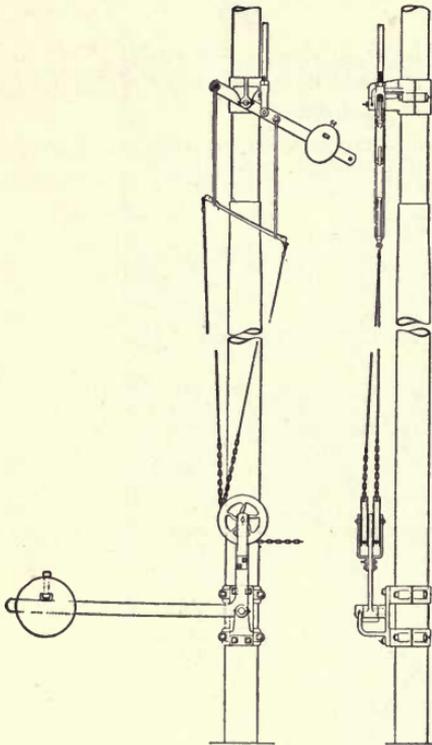


FIG. 59.—Wire compensator.

3. In case the pipe line is to be run on a bank, sufficient space should be provided to strongly brace the foundations. In case the line is to be run in a ditch, proper drainage should be provided; also the slopes of banks should be graded or a wall constructed to prevent earth sliding. Pipe lines should not be run under station platforms where it can be avoided.

4. Where necessary to run pipe lines under ground, as at road crossings, platforms, water tubs, stand pipes, etc., it is recommended that where proper drainage can be provided concrete side walls with plank covering be used around the pipe line; at points where proper drainage cannot be provided each pipe

should be run in a larger pipe with oil and provided with a stuffing box on each end.

5. Stakes showing the final elevation of the rail should be accurately driven every fifty feet, then by using intermediate stakes a line should be stretched from which the foundations should be set.

6. The location of crank and bolt-lock foundations should be determined upon first in order that pipe carrier foundations can be so spaced as not to interfere with cranks and bolt-locks. Piles should be driven for supporting crank, compensator and bolt-lock foundations (and pipe carrier foundations if necessary) where the ground is swampy or marshy. Everything should be done to have the support for all pipe line apparatus as solid as possible and sufficiently braced to prevent shifting.

7. In providing compensation for pipe lines the mean temperature of the interlocking location should be known; in most cases, it will be the same as at the nearest city and can be obtained from the Weather Bureau. R. S. A. Drawing 1102, Compensation Table, must be used when cutting in pipe lines.

8. Crosspipes should not be installed until all ties supporting pipe carriers are properly spaced and tamped and all tracks are brought to the final elevation and line, which should be the same for all tracks in the interlocking limits.

9. Crank and compensator foundations should be set to template so that with the crank and compensator arms both normal and reversed the center of the hole in the arm will coincide with the center of the pipe line. Rough forms should be used for the bottoms of foundations where necessary; but finished knock-down forms should be used for the top portions of the foundations. Where foundations are likely to be disturbed by frost, cinders should be placed in the bottom of the foundation hole as well as around the sides, the rough forms being made of uniform slope and left in the ground.

10. Concrete for foundations should be mixed at a central point where practicable, from which it can be distributed to foundation locations by track barrows or dollies, or mixed on a flat car which can be pushed from one point to another.

**34. Horizontal Cranks and Radial Arms.**—An abrupt change in the horizontal direction of a pipe line may be made by means

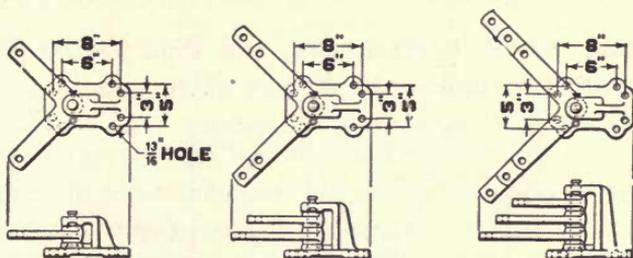


FIG. 60.—R. S. A. one-, two-, and three-way cranks.

of an angle crank, deflecting bar, or radial arm. The most commonly used of these is the angle crank, which may be one-way, two-way, or three-way, as shown in Fig. 60. The angle between the arms is usually 90 degrees, although other angles both smaller and larger are occasionally used. Figure 61 represents an acute angle crank. A three-arm crank, illustrated in Fig. 62, is used extensively in connection with switch arrangements. The radial arm, shown in Fig. 63, is convenient for changing directions

where the angle is comparatively small. A horizontal deflecting bar is shown in Fig. 48. Where the change in direction is gradual,

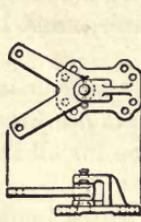


FIG. 61.—R. S. A. acute angle crank.

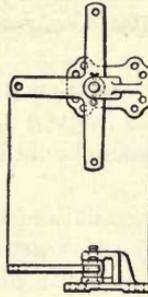


FIG. 62.—R. S. A. three-arm crank.

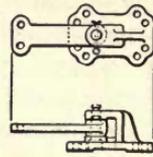


FIG. 63.—R. S. A. radial arm.

as when following an easy curve in the track, the pipes may be sprung into place.

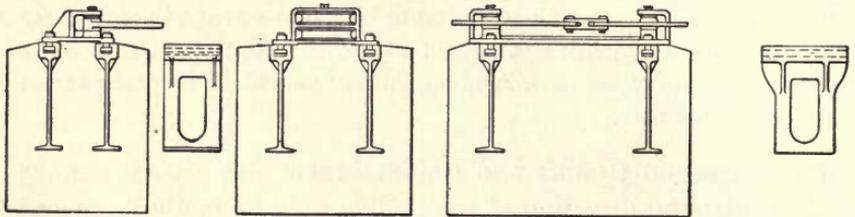


FIG. 64a.—Foundations for cranks, wheels, and compensators.

**35. Crank, Wheel, Compensator, and Pipe Carrier Foundations.**—Figure 64a represents designs of concrete foundations

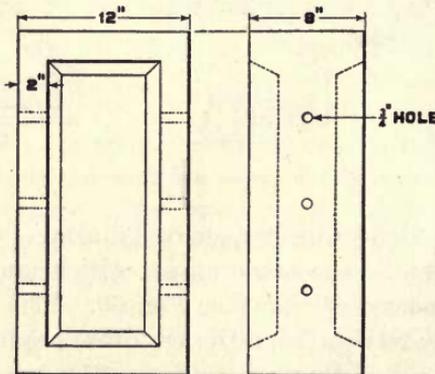


FIG. 64b.—R. S. A. pipe carrier foundation.

for cranks, wheels, and compensators. Figure 64b illustrates a design of a foundation for a pipe carrier. The foundations

should be large enough to eliminate any possibility of their shifting due to the movement of the pipes.

**36. Facing Point Lock.**—To insure that a switch or point derail is properly closed and held in that position, some kind of locking equipment becomes necessary. Two devices have been used for the purpose, facing point locks, and switch and lock movements. In the case of facing point locks, two levers are necessary, one to throw the switch or derail and the other to lock it. Switches are locked in both open and closed positions. To throw the switch, the plunger is pulled back far enough to clear the lock rod, one end of which is fastened to the point of the switch and the other is flattened and passes through the facing

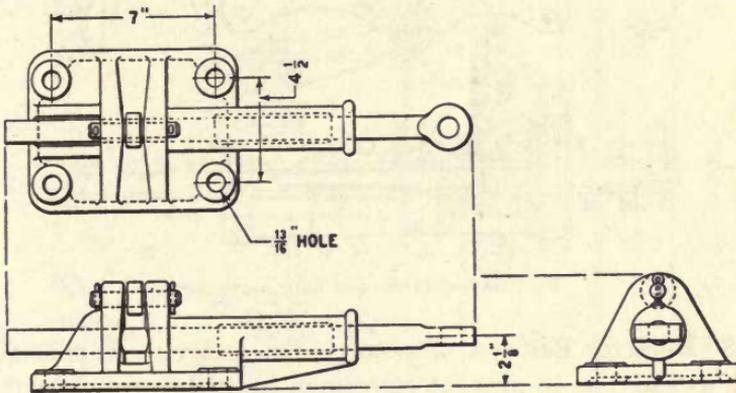


FIG. 65.—Facing point lock.

point lock casting. After the switch is thrown and is in the proper position, the plunger is pushed back through a second hole in the lock rod, holding the switch points firmly and preventing them from springing open while a train is passing over. The plunger of a facing point lock should not be placed between the rails, nor at any point where a dragging brakebeam can strike it and bend it over or tear it out. Figure 65 illustrates a facing point lock.

**37. Switch and Lock Movement.**—The switch and lock movement, a mechanism so constructed as to throw the switch and lock it all with one lever movement, is shown in Fig. 66. In the figure the pipe from the lever is connected to the slide bar 14-15. Another bar runs from escapement crank 20 to the switch or derail point. Between upper slide bar 12 and lower slide bar 13 is a roller, 21. As the slide bar is pushed or pulled, the

roller engages the escapement crank, causing arm 20 to move, shifting the switch or derail. There is a short plunger that passes through a hole in the lock rod as in the case of the facing point lock. The first part of the throw of the lever unlocks the switch or derail and throws the detector bar described in the following paragraph; the second part throws the switch or derail; and the third part locks it in its new position.

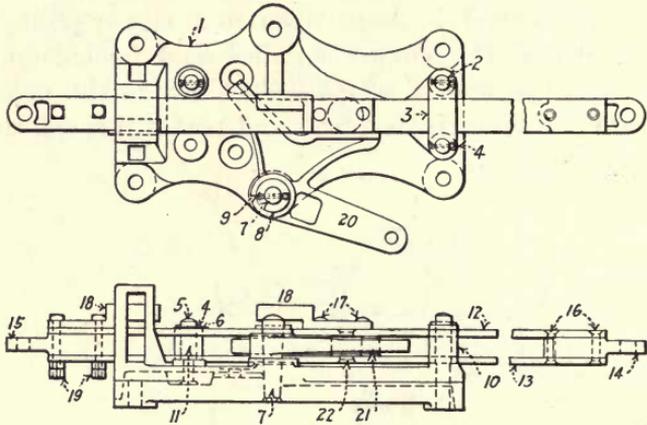


FIG. 66.—Switch and lock movement.

**38. Detector Bar.**—A detector bar is a device so constructed and operated as to prevent towermen from throwing a switch or derail under a moving train. It is a flat bar of steel  $\frac{3}{8}$  to  $\frac{1}{2}$  in. thick,  $2\frac{1}{4}$  in. high, and 53 ft. long, placed along the side of the rail and held in position by clips. The bar is connected to the same pipe that throws the plunger of the facing point lock or that operates the switch and lock movement. As these functions are thrown, the detector bar must travel horizontally parallel to the rail. It is so constructed that while it moves horizontally it must also move vertically, rising as it moves an inch or more above the top of the rail. If a train should be standing or moving on the rail, any attempt to throw the switch or derail would fail when the detector bar rises against the tread of the wheel. Four different types of detector bars are shown in Fig. 67.

**39. Bolt Lock.**—The bolt lock is an appliance to guarantee that the home signal cannot be placed in the proceed position until the derail or switch is cleared. In addition to the throw rod and lock rod, another rod or bar is sometimes connected to the switch point or derail. This bar extends out to cross the pipe

or wire line that operates the home signal. In the pipe line at this particular point is inserted a flat bar. Each of these bars crossing at right angles has a notch so placed as to preclude a certain order of switch and signal movement. If for any reason

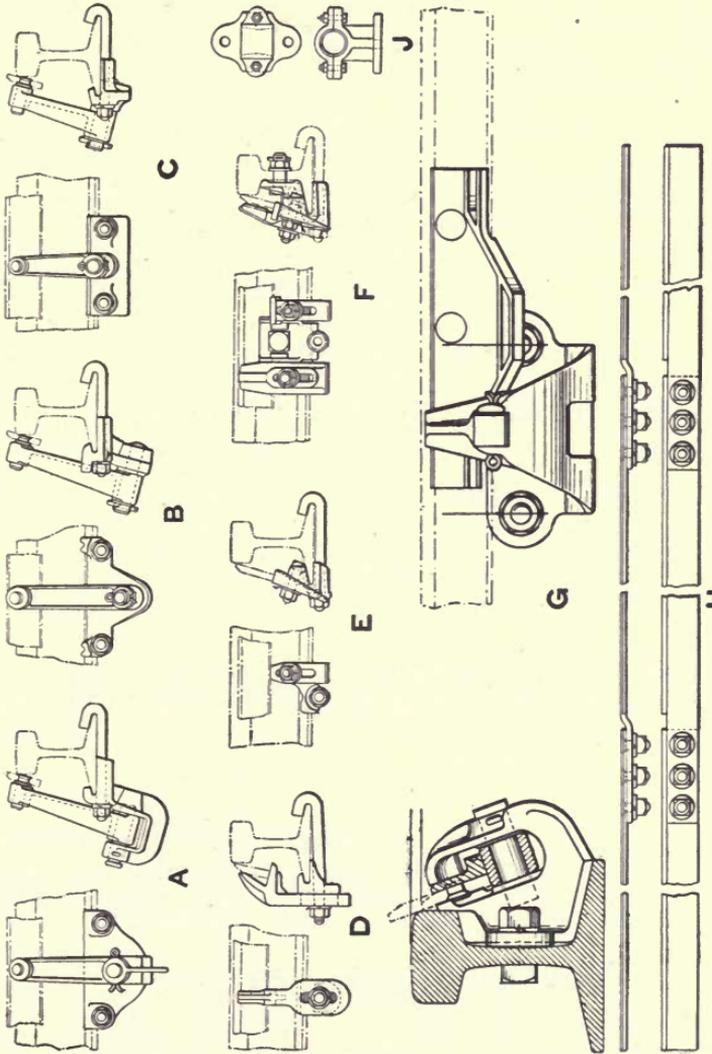


Fig. 67.—Detector bars.

the switch should fail to be moved, even though its signal lever had been thrown, the home signal could not be operated. Figure 68 shows a one-way bolt lock. All of these additional precautions and safety devices are installed to guarantee against any possibility of failure on the part of pipes or other ground equipment.

40. **Head Rod and Switch Adjustment.**—The two switch points are connected near the end by a head rod shown in Fig. 72. If track circuits are installed for any purpose, it becomes neces-

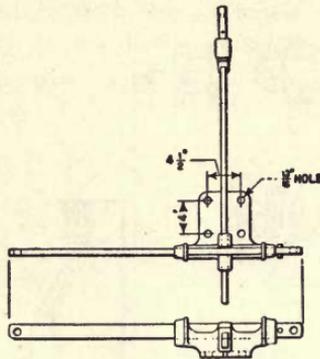


FIG. 68.—One-way bolt lock.

sary to insulate the two rails to avoid a short-circuit. To accomplish this, some kind of fiber is generally used for insulation. To this head rod is fastened one end of the throw rod that

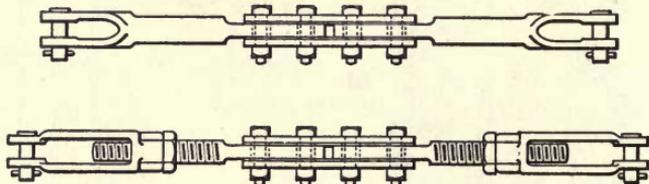


FIG. 69.—R. S. A. insulated rods.

operates the switch. There is an adjusting arrangement where the throw rod connects to the head rod whereby the former moves a certain distance before it begins to throw the switch.

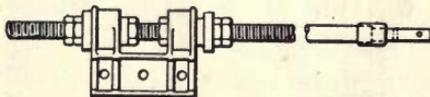


FIG. 70.—Switch adjustment.

This is done to offset a part of the difference in travel between the lever throw and the switch movement. The remainder of the difference is taken up by using unequal lengths of crank arms.

**41. Lock Rod.**—An insulated front rod and a lock rod used in connection with facing point locks and switch and lock movements is shown in Fig. 71. Figure 72 represents a switch locked

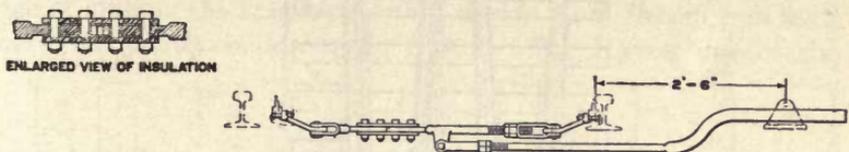


FIG. 71.—Insulated front and lock rods.

by a facing point lock after it is thrown by a separate lever, and Fig. 73 represents a switch operated by a switch and lock movement. In both cases the detector bar and bolt lock attachment

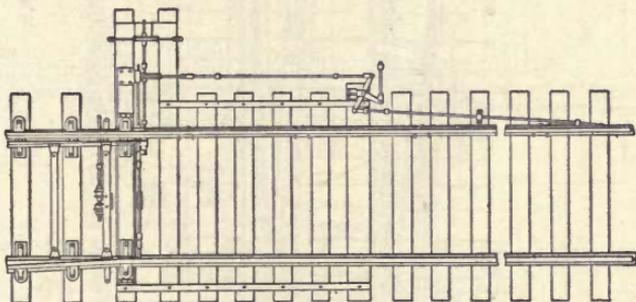


FIG. 72.—Facing point lock and bolt lock applied to a switch.

are added. The detector bar stands in front of the switch points. Figure 74 shows the layout for a double slip switch with movable point frogs. One lever operates by means of a three-way crank

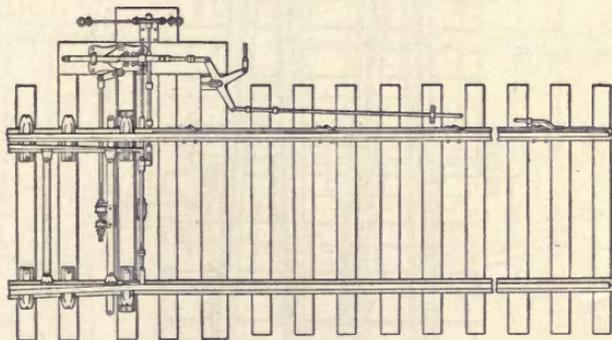


FIG. 73.—Switch and lock movement and bolt lock applied to a switch.

and a rocker shaft one facing point lock for each pair of slip switches.

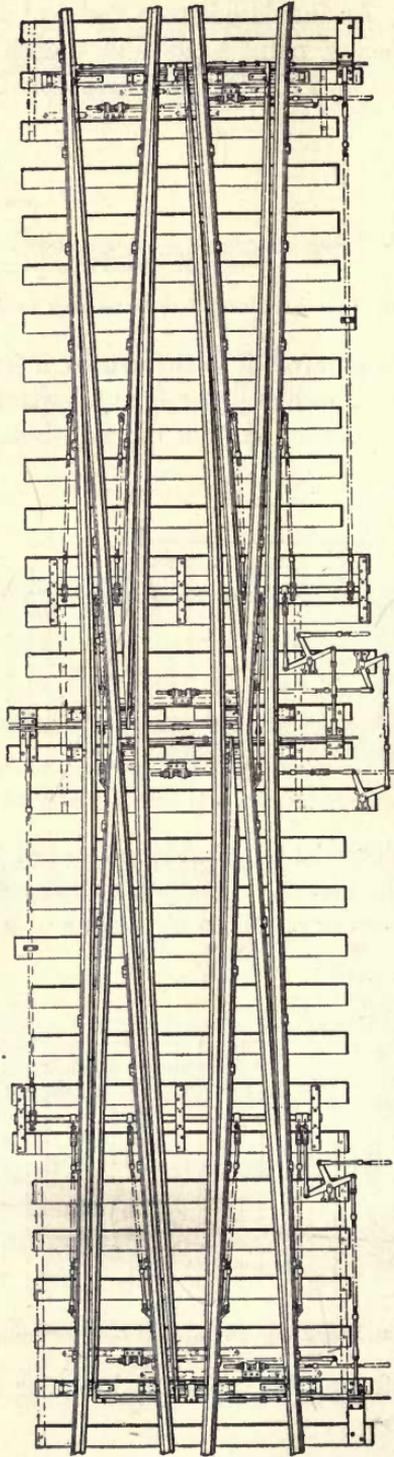


Fig. 74.—Double slip switch and movable point frogs.

**42. Derails.**—There are three types of derails used in connection with interlocking plants. The oldest is the split point, shown in Fig. 75. As this has one rail broken it has the disadvantage of making the track somewhat unsafe, and therefore is used most frequently in low-speed routes. The Hayes, one of the

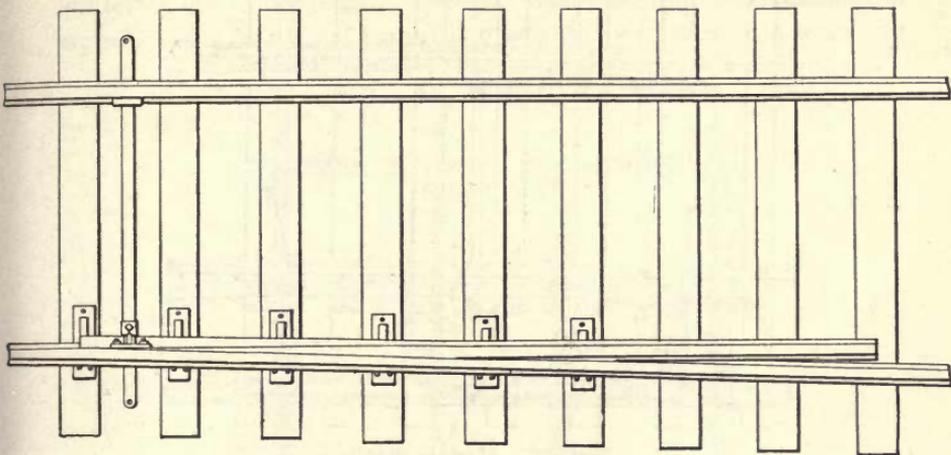


FIG. 75.—Split point derail.

lifting block type, shown in Fig. 76, rests on top of the rail when set to stop traffic; and although it allows the rails to be continuous, it is used largely on medium-speed and low-speed routes. The lifting rail type, one form of which is shown in Fig. 77, is so built that a sharp point fits against the inside of one rail and a flat

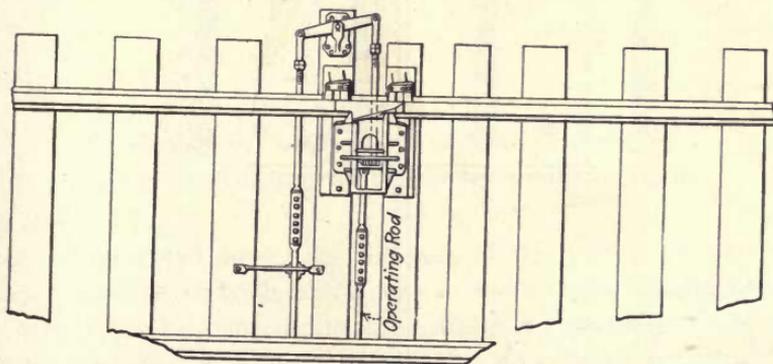


FIG. 76.—Hayes derail.

riser point against the outside of the head of the outer rail when set to stop traffic. The sharp point derails the wheels on one side while the flat point lifts those on the other side high enough to allow the flange to clear the top of the rail. In this type both

track rails are continuous. Several others are built on the same principle, some of which have the flat point lying on top of the rail instead of on the side of it. The two points are connected by means of tie rods and are moved simultaneously into positions

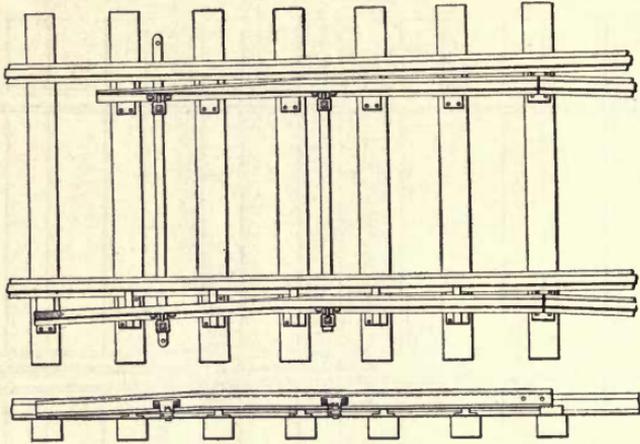


FIG. 77.—Morden derail.

for clearing or derailing trains. This type is used principally on high-speed routes.

**43. Crossing Bars.**—Crossing bars are used at interlocking plants to prevent a towerman from changing a line-up while a

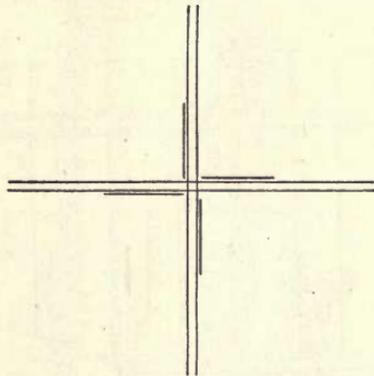


FIG. 78.—Crossing bars.

car or locomotive is standing on a railroad crossing. They are just ordinary detector bars placed as near to the crossing frog as possible, one on each side of the crossing in each track. These bars lock the derails both normal and reversed so that they cannot

be moved without operating the crossing bars. If a car should be standing on the crossing, it would be impossible to move the bar and hence impossible to change the derails and the signals on that route.

**44. Semaphore Signals.**—Figure 79 shows the method of constructing and operating a one-arm two-position lower quadrant signal. The left-hand signal is operated by a pipe line with the

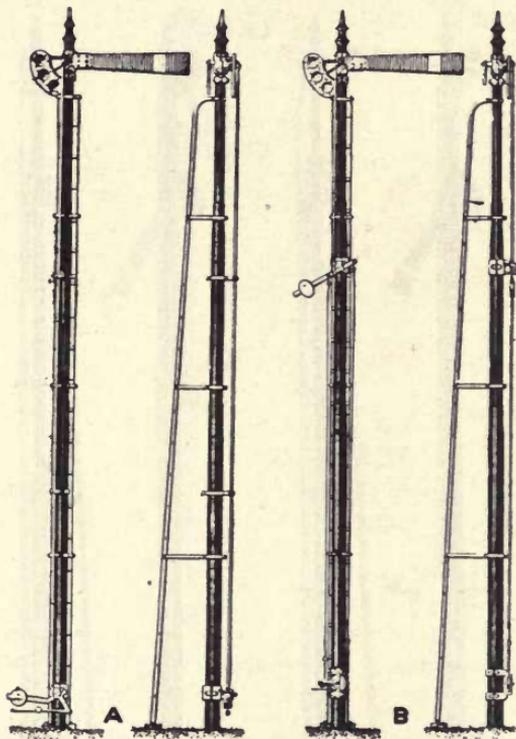


FIG. 79.—One-arm two-position lower quadrant signals.

counterweighted lever near the base of the post, while the right-hand signal is controlled by a wire line and chain running through a wheel at the base of the post and the counterweighted lever more than half way up on the post. Two wires are required to operate the signal. The post is made of three lengths of pipe, 4, 5, and 6 in. in diameter.

Figure 80 illustrates a pipe and wire operated two-arm two-position signal. The details of upper quadrant one and two-arm signal construction, as recommended by the Railway Signal

Association, are shown in Fig. 81, *a* and *b*. The mast proper of the one-arm signal is 25 ft. high, made up of two lengths of 5- and 6-in. pipe swaged together at the joints. The pinnacle, 3, brings the total height up to 26 ft. 8 in. above the foundation. The spectacle casting, 8, has three roundels, or glasses, properly spaced to allow for the 45- and 90-degree positions of the signal. The lamp is attached to the post just behind the right-hand

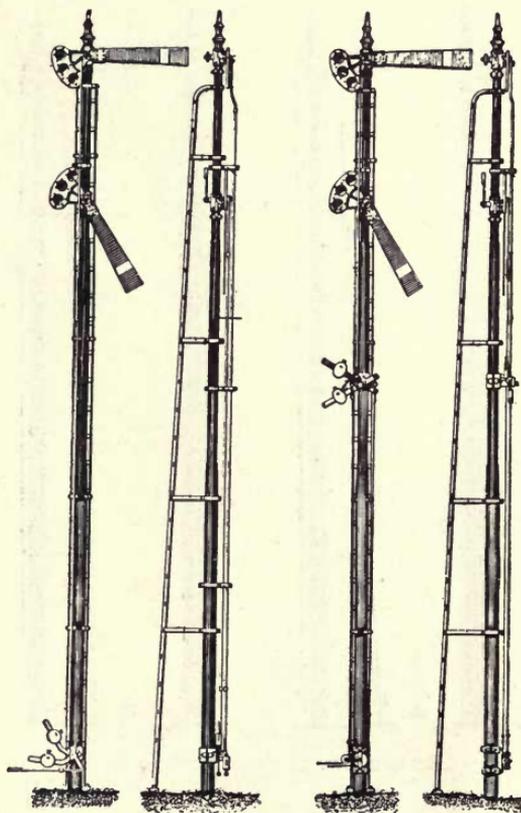


FIG. 80.—Two-arm two-position lower quadrant signals.

roundel. The blade, 9, is made either of wood or sheet metal. The up-and-down rod, 11, is a 1-in. pipe fitted to the casting of the arm and the angle crank at the base to operate the signal. The upper quadrant type of construction does not need the counterweighted arm. All the appliances are attached to the post by means of clamps. The foundation and anchoring plans are also shown in the figure.

Figure 81c represents a three-arm signal that corresponds to the arrangement in Scheme 3, Appendix B. A two-position bracket signal is shown in Fig. 82, while some of the details of construction of a three-arm bridge or bracket signal are presented in Fig. 83. Figure 84 is a cantilever attachment for a doll post.

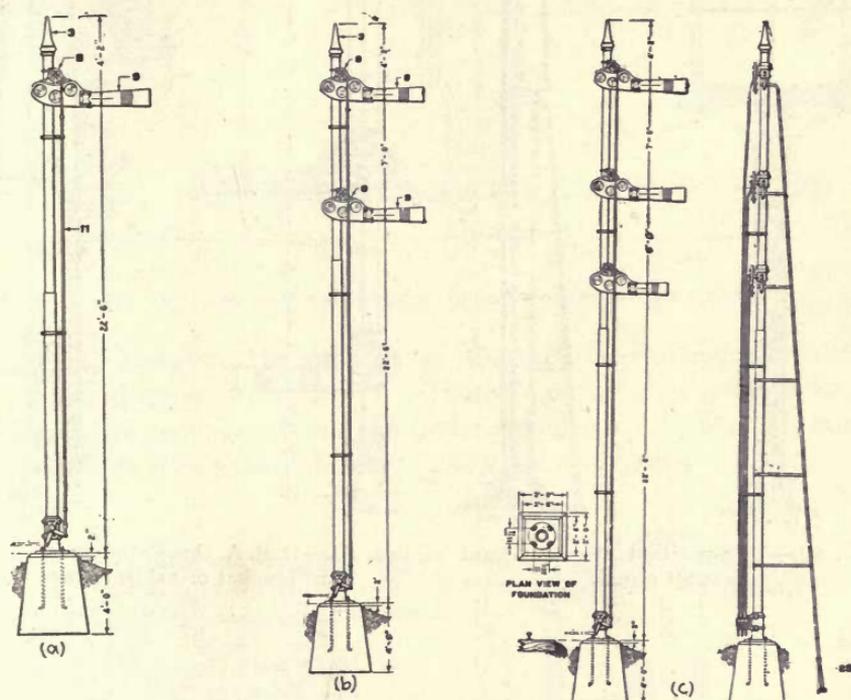


FIG. 81.—R. S. A. standard upper quadrant signals.

**45. Dwarf Signals.**—Figure 85 represents a one-arm two-position upper quadrant dwarf signal. Attached to the operating mechanism is a spring that is placed under compression when the proceed indication of the signal is given so that if the wire line that operates the signal fails the blade automatically goes to the stop position. The blade of the dwarf signal is made flexible so that it can be struck without injury. Figure 86 is a Railway Signal Association upper quadrant pipe-operated dwarf signal.

**46. Time Lock.**—A time lock illustrated in Fig. 88 is a mechanical appliance used in connection with the home signal lever of a mechanical interlocking plant to prevent the towerman from

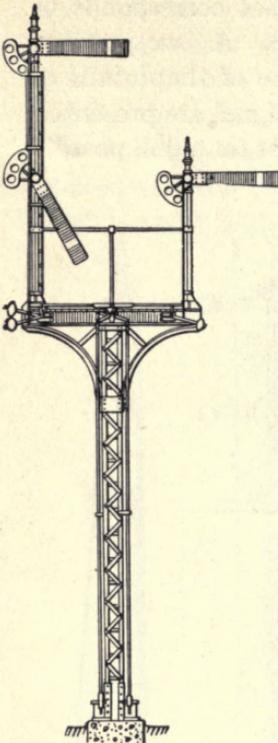


FIG. 82.—Two-position lower quadrant bracket signal.

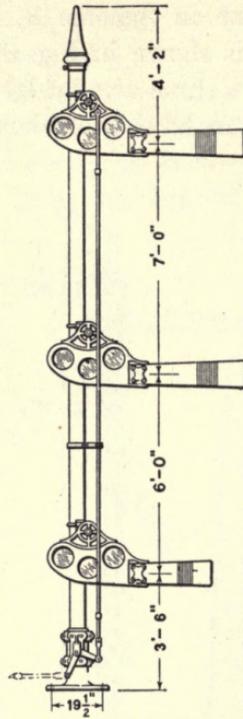
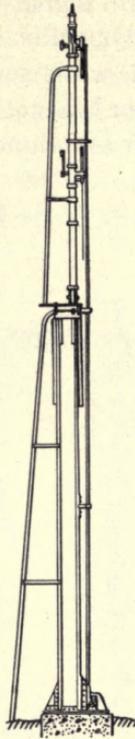


FIG. 83.—R. S. A. three-arm upper quadrant bracket or bridge signal.

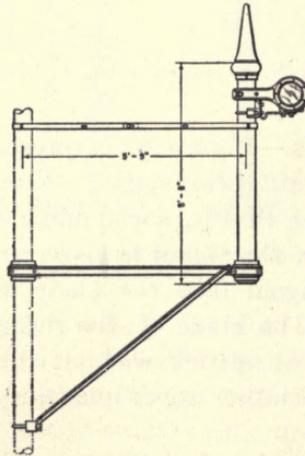
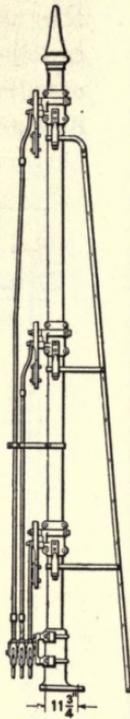


FIG. 84.—Cantilever bracket.

quickly changing a line-up after it has been accepted by a train. A heavy rack, supported vertically, is raised quickly by reversing the lever, and is held in that position until the lever is thrown towards the normal position. As soon as the lever is placed

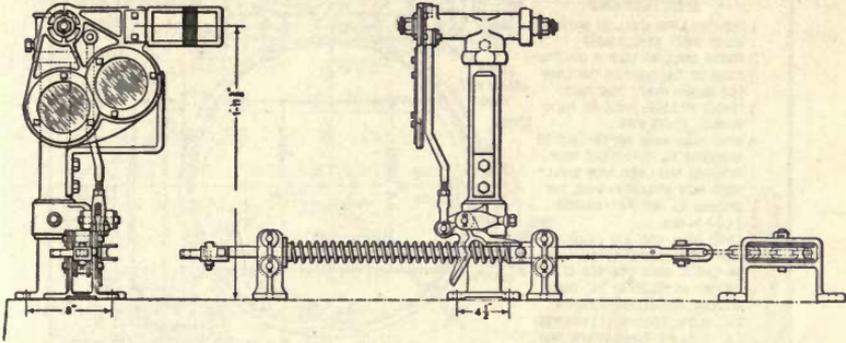


FIG. 85.—One-arm two-position upper quadrant dwarf signal.

normal, however, the support for the rack is removed, and the rack is dropped very slowly. There is nothing to prevent the towerman from returning the home signal lever to normal, but he cannot release his latch until the rack runs down.

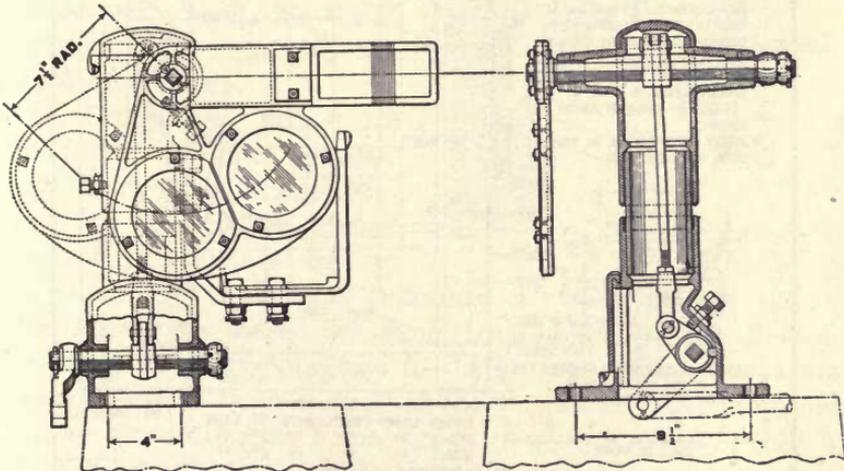


FIG. 86.—R. S. A. dwarf signal for pipe connection.

The weight of the rack actuates a double pendulum in such a manner that each swing of the pendulum drops the rack one tooth. A roller on the end of the cross-lock connected with the locking bed in the case of the Saxby and Farmer machine, en-

gages the back of the rack and prevents the lever latch from being placed entirely normal while the rack is up. There is a notch in the back of this rack located at just the point to contain

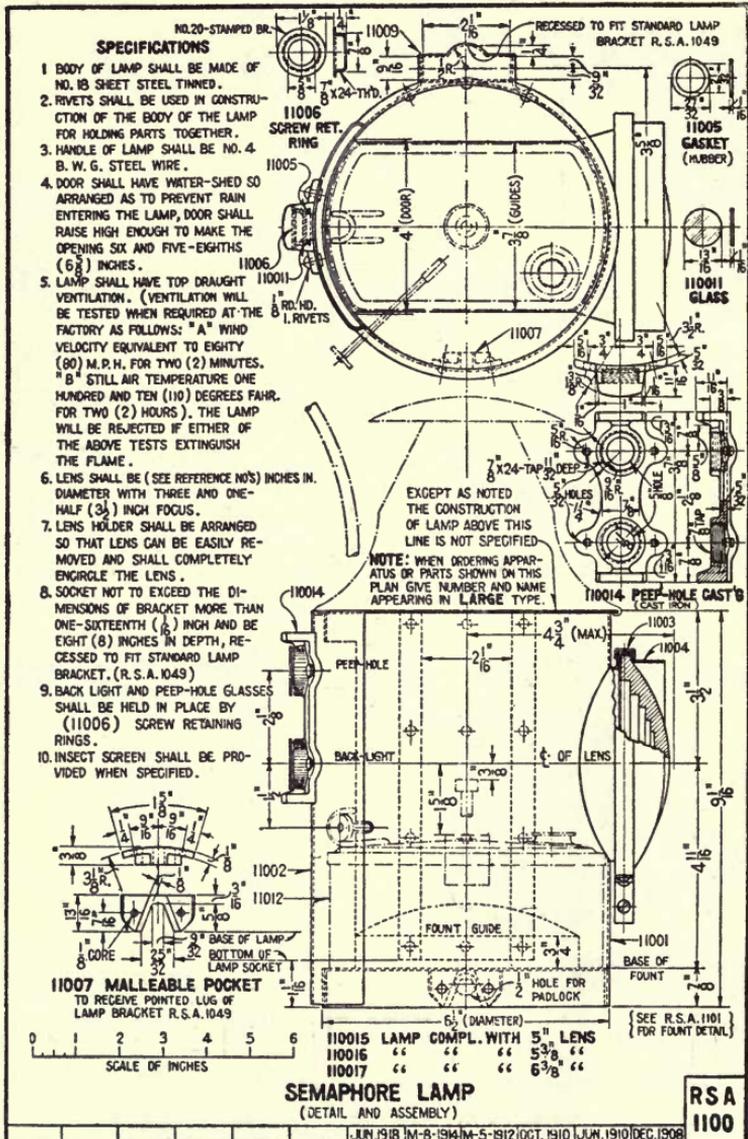


Fig. 87.—R. S. A. semaphore lamp.

the roller when the rack is entirely down. The cross-lock is free to move when the rack is down, releasing the home lever latch and allowing it to finish its throw to normal. After the latch is

in its normal position, the derail may be opened and another route lined up. In the case of the Style A machine the cross-lock is connected with one end of the rocker-link, but its action is practically the same.

These time locks are so adjusted as to require from one minute to one minute and twenty seconds or even longer to run down. This means that the towerman will have to wait this amount of time to throw the derail after he has thrown the home signal to danger. The length of that time would be sufficient to allow a train running at average high-speed at the distant signal to get far enough over the plant to be out of danger or to come to a stop before the towerman would have time to open the derails, should he suddenly decide to take the signals away from this train and give them to another on a conflicting route.

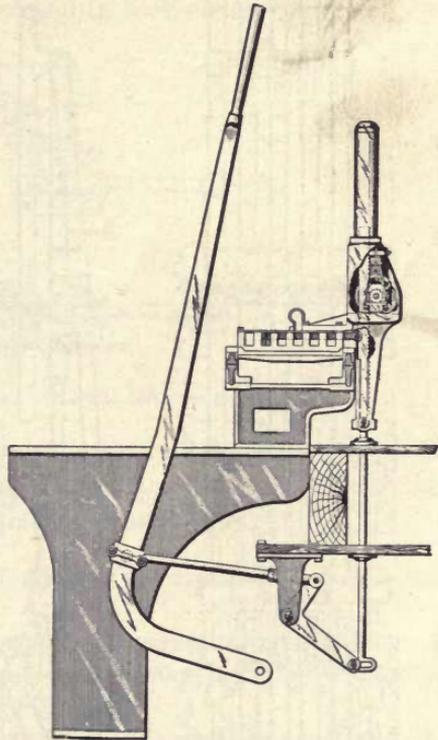


FIG. 88.—Time lock.

**47. Calling-on Arm.**—It sometimes becomes necessary when a home signal is used for interlocking where block signal circuits are in operation, to install what is termed a calling-on arm signal. After a train has passed the home signal in such an installation, the signal automatically goes to the stop position. There are times while this train is making the station or other stop and thereby preventing the home signal from being cleared, that it becomes expedient to signal a following train to pass the home signal and proceed slowly towards the station or other point in the interlocked territory. To advance the second train past the home signal the towerman must use the calling-on arm. It is mounted on the same post as the home signal arm, but generally has a shorter blade. It is operated independently of any track circuit by the same kind of mechanical or power appliances as are

used to throw the derails and switches. In *c*, Fig. 81, the upper blade governs the superior route, the middle one the inferior route, and the lower one may be a calling-on arm for either.

**48. Movable Bridge Couplers and Locks.**—Figure 89 shows the four-way bridge coupler used to open and close pipe lines where

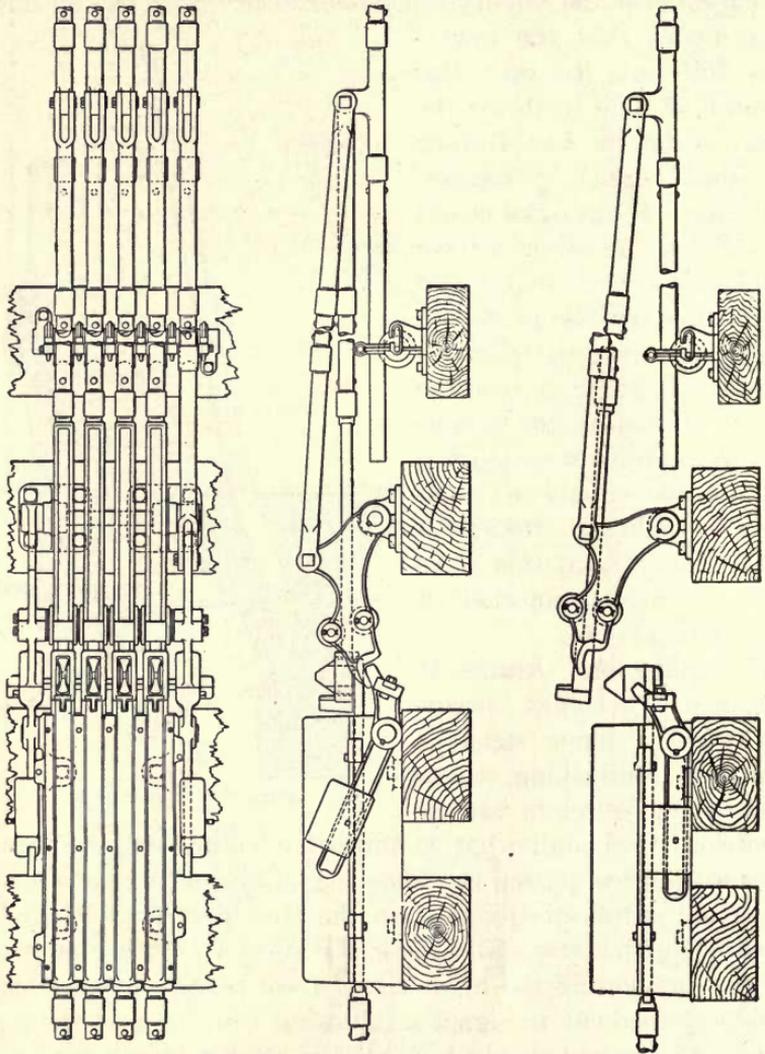


FIG. 89.—Swing bridge coupler. (*Signal Dictionary.*)

they cross the ends of movable bridges. A device for checking the position of lift bridges when closed is shown in Fig. 90. *A* is fastened to the bridge. The tumbler *F* has a notch in it that engages the stud *B* when the bridge drops into position and is

closed. *E* is fastened to the bridge seat. When the bridge is closed, plunger *D* will pass through the opening on the back end of *E*. When the bridge is raised, the tumbler *F* pivoted at *C*, will drop in front of this opening stopping the movement of *D* and holding all signals and derails in the normal position. As soon as the bridge is properly locked, however, the track may be cleared. Devices very similar to this are used to lock swing bridges.

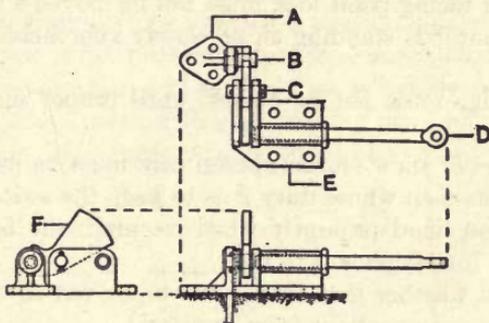


FIG. 90.—Bridge lock. (*Signal Dictionary*.)

**49. Rules.**—The following rules prepared for the benefit of train and motor crews and signalmen are reprinted from the *Proceedings* of the Railway Signal Association, 1914:<sup>1</sup>

*“Interlocking Signal Rules.*—Interlocking signal rules govern the use of interlocking signals.

“Interlocking signals are used to govern movements over tracks where there are switches, drawbridges, railroad crossings at grade and other conditions affecting the movement of trains.

“Hand signals must not be accepted as authority to pass any signal indicating **STOP**, except for switching movements when the governing signal cannot be cleared. They must be given by the signalman from the ground, upon the track for which they are intended, and only after the train or motor which is to make the movement has been stopped, and the situation fully explained and understood.

*“Interlocking Signal Rules.*—For train and motor crews. A signal indicating **STOP** must not be passed except as provided by the Rules.

“Interlocking signals when at **PROCEED** indicate the particular route set and show that switches are locked for the train to proceed, but not that the track is unoccupied.

“Interlocking signals indicate that a movement may be made only within the limits of the interlocking plant.

“Trains or motors stopped while within the limits of an interlocking

<sup>1</sup> Page 120.

plant, must not move in either direction until they have received the proper signal.

*Interlocking Signal Rules.*—For signalmen. If necessary to stop a train at a point at which clear signals have been displayed for it, signals must be changed to give the **STOP** indication, but locks and switches must not be changed or signals cleared for a conflicting movement until the train which had accepted the indication to proceed has stopped.

“A switch or facing point lock must not be moved when any portion of a train or motor is standing on or closely approaching the switch or detector bar.

“A drawbridge must not be opened until proper signals have been displayed.

“During sleet or snow storms special care must be used in operating switches. If the men whose duty it is to keep the switches in working order are not on hand promptly when required, the fact must be reported by wire (or telephone) to the .....

“During cold weather the levers must be moved as often as may be necessary to keep connections from freezing.

“Salt must not be used on interlocked switches, or other appliances, except on authority of .....

“Levers must be operated with a careful uniform movement. If the operation of a lever or other apparatus indicates a disarrangement of the parts, the signals must be restored to give the normal indication, and an examination made at once to ascertain if the parts are in safe and proper working order.

“Signalmen must see that lever is latched after lever movement has been completed.

“Should it be impossible to lock a facing point switch, the switch must be examined and spiked in proper position before train is allowed to pass.

“When switches, signals and their connections are undergoing repairs, **PROCEED** signals must not be given for movement over track sections affected by such repairs, until it has been ascertained that the switches are properly set and secured.

“Signals must not be cleared for trains to proceed except by working the lever provided for the purpose.

“When a switch, movable-point frog, derail, lock, detector-bar or switch-locking circuit is inoperative, the signalman will be given notice in writing by the maintainer and will make record of same on block sheet. The signalman must know that each switch, frog, and derail is spiked for the desired route and, when practicable, locked with plunger so that it cannot be withdrawn, before such route is used by trains. The . . . . must be notified promptly of the condition of the apparatus and the home signal governing movements over the route must indi-

cate **STOP**, and each train must be given a hand signal to proceed, unless other instructions are received from the . . . . .

“When a switch or movable-point frog is spiked a man must be stationed by the section foreman or maintainer to see that such parts are properly set for the route indicated by the signalman, before allowing train to pass. The signalman must know that switch or frog is properly set and secured for the desired route.

“When a home signal is disconnected, it must be fastened in the **STOP** position.

“If there is a derailment, or a switch is run through, or if any damage occurs to the track or interlocking plant, the signals must be restored to give the **STOP** indication and no train or switching movement must be permitted until all parts of the interlocking plant and track liable to consequent injury have been examined and are known to be in a safe condition.”

## CHAPTER VI

### ELECTRO-PNEUMATIC INTERLOCKING

In electro-pneumatic interlocking plants compressed air is used to throw switches, signals and derails operating them by means of cylinders whose valves are controlled by electricity. As the action is quicker than is the case in the mechanical and electrical plants, the system finds its best application in large terminals, in subway and elevated lines, and in other places where there is frequent traffic.

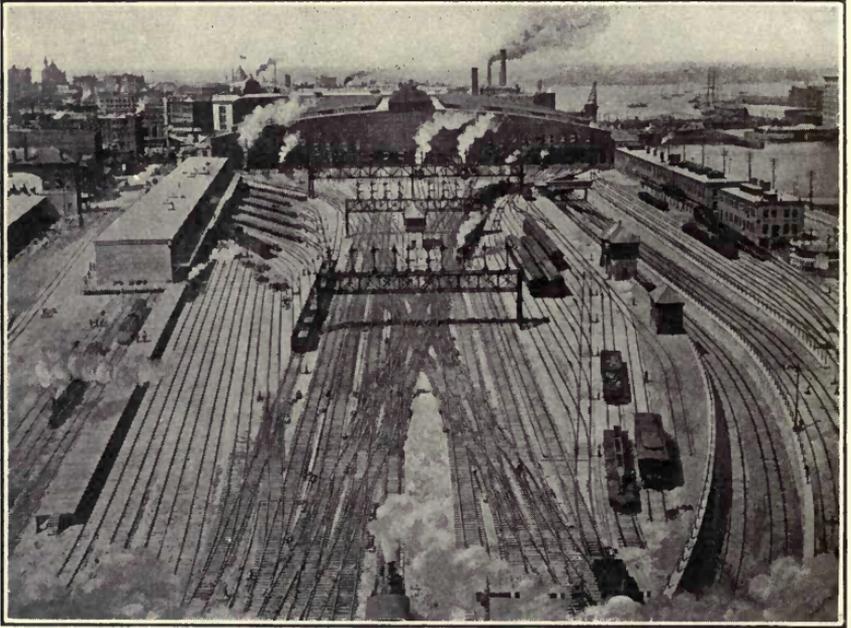


FIG. 91.—South Station, Boston, Mass.

**50. Air Supply.**—At points where such plants are likely to be installed there is frequently an adequate supply of air already available that needs only to be piped to the immediate places where it is to be used. In case no such supply is convenient it becomes necessary to install a compressor, operated either by a gasoline engine or by an electric motor. The air is pumped into storage reservoirs to maintain an adequate supply, the pressure

of which usually averages about 75 lb. a square inch. A typical plant is illustrated by Fig. 92.

After-coolers of the water and air-cooled type are usually employed to reduce the temperature of the air to normal after it has passed through the compressor. The storage tanks provided for the air are usually set low enough to collect the moisture that results from condensation, thus eliminating the danger of the freezing of the plant in the winter. The air pipes that connect with the storage supply and furnish the trunk line of the piping system are usually about 2 in. in diameter. The branch pipes are usually  $\frac{3}{4}$  in. in diameter with  $\frac{1}{2}$ -in. connections to switches and signals. On account of the flexibility and vibration of the

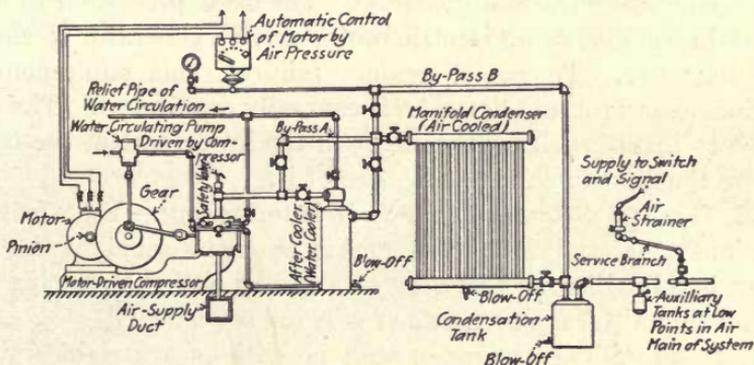


FIG. 92.—Diagram of typical air compressing, cooling and distributing system for electro-pneumatic interlocking.

track, the connection to switches is usually made with an armored hose.

The pipe is generally galvanized, and where it is laid across the tracks is placed a few inches beneath the surface of the ground; where the pipe is laid parallel with the tracks, it is usually supported a few inches above the ground on wooden stakes or concrete piers. Usually two routes are provided to each switch and signal to insure an air supply in case of failure in some part of the pipe line. Gate valves are located in the mains and stop-cocks in the branches in order to be able to shut off the air and cut out a section should it become necessary to repair a pipe or break a connection to a switch or signal.

Expansion in the mains is provided for by bends or by sliding expansion joints. Branch pipes should come out of the tops of

mains, thereby eliminating the possibility of having water drawn over if the main should not be properly drained. An auxiliary air reservoir is usually provided near each switch or signal to furnish an immediate supply of air and to provide a sump for any water that may have collected in the pipe. A strainer is placed in the line where it joins the operating equipment to clear the pipe of any moisture or sediment that may accumulate while the air is passing through. All of the reservoirs along the line are so constructed that the water may be blown out as often as desired.

**51. Electricity.**—The supply of electricity for most electro-pneumatic plants is furnished by storage cells, although a few have been built for 110-volt alternating current. Six or seven cells of the lead type or 12 of the Edison, furnishing approximately 12 volts, constitute the main battery. The usual practice is to have a gasoline engine or an electric motor drive a generator to charge the batteries. To guard against failures, this equipment of engine, generator and batteries is generally duplicated. The best place to install such equipment is in the lower part of the tower where the signalmen can take care of it.

**52. General Sequence in Power Interlocking.**—From considerations of safety it is fundamental in power interlocking that the steps involved in the throwing of a switch and the clearing of a signal should take place in the following sequence:

1. In providing assurance that conditions are right for the throwing of the switch. The mechanical locking insures that no conflicting routes are set up and that no signals are cleared for movement over the switch. The detector locking, which electrically locks the switch levers, insures that no train is within a certain distance of the switch. Thus the lever is mechanically and electrically unlocked if conditions are right. When detector locking is not installed, detector bars operated by the switch movement provide mechanically against movement of the switch while a train is over the detector bar.

2. In making a preliminary lever movement which mechanically locks conflicting levers, and effects circuit changes which cause the switch to be thrown.

3. In receiving an indication that the switch has been thrown and locked.

4. In completing the lever stroke, which frees the mechanical locking for other lever movements.

5. In throwing the signal-lever which clears the signal. No

indication is required that the signal actually clears since it would not be an unsafe condition if it should fail to clear.

After the train has accepted the signal and passed through the route, it may be desired to change the route for other train movements. In order to do so it is necessary to:

1. Restore the signal to stop by preliminary lever movement.
2. Receive an indication that the signal has gone to the stop position.
3. Place the lever in full normal position, thus freeing the mechanical locking for other lever movements.

A description of the different parts of the electro-pneumatic system follows with an explanation of how each functions in the sequence outlined above.

**53. Interlocking Machine.**—Figure 93 shows a Model 14 electro-pneumatic interlocking machine. The operating levers are

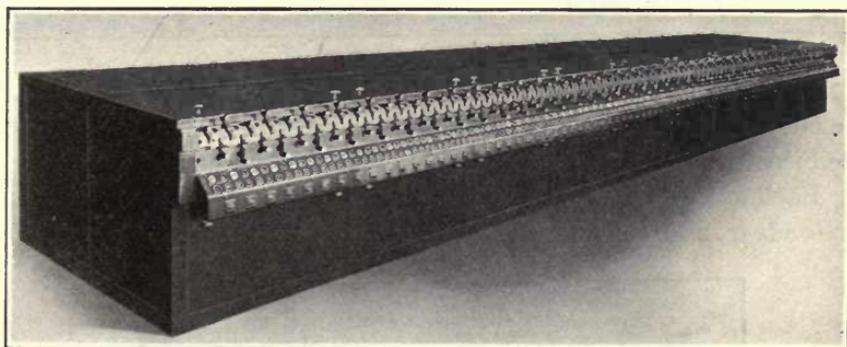


FIG. 93.—Electro-pneumatic interlocking machine.

arranged in a row across the front of the machine and are numbered from left to right. Those turned upwards are switch levers and bear odd numbers, while those hanging vertically downwards are signal levers and bear even numbers. In its normal position the switch lever stands 30 degrees to the left of the vertical, and when reversed it stands 30 degrees to the right of the vertical, moving through an angle of 60 degrees. One switch lever may control one, two and sometimes three switches, derails or movable point frogs. The signal lever points vertically downwards when normal; thrown 30 degrees to the left it serves to clear its corresponding signal or the selected one of a group of signals; thrown 30 degrees to the right it clears another given signal or selected one of a group, for train movement in the opposite di-

rection. All signals that may be controlled by a given lever, however, must be those that govern movements over a common section of track. The ability to control more than one switch, or more than one signal, from a given lever saves a great many

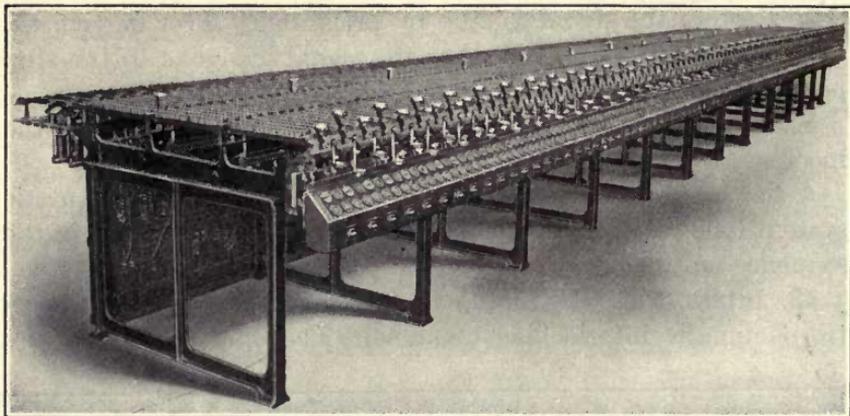


FIG. 94.—Electro-pneumatic interlocking machine. Case removed.

levers, makes it possible to erect a smaller and cheaper tower, and reduces the number of operators required on large plants.

Each lever of the machine is fastened to a horizontal shaft that extends from the front to the back of the machine, and is equipped

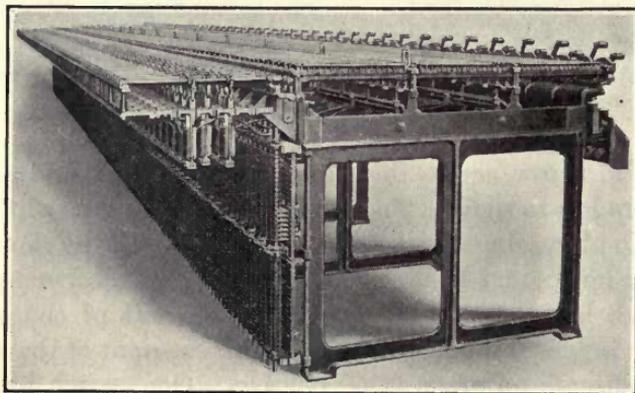


FIG. 95.—Electro-pneumatic interlocking machine. Rear view.

with a latch that is operated by turning the handle. As the lever is rotated, the latch moves over a notched quadrant on the front of the machine. In order to move a lever it is first necessary to turn the handle and thus to raise the latch out of its notch.

The front portion of each lever shaft operates one of the locking bars of a mechanical locking bed, as shown in Fig. 98. This locking bed is similar to that used on a Saxby and Farmer machine, except that it is constructed on a smaller scale. A segmental gear fitted to the shaft meshes in a rack cut on the under side of the locking bar. As the shaft is rotated the bar is shifted. The rear section of the shaft carries the segments that engage the

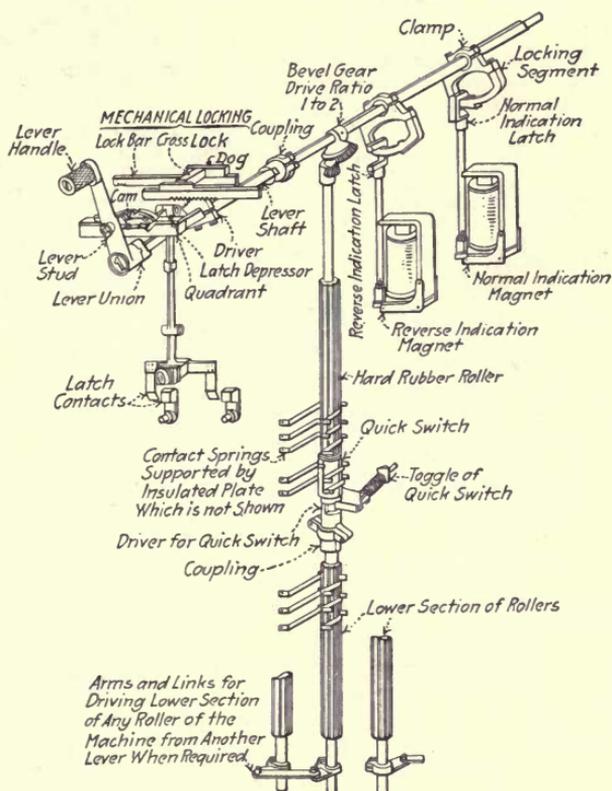


FIG. 96.—Switch lever complete.

indication latches. These latches are dropped and locked by gravity and are raised and unlocked by the armatures of the electro-magnets. Projections on the segments are engaged by the latches unless the magnets are energized at the proper time.

There are two indication magnets for each switch lever, the normal and the reverse. The segments are arranged to provide detector locking and, after the preliminary movement, to restrict further lever movement until the switch indication has been received. Figure 97 gives a diagram of a switch lever and a re-

verse indication segment. Each signal lever has one magnet, often called the lock magnet. Its function is to prevent the placing of the signal lever in the full normal position until the indication is received that the signal has gone to the stop position. Figure 98 shows a signal lever in its "L" (reversed) position. Figure 99 gives a diagram of its positions and operations.

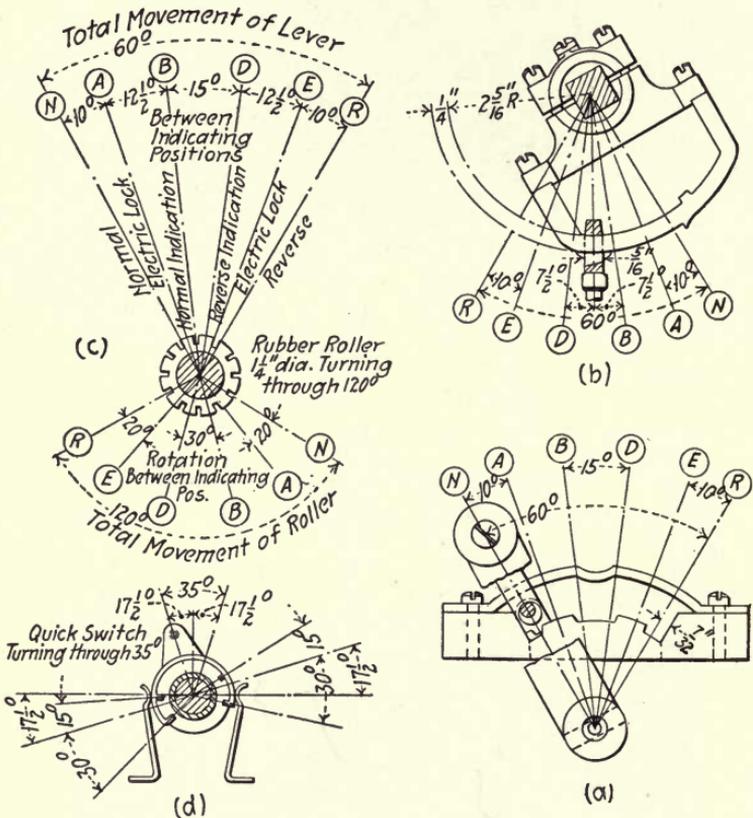


FIG. 97.—Diagram of a switch lever and its operation.

As shown in Figs. 96 and 98, a set of bevel gears near the middle of the lever shaft serves to transmit motion to a vertical shaft. This vertical shaft forms a part of the "combination" or circuit controller that is used to govern the movements of switches and signals. It is encased in a hard rubber roller upon which are mounted phosphor bronze bands that turn between flat phosphor bronze springs extending out from a vertical plate of moulded insulating material. These rollers have a number of fine longitudinal saw-cuts which receive and hold the turned-in ends of the

contact bands as illustrated in Fig. 97d. The contact bands as well as the contact springs are made in several lengths so that it is possible to arrange a circuit to open or close at any desired position of the operating lever. The adjustment of these circuit controllers is made much easier by the fact that the roller is constructed to turn through twice as many degrees as the lever shaft by the ratio of the bevel driving gears.

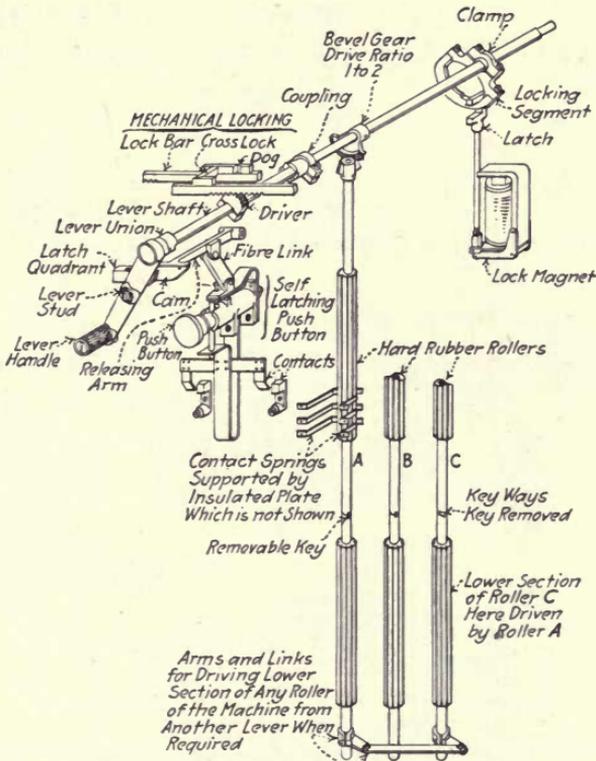


FIG. 98.—Signal lever complete.

In an earlier type of the machine, the contact rollers were made an intermediate part of the lever shaft; and the insulating plate supporting the contact springs was held in a horizontal position below it. This machine is called the horizontal roller type, while the Model 14 machine is known as the vertical roller type.

On the end of each switch roller is a hard rubber collar, or sleeve, on which are mounted two contact bands that operate between springs mounted on the same insulating plate. This collar or sleeve does not turn with the shaft until the lever has



treme position. This arrangement is called the "quick switch," and is illustrated in Figs. 96, 97*d*, and 100.

The working parts of the machine are enclosed in an enameled steel case to prevent the accumulating of dust and the tampering with the parts by unauthorized persons.

**54. Mechanism for Throwing Switches and Derails.**—The switches are operated by means of switch and lock movements similar to the ones used in mechanical interlocking, the actuating power, however, being compressed air. The piston rod of the air cylinder connects directly with the slide bar of the switch and

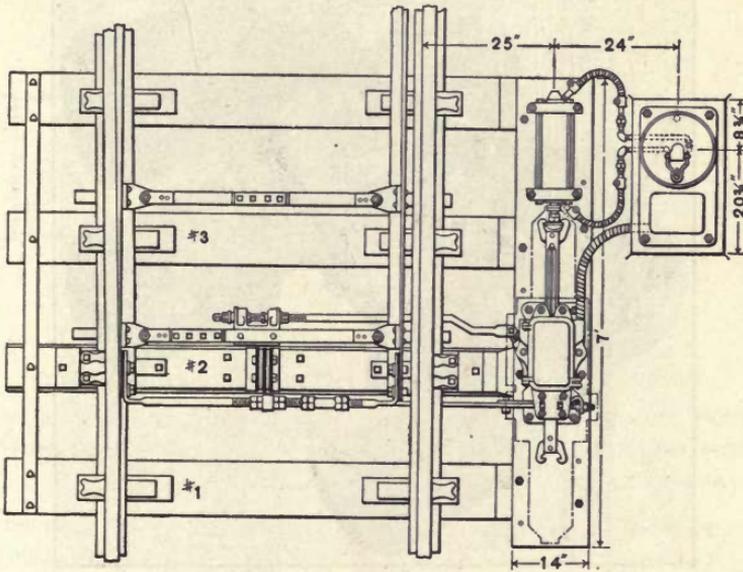


FIG. 101.—Electro-pneumatic switch and lock movement.

lock movement, as indicated by Fig. 101. The stroke of the piston rod and of the switch and lock movement is 12 in. The first 2 in. of the stroke unlocks the switch and throws the detector bar, the next 8 in. throws the switch, and the last 2 in. locks it in its new position.

The switch cylinder and piston operate very much like the cylinder and piston on a steam engine. On the side of the switch cylinder, but sometimes separately mounted, is a "D" slide valve, Figs. 102 and 103, which opens and closes the inlet and exhaust ports to the cylinder. This slide valve is driven by two small shifting pistons, one on each side, impelled by compressed air. The flow of air behind these pistons is, in turn, controlled

by the normal and reverse electro-magnets. Provision is made for locking the slide valve by a lock that is operated at right angles to the motion of the slide valve, and is actuated by a third piston. Air pressure behind the lock piston is controlled by the lock magnet. The lock piston also opens and closes a valve which controls the supply of air to the valve body. Thus it is seen that the switch valve has three magnets, normal, reverse and lock. To throw a switch it is necessary to energize the lock magnet in order to unlock the slide valve and admit air to the

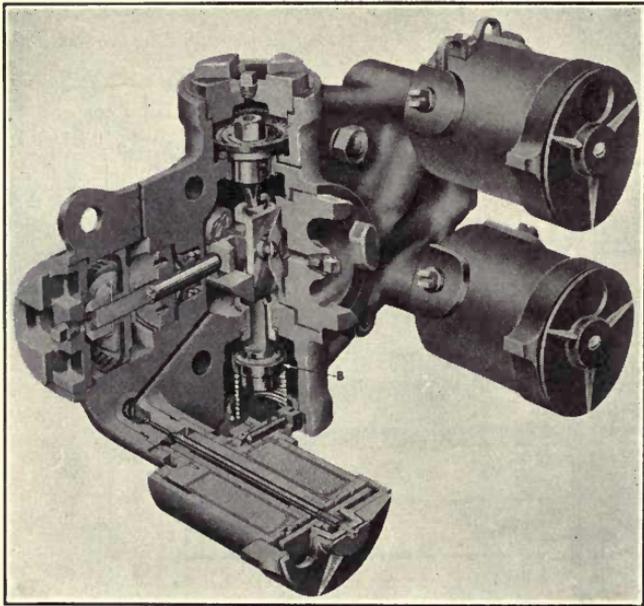


FIG. 102.—Switch valve and magnets.

valve body, and to deenergize one of the control magnets and energize the other in order to shift the slide valve. When the controlling lever is in full normal or reverse position, current is maintained on the corresponding control magnet, but is cut off from the lock magnet.

The operation of an electro-pneumatic magnet may be understood from an inspection of Fig. 104, which shows the type used on a signal. Between the armature and the coil are three short springs that keep the armature raised when the magnet is not energized. Attached to the armature and running down inside the coil is the armature stem, the lower end of which is so bevelled as to seat itself and hold the exhaust post closed when the mag-

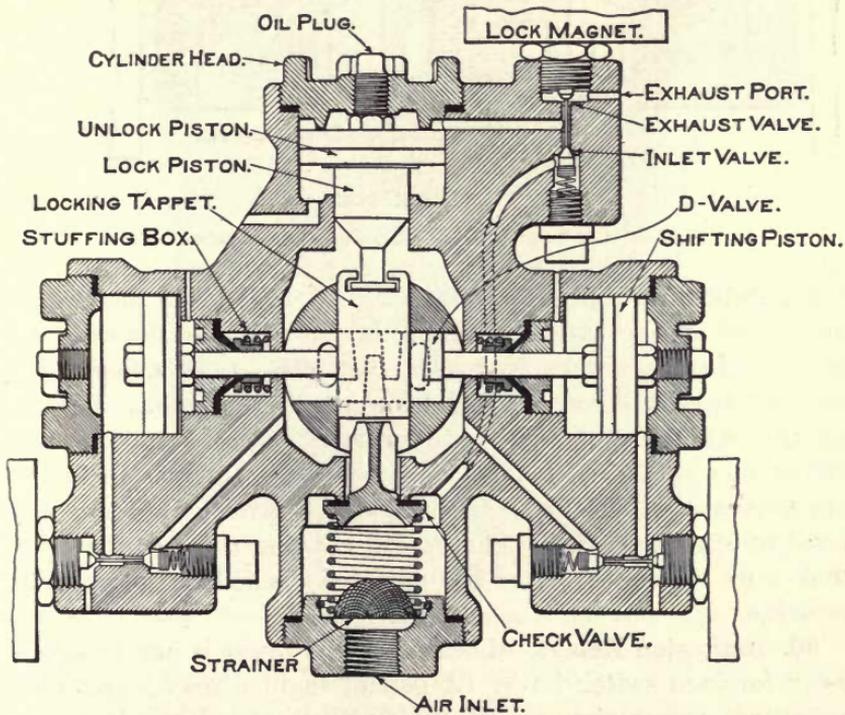
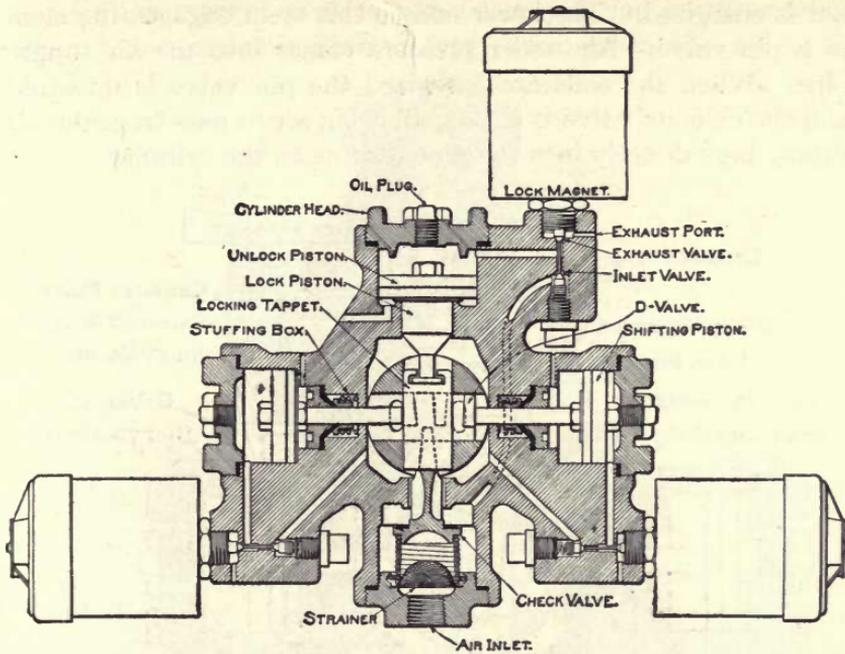


FIG. 103, PART 1.—Switch valve and magnets.

net is energized. The lower end of this stem engages the stem of a pin valve. Air under pressure comes into the air supply pipe. When the coils are energized the pin valve is unseated and the exhaust valve is closed, allowing air to pass from the air supply pipe directly into the pipe leading to the cylinder.

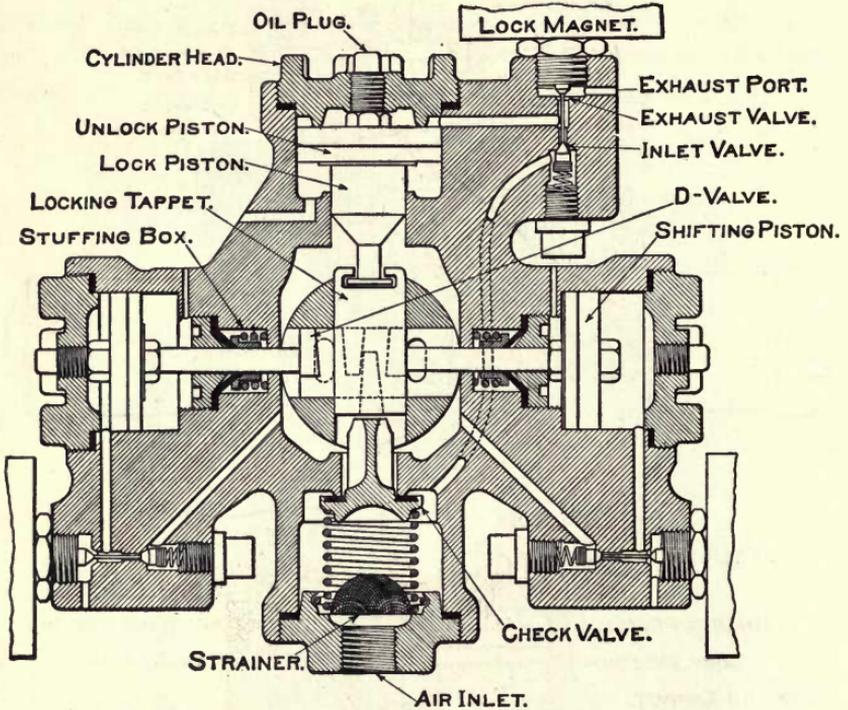


FIG. 103, PART 2.—Switch valve and magnets.

**55. Indication Circuit Controller.**—Mounted on the switch movement and actuated by a cam plate attached to the slide bar is the indication circuit controller, Fig. 105. It is enclosed in a cast iron case, and consists of slides of insulating material bearing contact springs that move between contact points mounted on either side. The motion transmitted to the slides is such that one makes its movement before the switch is fully unlocked, and remains stationary while the switch is being thrown; the other makes its movement after the switch is locked in the opposite position.

**56. Indication Relays.**—Located in the tower is one polarized relay for each switch lever. A pair of small wires connect each relay to a switch circuit controller. When the switch is normal

and locked, current of a certain polarity is fed to these wires through the indication circuit controller; when the switch is

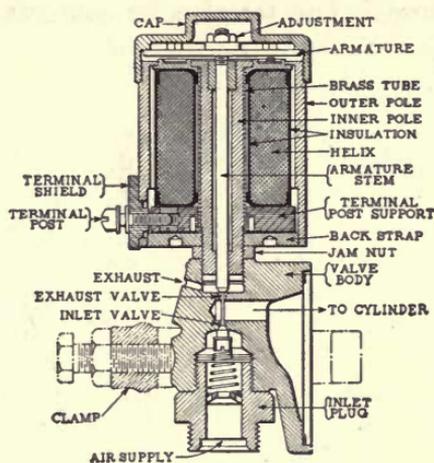


FIG. 104.—Cross-section of pin valve.

unlocked or open, these wires are disconnected from their source of energy and are connected together; when the switch is reversed



FIG. 105.—Pole-changing indication circuit controller.

and locked, current of a polarity opposite to that used for normal indication is fed to the indication wires. Thus the relay in the

tower is made to repeat the position of the switch. Unless the switch is fully locked the relay contacts will be open. When the switch is normal, one set of polar contacts on the relay is

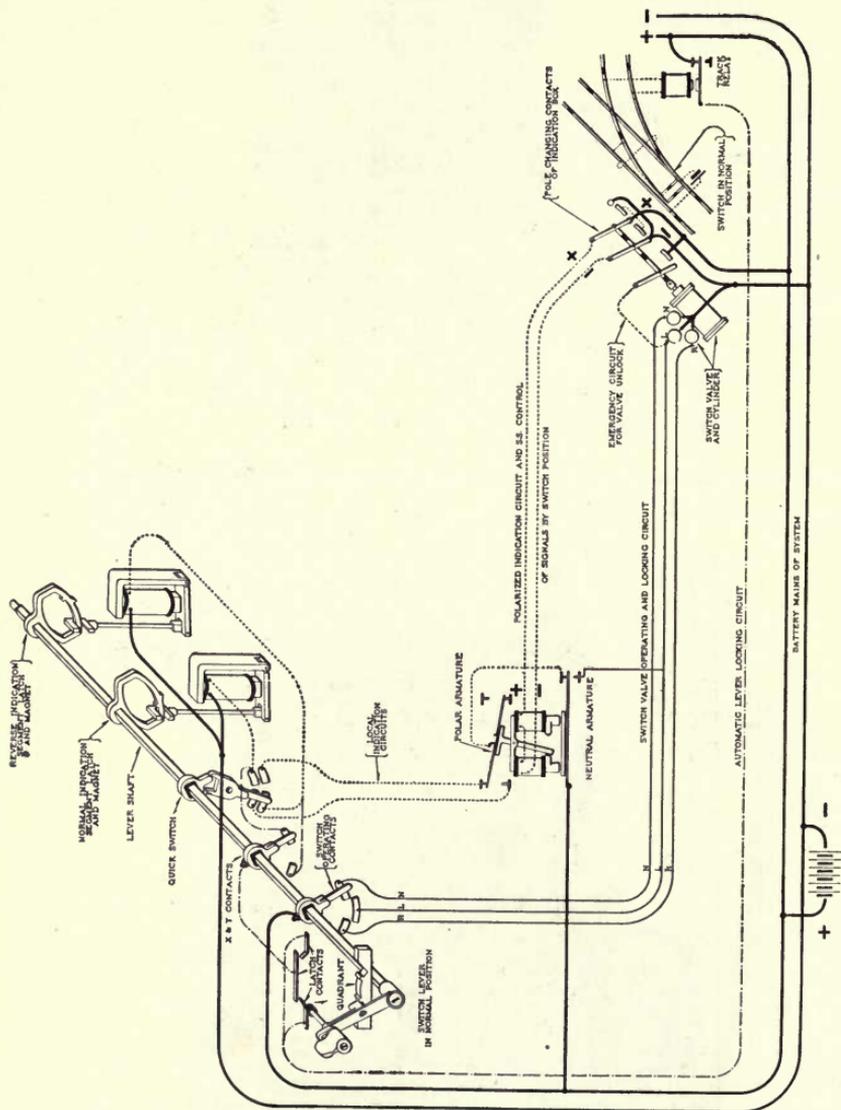


Fig. 106.—Diagram of complete switch control, indication and locking circuits; switch and lever in the normal position.

closed; when the switch is reversed, the other set of polar contacts is closed. Current for picking up the switch lever indication magnets is taken locally through both neutral and polar contacts of the polarized relays. Thus the indication magnets can



**57. Detector Locking.**—At the extreme end of the lever stroke, the magnet which has been disconnected by the quick switch from its source of current coming through the indication relay, is connected by the “X” or “Y” springs to another source of energy controlled by the track relay of that section in which the switch is located. Thus the indication magnets also serve as detector magnets, for the levers in full normal or full reverse position are locked in place unless the corresponding magnet can be energized. A switch could not be thrown with a train in that particular track section because the track relay would be open, interrupting the flow of current. The current for this circuit is also passed through a normally open contact actuated by the lever latch so that the magnet is not continually using current.

**58. “SS” Control.**—Current from the signal levers for clearing the different signals is carried over contacts on the indication relays of those switches in the route governed. This arrangement provides assurance in addition to the mechanical locking that all switches are properly set in order to get a clear signal and makes certain that no switches have been improperly set by hand after the indication was received, a point which would not be checked by the mechanical locking.

**59. Throwing a Switch.**—When the lever is in its normal or reverse position and its latch is lifted, it completes the circuit from the track relay through the latch contact energizing the magnet of the normal or reverse indication segment latch, provided there is no train to short-circuit the track relay and drop its armature, as shown in Fig. 106. This unlocks the lever and allows it to be rotated. In following the cycle of throwing a switch, the switch is considered to be in its normal position and will be thrown from normal to reverse.

When the lever shaft has been turned 10 degrees to the right, the contact is made on the hard rubber roller that energizes the lock magnet at the switch cylinder, unlocking the slide valve in the cylinder. The further rotation of the lever shaft up to a total angle of  $37\frac{1}{2}$  degrees makes other contacts on the hard rubber roller, deenergizing the normal magnet and at the same time energizing the reverse magnet. This permits the air to escape from behind one of the small pistons and to exert a pressure behind the other so as to move the slide valve and admit air behind the piston of the switch cylinder. This pressure causes the piston to travel the length of its stroke throwing the switch

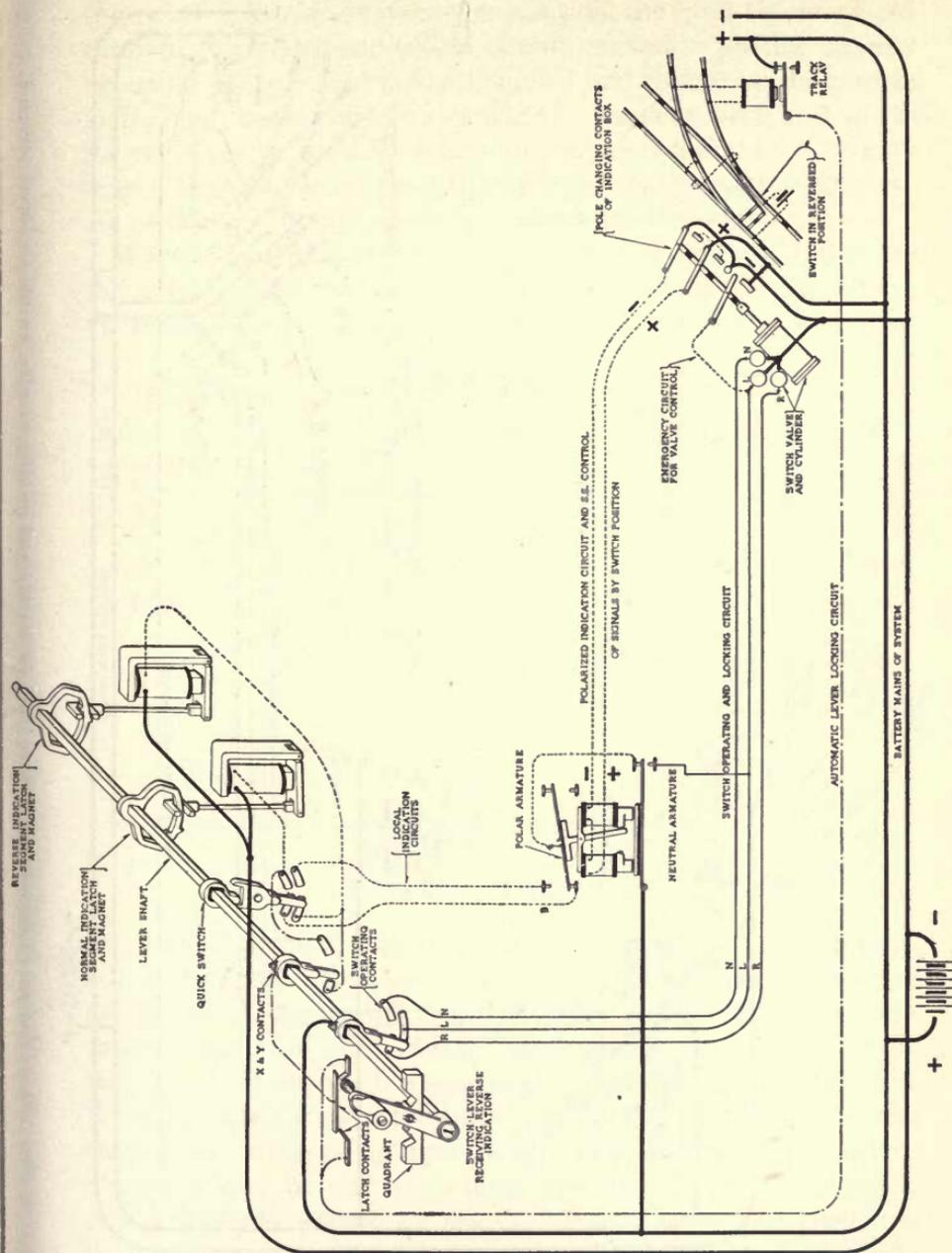


Fig. 108.—Diagram of complete switch control, indication and locking circuits; switch reversed, lever about to receive the indication.

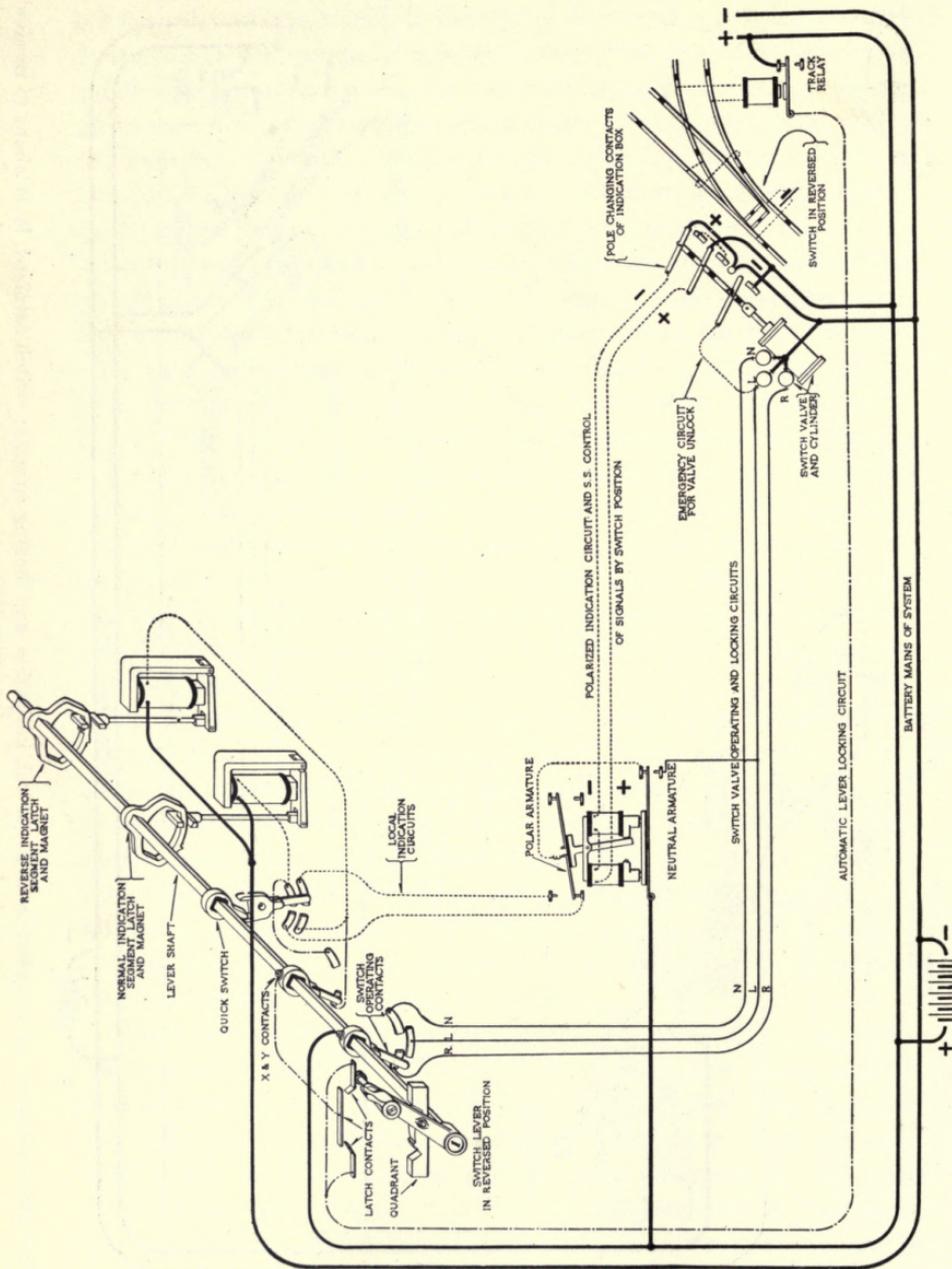


Fig. 109.—Diagram of complete switch control, indication and locking circuits; switch and lever reversed.

and locking it by means of the switch and lock movement. When the switch is thrown to its proper position, the circuit is completed through the switch indication circuit controller picking up and reversing the polarized indication relay and energizing the reverse indication magnet, thereby raising the segment latch and allowing the lever to finish its stroke to the extreme right. The lock magnet is now deenergized, but the reverse control magnet remains energized until the switch points are thrown back.

When the movement of the lever is being completed, it operates the quick switch, which opens the indication circuit for the reverse indication magnet and closes the corresponding circuit for

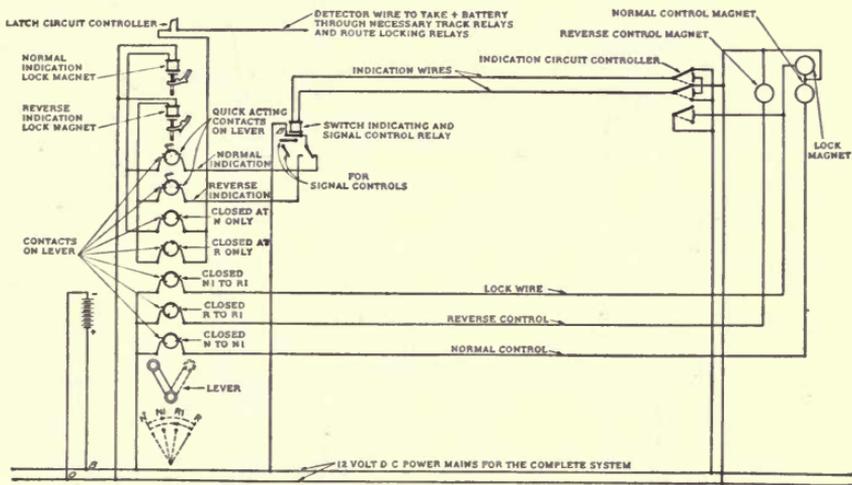


FIG. 110.—Diagram of complete control, indication and locking circuits for single switch with D.C. indication.

the normal magnet, although the latter magnet cannot receive any current until the polarized relay has responded to the next movement of the switch. As the quick switch opens the indication circuit, the "Y" springs close the circuit from the track relay to the reverse indication magnet through the latch contact. When the latch drops into its notch, the latch contact opens, thus leaving the magnet on open circuit to economize on current. Should it later be desired to move the switch back to normal it would first be necessary to raise the lever latch which closes the detector circuit for the reverse magnet in order to raise the indication latch and unlock the lever. If a train is on the track circuit, the track relay contacts will be open, the magnet cannot be picked up and the lever is locked in place. Complete move-

ment from reverse to normal is exactly similar to that described above.

Only during the time when the lock magnet on the switch is energized is air admitted through the slide valve into the switch cylinder and the pressure maintained. When the lock magnet is deenergized not only does it lock the slide valve, but also it cuts off the supply of air to the slide valve chamber and consequently to the switch cylinder. This arrangement avoids the waste of air that would occur by leakage if the pressure should be maintained

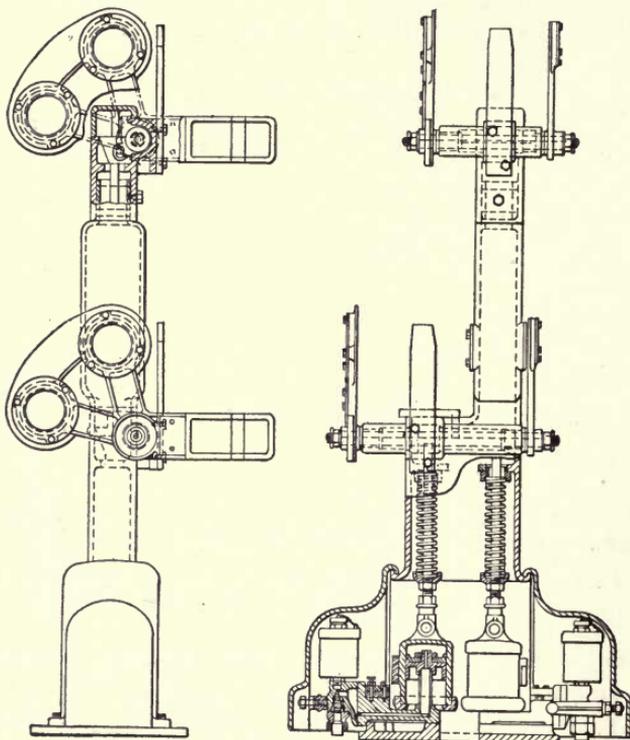


FIG. 111.—Two-arm electro-pneumatic dwarf signal.

constantly in the cylinder. Figure 110 is a diagram showing complete control, indication, and locking circuits for a single switch with direct current indication.

**60. Signal Operating Mechanism.**—The air cylinder that operates a high signal is usually placed at the base of the pole. The up-and-down signal rod operates inside the pole and is connected to the piston of the air cylinder by a balance lever. As the spectacle casting is counterweighted causing the signal to go

to stop by gravity, the air is used only to clear the signal, thus requiring merely a single acting cylinder. An electro-magnet fastened to the signal cylinder controls the movement of the air. There is a circuit breaker on the signal cylinder that gives an indication only when the signal is at normal. There is no indication when the signal is cleared. The stroke of the piston is  $4\frac{1}{4}$  in. and the diameter of the cylinder is 3 in.

In the construction of the dwarf signal, shown in Fig. 111, the up-and-down rod is attached directly to the signal cylinder; the piston remains stationary. As the air is admitted to the cylinder by means of an electro-magnet, the cylinder itself moves upwards

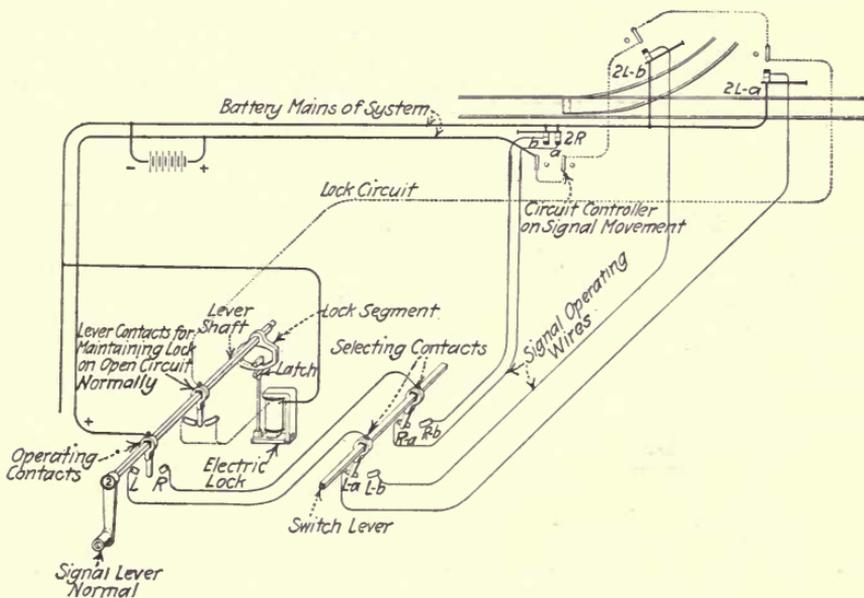


FIG. 112.—Diagram of complete signal control and indication circuits; lever and signals normal.

clearing the signal, but compressing a coil spring on the up-and-down-rod. As soon as the air is released, the coil spring restores the signal to normal. A pair of contact springs placed on the side of the air cylinder acts as a circuit breaker and completes the circuit when the signal is normal. The stroke of the dwarf signal is  $2\frac{1}{4}$  in. The diameter of the piston is 3 in. the same as the high signal.

**61. Operating a Signal.**—For the purpose of explanation it will be assumed that the signal is in its normal position. The lever may be turned to the left or right as the case may require.

After it has been rotated through an angle of about 25 degrees, contact is made by the bronze band on the hard rubber roller completing the circuit to the electro-magnet at the signal cylinder admitting the air and moving the piston rod to clear the signal. To reverse the operation, the lever is rotated a short distance thereby breaking the circuit to the electro-magnet at the signal cylinder and releasing the air that holds the signal clear. Before it can be restored to normal the signal must go to the stop position so as to make contact with the circuit breaker to unlock the lock magnet on the lever shaft. Figures 112 and 113 show a signal lever and its circuits.

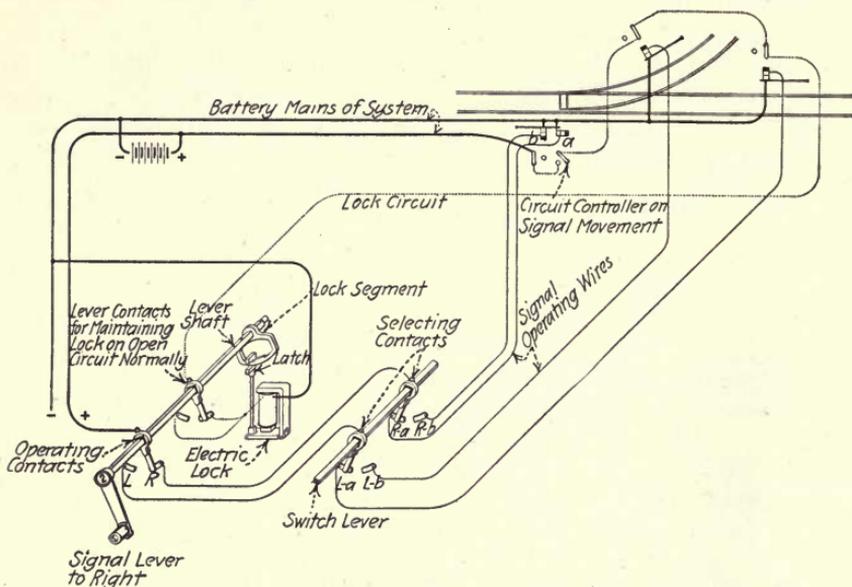


FIG. 113.—Diagram of complete signal control and indication circuits; lever and one signal reversed.

The electro-magnets that control the segment latches on the back end of the lever shaft are wound to a resistance of 130 ohms. As these are energized for very short periods during the rotation of the levers, their total consumption of current is comparatively small. The electro-magnets on the switches and signals are energized for longer periods, however, and consume more current. One magnet on the switch cylinder is energized all the time and the magnet on the signal is energized during the time it indicates proceed. To reduce the amount of current as much as consistent, signal coils are wound to a resistance of 400 ohms. No. 16 wire is used for conductors except the two mains, where

not over No. 9 is necessary. The five wires leading to a switch are put in a cable with different colors for each wire. These wires are laid in trunking to protect them from the weather and from mechanical wear.

**62. Advantages.**—As the main function of the levers in an electro-pneumatic plant is to make and break circuits, the lever equipment is much lighter and much more compact than that in a mechanical plant; consequently, it requires much less space to house the plant and fewer men to operate it.

As the connections between the levers and the functions they operate are made by wires, a great deal of space is saved for buildings and tracks that would be required for pipes if mechanical equipment should be used. It is easily adapted to any kind of yard conditions where there are sharp curves, complicated switches, and movable point frogs.

Since the movements of the switches and signals can be very quickly made, train movements in busy terminals are subjected to a minimum of delay on account of interlocking.

The many ways of checking and locking and guarding against plant failure and consequent danger promote safety in train operation.

On account of the adaptability of the plant, more signals and switches can be thrown with a single lever than can be done with a mechanical plant.

## CHAPTER VII

### ELECTRIC INTERLOCKING

The source of power used to operate an electric interlocking plant generally consists of 110-volt storage battery with its charging unit. During the past 20 years, direct current has been used almost exclusively to operate electric interlocking, but a few plants have been installed that employ alternating current. The interlocking plant is such a vital part of a railway system that an unfailing source of power such as a storage battery is generally considered necessary. The levers in the interlocking machine are operated by hand, but their only purpose is to make and break, in the proper sequence, contacts in the circuits that supply current to the motors which operate derails, switches and signals. A large percentage of plants now being installed are electric, for electric interlocking is well adapted to the operation of all types of yards, terminals and crossings under every traffic and climatic condition.

#### THE GENERAL RAILWAY SIGNAL COMPANY SYSTEM<sup>1</sup>

**63. Electricity.**—The current for operating the switches and signals of the General Railway Signal plant is generally furnished by a 110-volt storage battery which is composed of 57 cells of the chloride accumulator (lead) type or 92 cells of the Edison type. Where the chloride accumulator type is used, the battery should have sufficient ampere-hour capacity to operate the plant seven or eight days, and where the Edison type is used the capacity should be sufficient to operate the plant four or five days. It is customary to provide space in the lower part of the interlocking tower for the storage battery with its charging unit. The battery is usually charged by a generator driven by an electric motor or by a gasoline engine, but in a few cases it is charged by a mercury arc rectifier.

**64. Operating Switchboard.**—Figure 114 represents an operating switchboard where all functions in the plant are controlled by a single circuit breaker. The apparatus mounted on

<sup>1</sup> General Railway Signal Handbook, "Electric Interlocking."

the board consists of the cross protection circuit breaker with its indicating red lamp, a polarized relay, a ground lamp and switch, and a voltmeter and ammeter.

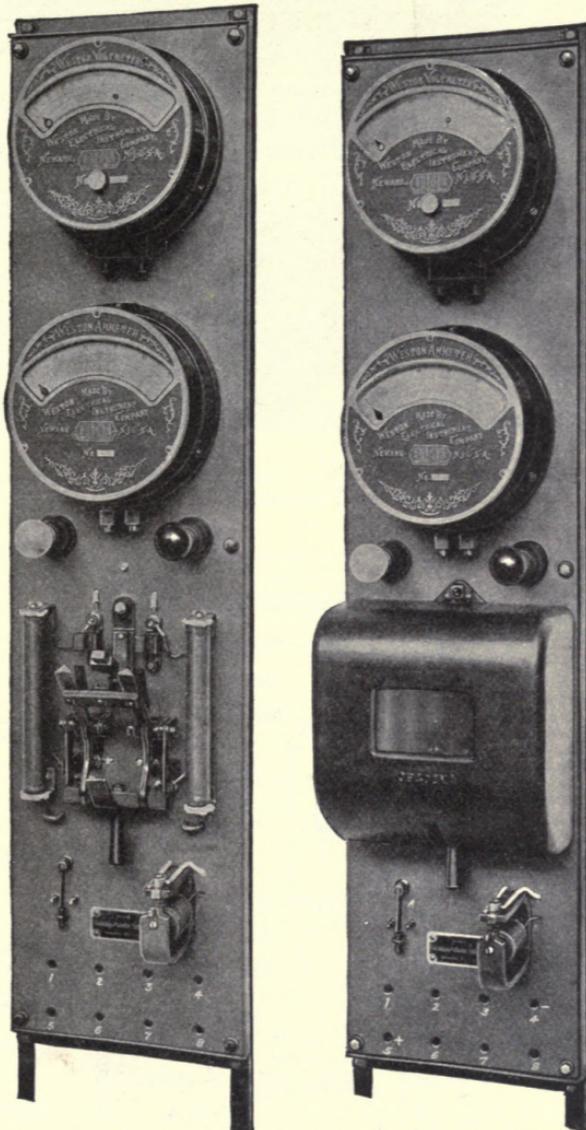


FIG. 114.—Operating switchboard.

**65. Interlocking Machine.**—Figure 115 represents a perspective of a Model 2 interlocking machine, while Fig. 116 shows a section parallel with the levers. This type of machine

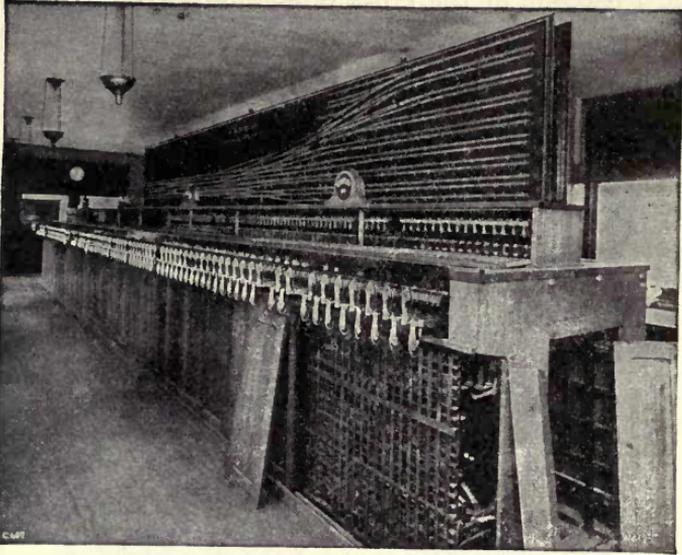


Fig. 115.—Model 2 unit lever type interlocking machine. Lake Street Interlocking Plant, Chicago Terminal, C. & N. W. R'y.

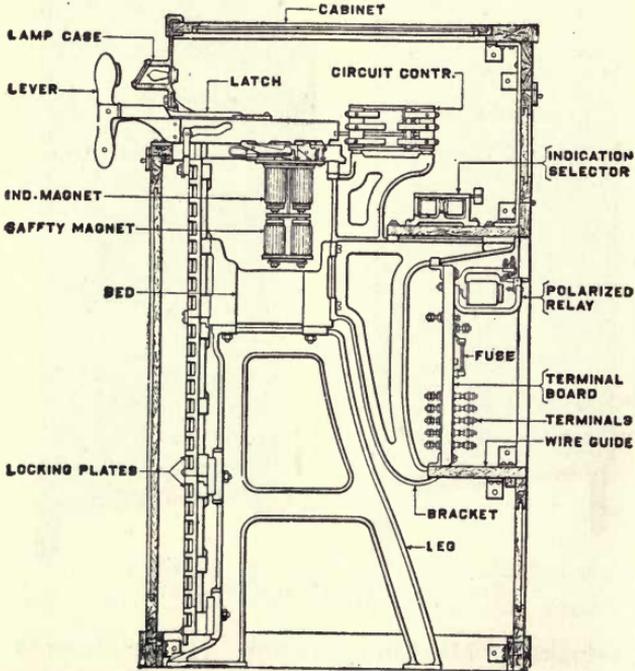


Fig. 116.—Cross section of Model 2 unit lever type interlocking machine.

requires less room to house than the mechanical and fewer operators to manipulate the levers. There are also more checks to guard against failure, for it has both electrical and mechanical locking with provision for safeguarding against false indications.

Figure 117 represents a switch lever used in this system of interlocking. Figure 117*a* shows the lever in the normal position. The lever is moved a short distance horizontally to operate first the mechanical locking and then the switch. The movement is checked in the reverse indication position, shown in Fig. 117*b*,

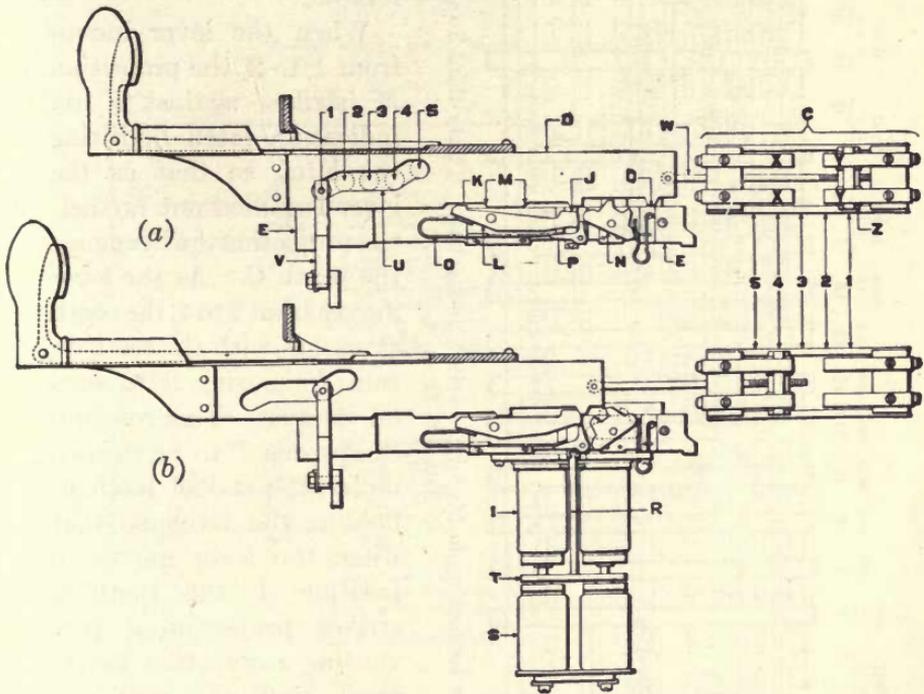


FIG. 117.—Switch lever, unit type.

until the indication current comes in from the switch and releases the lever for movement to its full reverse position.

There is a vertical locking system in the front of the machine very similar in design to that on the Style A machine. A typical arrangement of this locking is shown in Fig. 118. *V* in Fig. 117*a*, connects with a tappet in this locking bed. The roller on the upper end of *V* rolls in a slot *U* in the lever body. When the lever moves from 1 to 2, the tappet is raised one-half of its stroke and locks by means of the mechanical locking any levers that operate conflicting functions. When the lever moves from

2 to 4, the tappet remains stationary, but the contact block *Z* connected to the lever by the rod *W* breaks contact with springs *Y-Y* and makes contact with springs *X-X*. This throws the

batteries into the circuit to operate the switch. The lever cannot be pulled out any farther until it is unlocked, the operation of which is explained as follows:

When the lever moves from 1 to 2, the projection *M* strikes against *K* on indication latch *L*, tilting the latch so that as the lever is pulled out farther, the projection *J* will engage the tooth *Q*. As the lever moves from 2 to 4, the tooth *Q* meshes with the teeth on cam *N* causing it to turn on its axis. This rotation causes dog *P* to be thrown under the end of latch *L*, holding the latch so that when the lever moves to position 4, the tooth *Q* strikes projection *J* preventing any further movement until the switch is thrown and indication given. The indication current through indication magnet *I* lifts the armature *T* causing plunger *R* to strike the dog *P* which turns to release latch *L* and

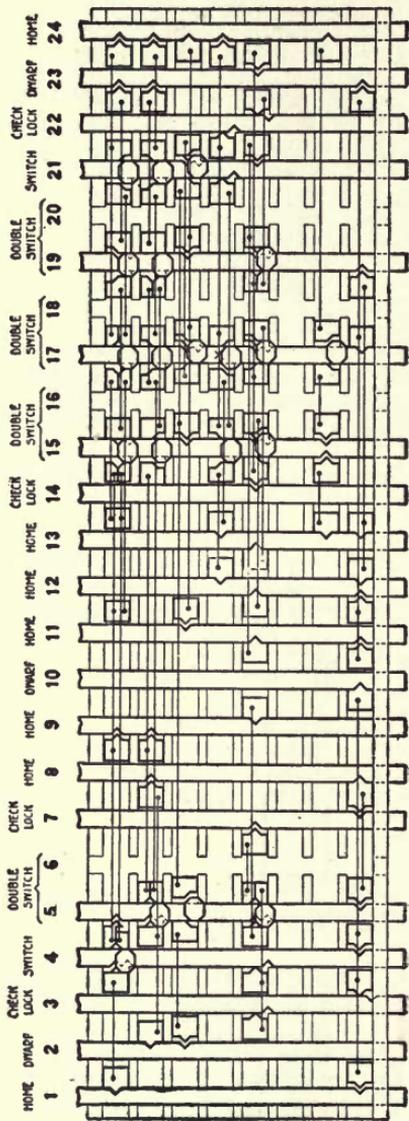


Fig. 118.—Dog chart for locking in Model 2 interlocking machine. Thirty-third Street Station, Hudson Tunnels, H. & M. R. R.

unlocks the lever for final movement from 4 to 5. The movement from 4 to 5 allows the tappet to complete its throw and unlocks sufficient levers to complete the line-up. If the lever moves beyond 3, it cannot be advanced beyond 4 nor returned beyond 2

unless an indication is given. Such an indication cannot be obtained until the switch movement is complete, either entirely open or entirely closed.

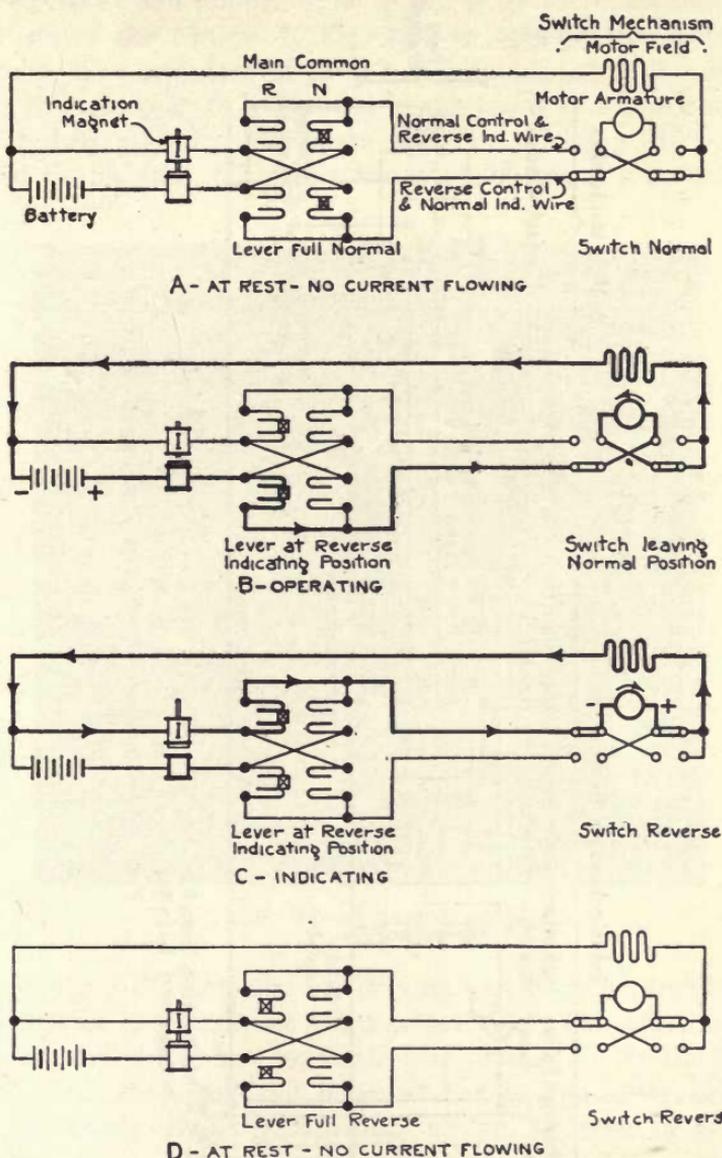


Fig. 119.—Simplified circuits for Model 2 or Model 4 switch machine.

**66. Switch Lever Wiring.**—The movement of the switch is controlled by three wires—a main common wire on which the battery is located, and a normal and a reverse control. These

control wires are also used for giving indications, the normal control for reverse indications and the reverse control for normal indica-

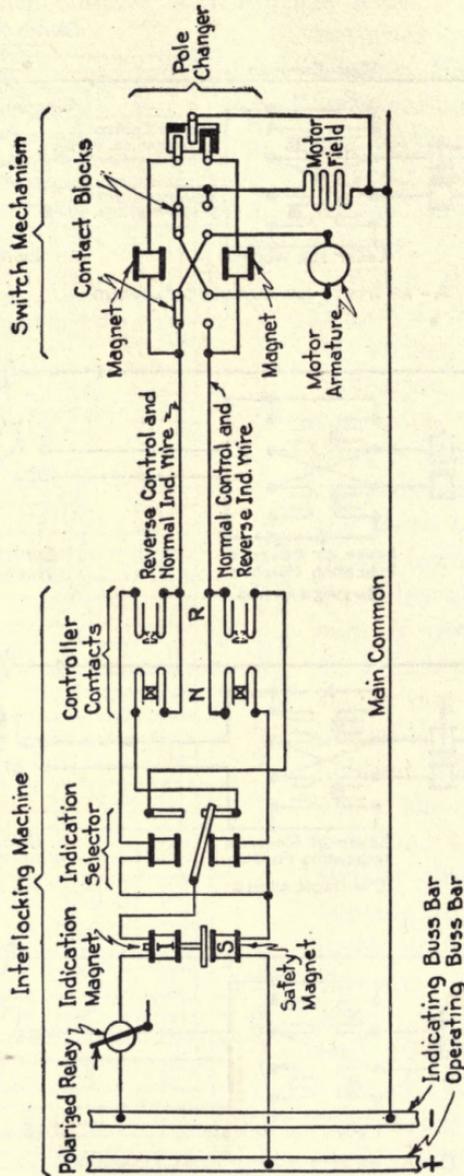


Fig. 120.—Circuits for Model 2 or Model 4 switch machine.

tions. The two control wires are connected to opposite springs of the circuit controller.

**67. Model 2 Switch Machine.**—When the lever is moved to position 4 in Fig. 117a, the circuit is made through the controller

contacts and current flows from the plus or operating bus bar through the safety magnet *S*, Fig. 120, through the indication selector and controller contacts and through the reverse control wire to the switch motor. The return is by the main common. This causes the Motor *A*, Fig. 122, to operate the switch as follows: The armature of Motor *A* is connected by a series of gears to main gear *D*<sub>1</sub>. Pivoted to the frame is a cam crank *E* actuated by a stud on the main gear *D*<sub>1</sub>. Driving rod *G*, connected to this stud, operates a tee crank *H*, one arm of which is

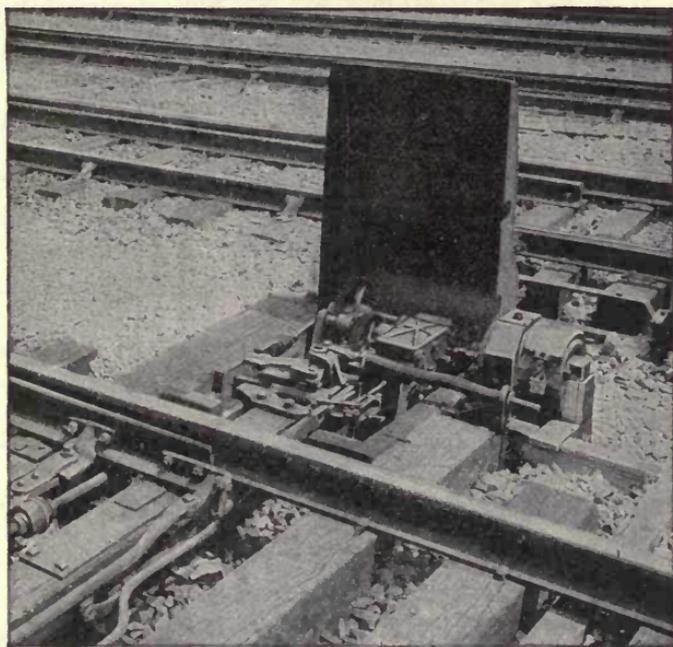


FIG. 121.—Model 2 switch machine.

connected by the detector bar driving link *N* to a straight bar compensator that operates the detector bar. The other arm of the tee crank *H* is connected to the lock plunger *I*. In the newer installations, however, the detector bar is frequently omitted and the track circuit substituted, as will be seen in a later chapter.

Fastened to the lower arm of the cam crank *E* is rod *J* that shifts the switch points. *B* is a pole changer that is operated by a rod *M* connected with the pole changer movement *L*, after lock plunger *I* has passed through the lock rod *K*. The lock

plunger *I* also passes through a hole in the flattened portion of *J* giving additional safety.

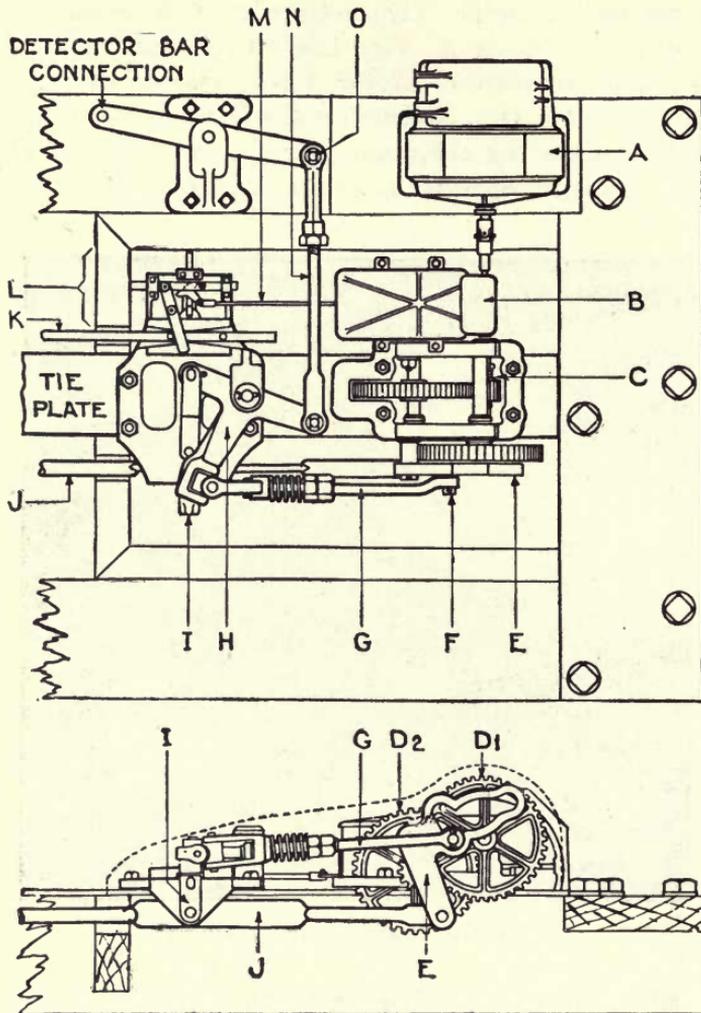


FIG. 122.—Model 2 switch machine.

- |   |                                      |
|---|--------------------------------------|
| <i>A</i> Motor                          | <i>H</i> Lock Crank                  |
| <i>B</i> Pole Changer                   | <i>I</i> Lock Plunger                |
| <i>C</i> Friction Clutch                | <i>J</i> Throw Rod                   |
| <i>D</i> <sub>1</sub> Main Gear         | <i>K</i> Lock Rod                    |
| <i>D</i> <sub>2</sub> Intermediate Gear | <i>L</i> Pole Changer Movement       |
| <i>E</i> Cam Crank                      | <i>M</i> Pole Changer Connecting Rod |
| <i>F</i> Stud on Main Gear              | <i>N</i> Detector Bar Driving Link   |
| <i>G</i> Driving Rod                    | <i>O</i> Pin                         |

The main gear *D*<sub>1</sub> makes one complete revolution while opening or closing the switch points. During the first third of

the revolution, the lock crank *H* is shifted, raising the detector bar and pulling the lock plunger *I* out, unlocking the switch; during the second third, the switch is thrown; and during the last third, the detector bar is lowered, the switch is locked, throwing the pole changer. The pole changer is thrown as soon as the plunger *I* passes through lock rod *K*. This disconnects the motor from the reverse control wire and closes contacts which connect the motor to the reverse indication wire. The mechanism is so constructed as to allow the armature to continue to run for a short time due to the momentum it had as a motor. The motor then becomes a generator driving indication current from the positive terminal through the main common, polarized relay, indication magnet, indication selector contact, lever contact, reverse indication wire and pole changer contact back to the armature which is negative when the motor is running as a generator. This lifts armature *T* and the plunger *R*, Fig. 117*b*, and disengages the latch *L* and allows the lever to finish its movement. This is called dynamic indication. The generator stops in a very short time, for driving this current acts as a "snubber."

The motor is a series-wound four-pole motor. For operating a single switch the four field coils are usually connected in series, but for operating more than one set of switch points, as movable frog points, the coils are divided into two sets of two coils each in series, and the two sets are connected in multiple. This connection gives the machine more power. The pole changer automatically disconnects the motor from the battery after a switch movement and at the same time reverses the armature terminals for indication purposes, thus leaving the motor connections in the proper position for the next operation. The reversal in the direction of rotation of the motor is accomplished by reversing the direction of current flow through the armature.

The contact block may be shifted also by means of two sets of solenoid magnets, Fig. 123. If any obstruction, such as snow or ice on the track, will not allow the switch points to fit snugly against the rail, the direction of the current through the motor may be reversed by shifting the lever between 2 and 4, reversing the direction of the current through the solenoids; and the switch may then be thrown in the opposite direction. If this movement back and forth be repeated a few times, the obstruction may frequently be removed. There are fuses on the control wire line of such size that in case a switch should stick or the armature

could not rotate for any reason while the current is applied, the fuses would melt before the motor would burn.

To guard against a false indication from a short-circuit between control wires while the battery current is flowing through the motor to move the switch, a safety magnet *S*, Fig. 120, is mounted beneath indication magnet *I*. The armature *T* of magnet *S* rests directly on the poles of *S*. Magnet *S* is in the battery circuit, and during the time the current is flowing to the switch motor, the armature *T* is held so firmly to *S* that it cannot be drawn to *I* and a false indication given.

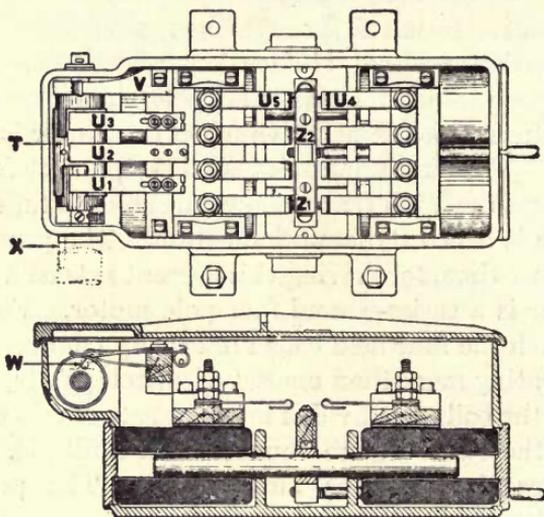


FIG. 123.—Pole changer for Model 2 switch machine.

The safety magnet protects against the possible receipt of an improper indication due to an accidental cross between control wires during the time when the current is flowing through the lever contacts to operate the function. From the time when the lever is moved to the new operating position until the movement of the switch machine is completed, the indication selector further insures against the possible receipt of an improper indication. At all other times protection against improper operation and indication is secured by means of the polarized relay. If there should be a foreign current flowing through the reverse control wire when the switch is normal, the armature of the polarized relay would operate to open the circuit breaker and disconnect the battery from the machine. If the foreign current should flow through the reverse control wire only when the battery

is flowing through the normal control, the safety magnet would prevent the indication magnet from operating and at the same time the polarized relay would operate to disconnect the battery.

**68. Model 4 Switch Machine.**—Figure 125 shows two views of the Model 4 switch machine. The motor is connected to a set of intermediate gears that drive the cam gear *D*. On the upper side of *D* is a cam slot that engages the roller on the end of the locking bar *F*. A link on the end of the locking bar connects with a straight bar compensator that operates the detector bar. The locking dogs *H* are so arranged on the locking bar *F* that when one dog has been withdrawn to unlock rod *I*, the other dog will not enter its slot until the switch points have been thrown to

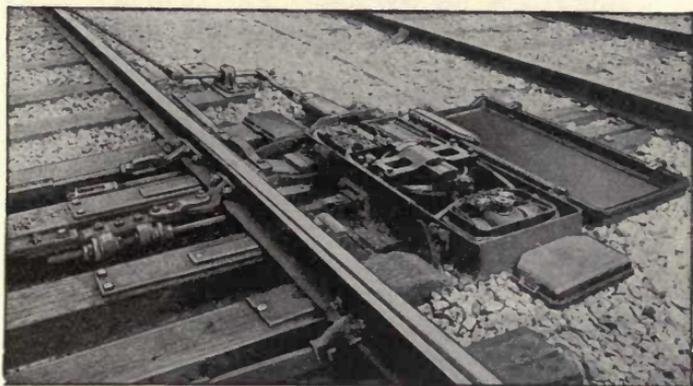
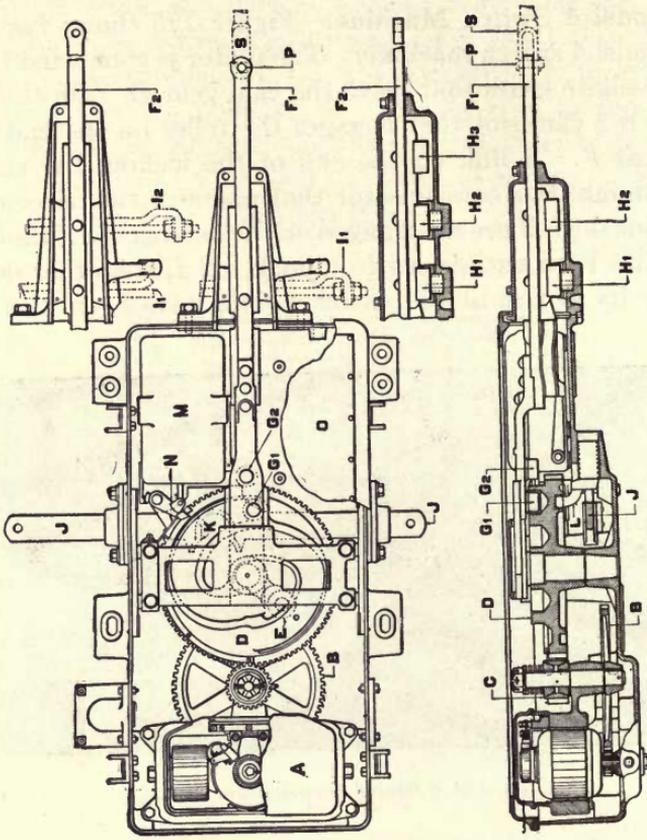


FIG. 124.—Model 4 switch machine.

the opposite side. A locking bolt *L* operated by the cam movement engages the throw rod *J* and also locks the switch in both open and closed positions, giving additional safety to the operation. To operate the pole changer of the Model 4 machine there is a tripper arm *N* which engages with a cam either on the upper or lower side of wheel *D* after the switch points have been shifted and locked in position for traffic. The tripper arm operates contact blocks *S*<sub>1</sub> and *S*<sub>2</sub>, Fig. 126. Roller *U* engages a cam slot on the locking rod *F* and operates the arm *T*<sub>2</sub> and the contact arm *V*.

**69. Model 5 Switch Machine.**—Figure 127 represents a plan and section of a Model 5 direct-current 110-volt switch machine complete with adjustable lock rod, double-end switch bar, detector bar connection, circuit controller and conduit con-



- A Motor
- B Intermediate Gear
- C Friction Clutch
- D Main or Cam Gear
- E Roller on Main Gear
- F<sub>1</sub> } Locking Bars
- F<sub>2</sub> }
- G<sub>1</sub> } Rollers on Locking Bar
- G<sub>2</sub> }
- H<sub>1</sub> } Locking Dogs
- H<sub>2</sub> }
- H<sub>3</sub> }
- I<sub>1</sub> } Lock Rods
- I<sub>2</sub> }
- J Throw Rod
- K Jaw in Throw Rod
- L Locking Bolt
- M Pole Changer
- N Tripper Arm
- O Switch Circuit Controller Location
- P Pin
- S Detector Bar Connection

Fig. 125.—Model 4 switch machine.  
Showing single and double locking cages.

nection to trunking. It operates very much like the Model 4 machine, but it is somewhat smaller and more compact.

**70. Semi-automatic Signal Control.**—In Fig. 128, when the signal lever is reversed, a battery circuit is set up from the plus bus bar through the reverse controller contact, the control wire, the signal motor operating field and armature, and main common. The first 40 degrees of the mechanism movement does not change the position of the signal arm, but puts under tension a set of coil springs which are strong enough to rotate the motor on the

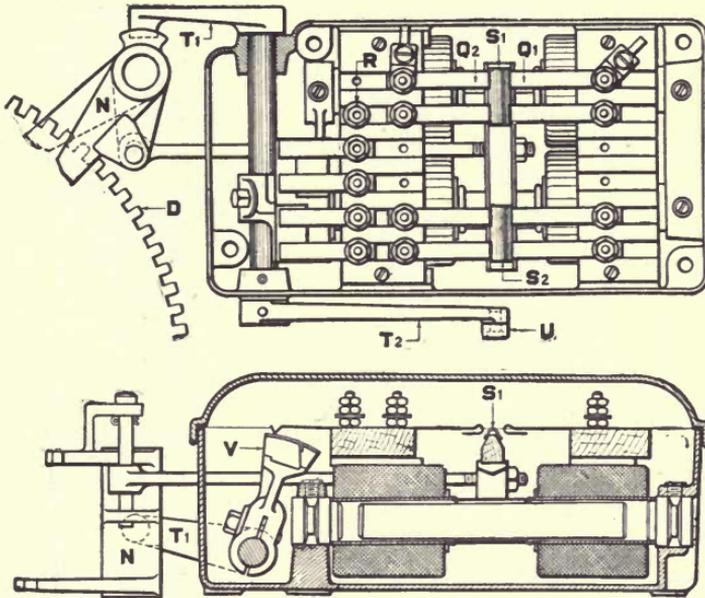


FIG. 126.—Pole changer for Model 4 switch machine.  
Tripper arm N shown at the top of its vertical movement.

return movement with sufficient speed to generate the current for energizing the indication magnet on the lever. If the track circuit be occupied, the mechanism is held in the zero position against the tension of the springs by the opening of contact  $B_1$  and the closing of contact  $A_1$  which connects the holding field in series with the operating field and armature of the signal motor. If the track circuit be not occupied, the mechanism will not stop in the zero position, but will continue its movement, taking current through the track relay armature contact and circuit breaker  $B_2$ , and bringing the signal blade to the proceed position. Just before it reaches this position, contact  $B_2$  opens

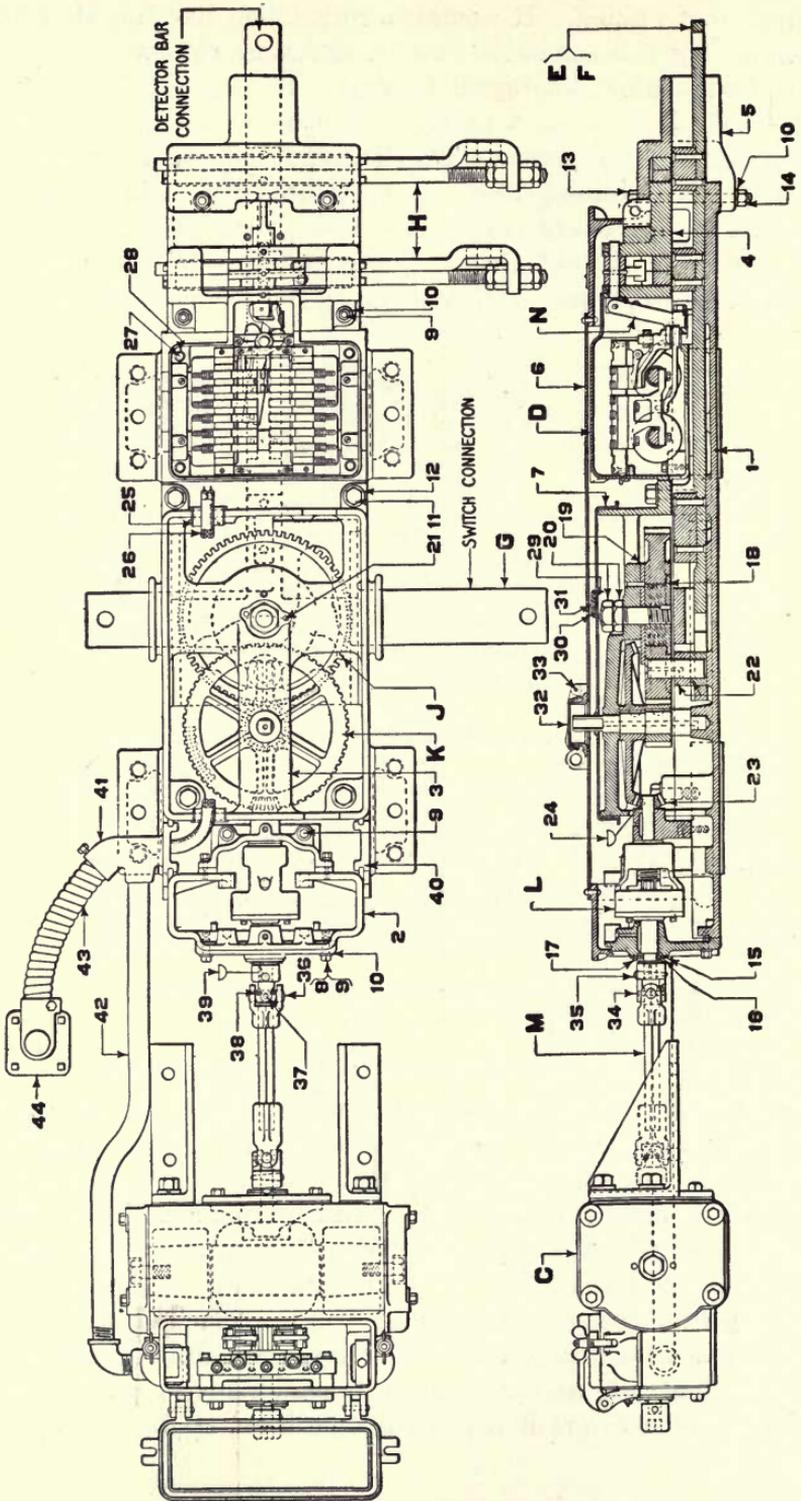


Fig. 127.—Model 5 switch machine.

and  $A_2$  closes, again cutting the holding field in series with the operating field, thereby retaining the signal mechanism and signal arm in the proceed position.

If a train enters the track section controlling the signal, the track relay becomes deenergized and its relay armature drops breaking the circuit and allowing the blade to return to the zero position. This movement of the blade causes the armature of the motor to run in the opposite direction making it act as a "snubber" to check the momentum of the blade. Circuit breaker contact  $A_1$  closes, thereby retaining the mechanism in the zero position during such time as its lever may be reversed. The signal arm cannot again be cleared until the mechanism is returned to its  $-40$ -degree position. When the lever is restored normal, energy is cut off from the motor, and the mechanism is returned to the  $-40$ -degree position by the tension of the coil springs. Just before the blade reaches this position, contact  $B_1$  closes, thereby connecting the motor armature and operating field in their original closed circuit, which includes the indication magnet. The backward motion of the motor generates enough current to energize the indication magnet and to allow the lever to go to its normal position. If the controlling lever be placed normal before a

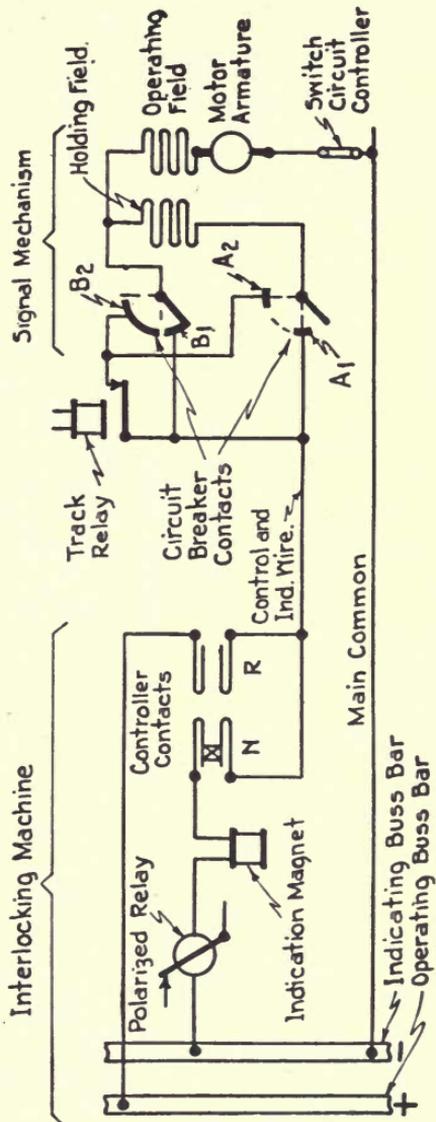


Fig. 128.—Circuits for Model 2A, two-position, semi-automatic signal.

train enters the track section, the signal arm returns to the stop position and the mechanism continues to run backwards until it reaches its -40-degree position, generating current to give the indication as before.

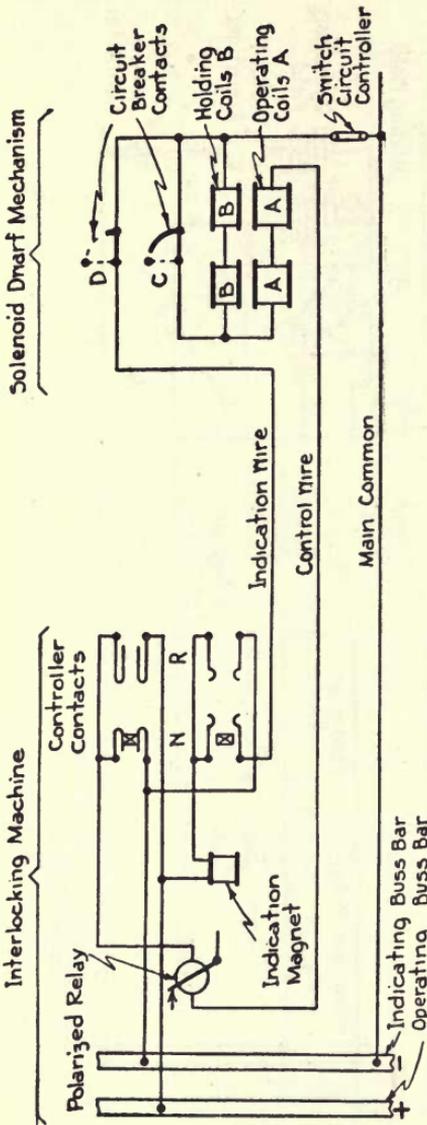


FIG. 129.—Circuits for Model 2 or Model 3 solenoid dwarf signal.

**71. Dwarf Signals.**—

Some dwarf signals are operated by means of solenoids. There are two sets of coils, a low-resistance operating coil and a high-resistance holding coil. The plungers of the solenoids are connected directly to the arm of the signal. As there is no means for getting dynamic indications, an indication wire in addition to the control wire is necessary. In Fig. 129, as soon as the signal lever is reversed as far as it will go, the battery circuit is set up from the plus bus bar through the lever controller contacts in reverse position and through the polarized relay to the operating coils A-A. This brings the signal arm to the proceed position. Just as the arm reaches this position, circuit breaker C is opened causing the current to flow through the

holding coils B-B in series with the operating coils A-A, retaining the arm in that position. No indication is given for this position. The coils B-B are high-resistance coils in order to reduce the current as much as possible. When the signal lever is returned towards normal as far as it will go, the battery circuit is broken to

the solenoid. The coil spring which was placed under compression when the signal was cleared now causes the arm to return to the horizontal position. Its first movement closes contact *C* and its final movement closes contact *D*. This permits battery current to flow through the indication wire and release the signal lever for final movement to normal. By observing Fig. 129, it is seen that in its final normal position, the indication circuit is broken in order to eliminate a waste of current. In Fig. 130 is a sketch of the Model 2 solenoid dwarf signal operating mechanism.

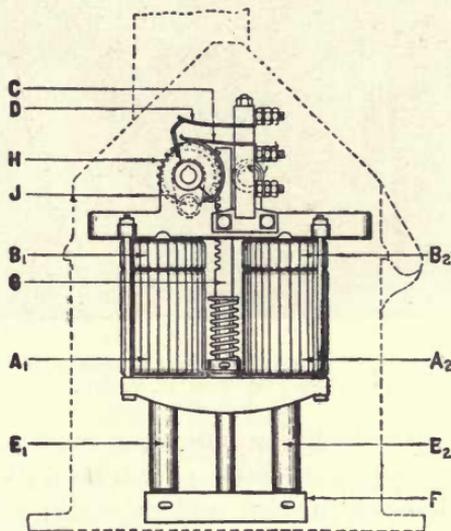


FIG. 130.—Model 2 solenoid dwarf signal operating mechanism.

<i>A</i> <sub>1</sub> – <i>A</i> <sub>2</sub> Operating Coils	<i>F</i> Yoke
<i>B</i> <sub>1</sub> – <i>B</i> <sub>2</sub> Holding Coils	<i>G</i> Rack
<i>C</i> Operating Contact	<i>H</i> Pinion
<i>D</i> Indicating Contact	<i>J</i> Crank
<i>E</i> <sub>1</sub> – <i>E</i> <sub>2</sub> Solenoid Plungers	

The two sets of coils *A*<sub>1</sub>–*A*<sub>2</sub> and *B*<sub>1</sub>–*B*<sub>2</sub> operate the plungers *E*<sub>1</sub>–*E*<sub>2</sub>. Motion is transmitted to the signal arm by means of the yoke *F*, rack *G*, pinion *H*, and crank *J*. The contact springs *C* and *D* are operated by a commutator on the same shaft as pinion *H*. Contacts *C* and *D* are both broken when the signal arm is clear. *D* is closed only when the arm is horizontal in order to give the indication.

**72. Cross Protection.**—When all functions are at rest they are on a closed circuit. In order to eliminate the possibility of foreign currents operating a function, one polarized relay of low resistance is placed in the plant for each lever on the machine.

It may be fastened to the terminal board on the back side of the machine or it may be mounted on top of the machine as shown in Fig. 131. It is placed in the indication circuit and is so con-

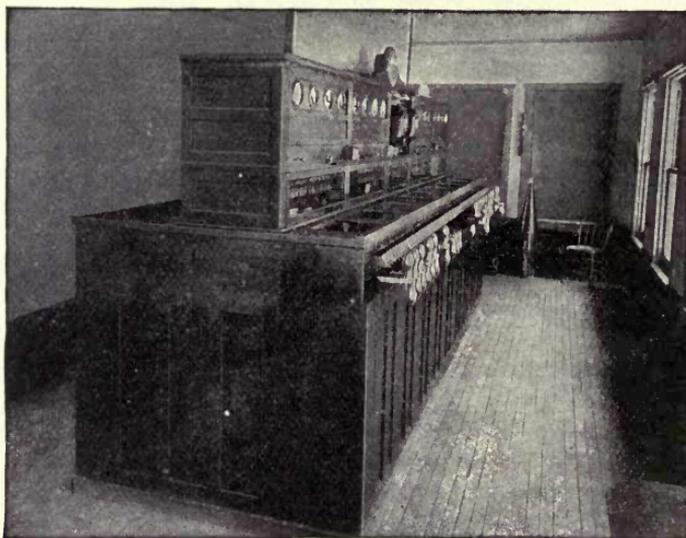


FIG. 131.—Model 2 unit lever type interlocking machine. Collinwood Interlocking Plant, L. S. & M. S. R'y.

nected that all currents giving indication must pass through the polarized relay in such a direction as will keep its contact closed, while all unauthorized current, such as would come from short-

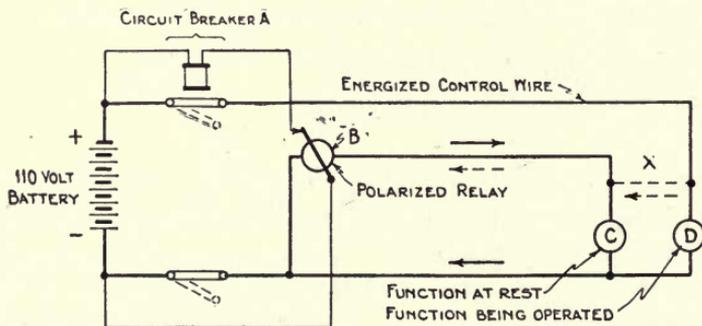


FIG. 132.—Simplified circuit showing the principles of the G. R. S. cross protection system.

circuits or from foreign circuits, must flow in the opposite direction. This causes the relay to break its contact and shut off the current to the whole plant. In Fig. 132 is a simplified circuit showing the principle of this system of cross protection. Func-

tion *C* is at rest. The current through *B* normally flows in the direction indicated by the heavy arrow. If there should be a short-circuit, as at *X*, while the function *D* is being operated, the current would travel through *B* in the opposite direction, as indicated by the dotted arrow, reverse its polarity and break contact through the circuit breaker *A*. This, in turn, would release its armature and break the circuit to the whole plant. Figure 133 is a more comprehensive sketch showing wiring for a switch and signal.

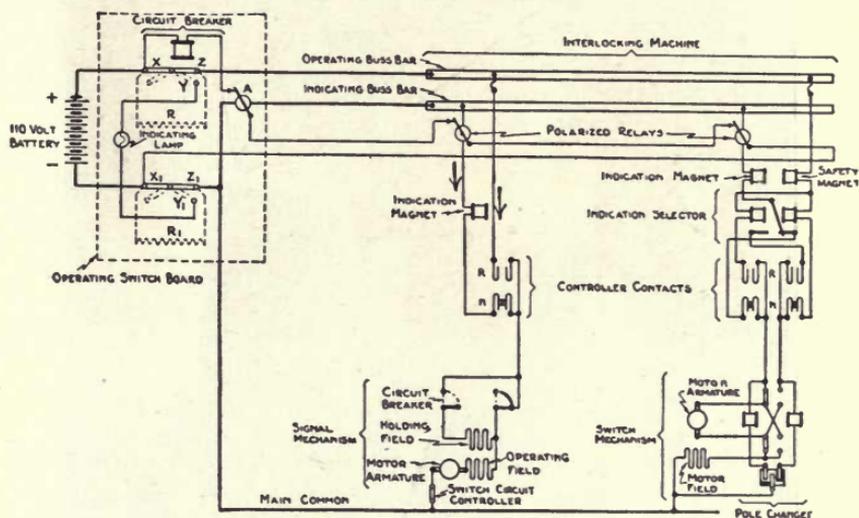


FIG. 133.—Circuits for operating switchboard, interlocking machine and switch and signal functions.

**73. Alternating-current Interlocking.**—In the case of alternating-current interlocking the switches and signals are operated directly from a 110-volt circuit, 25 or 60 cycles. The switches are operated as in the direct-current system and give a dynamic indication. The semaphore type of signals, however, is not equipped for dynamic indication. Indication is given by energy through a contact on the signal circuit breaker, which is closed when the signal is in the stop position. When the light type of signals is used with the alternating-current or direct-current systems, indication is given through a back contact on the controlling relay.

The use of alternating-current interlocking is not advisable unless two reliable sources of alternating-current power are available, and then its use is questionable unless a failure of the

source of signal power also takes away the motive power of the cars or trains, as is sometimes the case on electric railways.

**74. Illuminated Track Diagram.**—One of the features of a power interlocking plant is a track indicator, which is a miniature yard layout, placed above the interlocking machine in the tower to aid the towerman in following the movements of the trains. One such type of indicator is the illuminated track diagram in which the tracks, switches and signals are painted on a ground

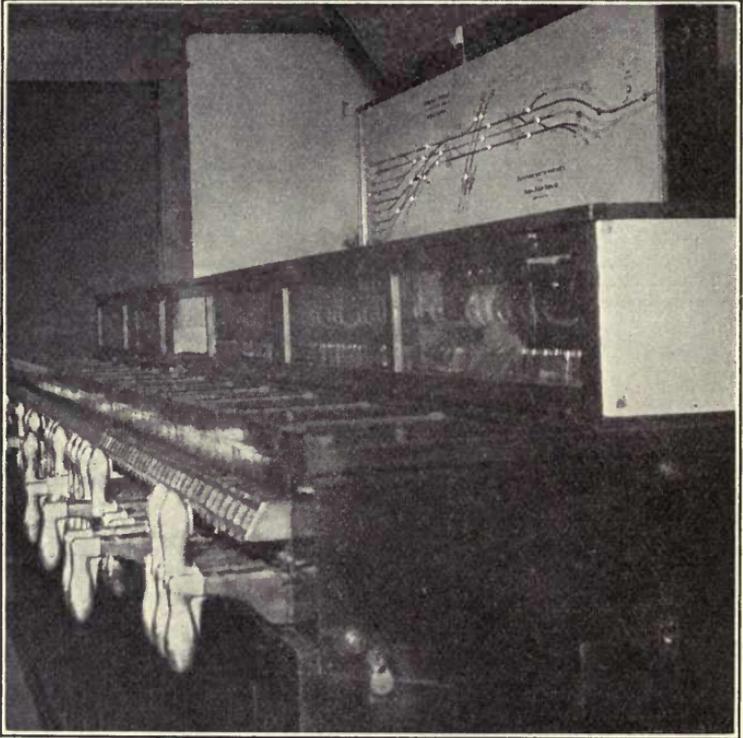


FIG. 134.—Illuminated diagram.

glass set directly above the interlocking machine, where it is plainly visible to the towerman. Very small incandescent lamps controlled by the track circuits are placed along each track behind the glass. Two colors of lamps are used alternately, red and white. When the track is not occupied, the white light burns and when it is occupied the red light burns. This furnishes the means for a signalman to follow easily the movements of every train through the yard, even though he cannot see the yard itself. Figure 115 shows such a diagram in the Chicago Terminal of the

Chicago and North Western Railway. A newer type of illuminated diagram is shown in Fig. 134. The miniature lamps on the face of the diagram are each connected to a track circuit. The current for illumination is taken through the relay points in that section or through a repeater relay located in the tower. The lamp may be normally lighted when the track circuit is

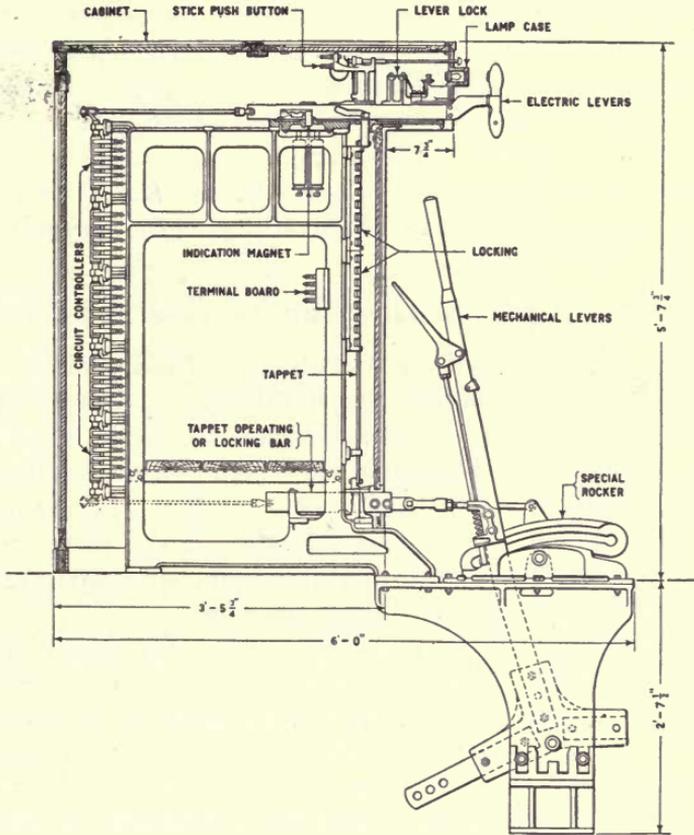


FIG. 135.—Electro-mechanical interlocking machine.

not occupied, in which case the light goes out as the train occupies that section. The more general way is to have the lamp illuminated only during the time the train is in the track circuit.

**75. Electro-mechanical Interlocking Machine.**—The electro-mechanical interlocking machine is a combination of electric and mechanical interlocking equipment. The large mechanical levers operate switches and derails, while the electric levers control signal, electric locking and indication circuits. The mechanical

levers are spaced 5 in. apart, while the electric levers are spaced  $2\frac{1}{2}$  in. apart. Those electric levers mounted in the same vertical plane as the mechanical are used for giving indications of the movements of switches or derails, and the others for controlling the signal circuits.

The mechanical locking is the vertical type, operated in the same manner as in the electric machine. The rotary controllers on the back of the machine operate around a vertical axis. They are made in five tiers with six contacts in each, making thirty contacts for each circuit controller. This arrangement of levers and locking provides for detector locking and for switch and signal indications. It permits a much smaller plant than would be required if all the levers should be of the mechanical type, and allows an extension of a plant without enlarging the tower for lever space.

#### UNION SWITCH AND SIGNAL COMPANY TYPE "F" SYSTEM

**76. General.**—This system of electric interlocking differs from all other existing systems of electric interlocking in that the actual power for operating the switch and signal mechanisms is drawn from a pair of busses or mains which extend throughout the interlocking plant so as to supply each function when required. In all other systems of electric interlocking the power which operates any function is fed to that function over a separate wire or set of wires from the interlocking machine.

**77. Power Supply.**—The usual source of power supply for the Type "F" interlocking plants is a set of storage cells, charged from local generators or mercury arc rectifiers. However, a number of Type "F" plants employ alternating current exclusively, in which case provision is made for taking this power from any one of two or three different power lines in order to provide a constant supply of power in the event of failure of any of the lines. In some installations devices are provided to change the connections automatically in case of failure of power on the line being used. One hundred and ten volts is the usual potential employed on the plant, whether alternating current or direct current.

**78. Interlocking Machine.**—This system is so similar to the electro-pneumatic system that the same interlocking machine, with slight modifications, is used. Operating on a higher voltage, the indication magnets for direct current are wound to about

2,000 ohms resistance. The contact arrangement for switch control is changed slightly; otherwise, the machine is just as described for the electro-pneumatic system.

**79. Power Mains.**—The power mains consist of a pair of relatively heavy wires extending throughout the plant with taps at each switch and signal, not unlike an electric light circuit. These power mains correspond to the compressed air line in the electro-pneumatic system. They do not have to be heavy enough to carry current for operating all the functions at the same time. Since the mechanical interlocking feature prevents the operation of many of the functions at one time, the mains

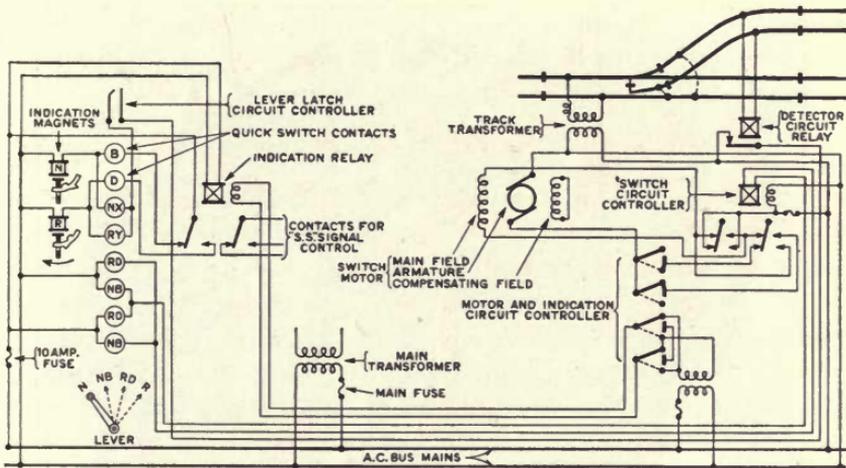


FIG. 136.—Complete operating and indication circuits for a single switch.

need to be only heavy enough to supply current to those that can be simultaneously operated.

At each switch movement is a controller connected to the combination board on the interlocking machine by a pair of small electric wires. These controllers correspond to the switch valves in an electro-pneumatic plant and govern the flow of current from the power mains to the switch motors. The switch circuit controller operates on the polarized principle and responds to reversals of polarity in the control wires by changing its contacts. Springs and bands on the switch lever roller in the interlocking machine are arranged as a pole changer. When the switch lever is reversed, the polarity of the controlling current is reversed, the controller contacts change and the switch motor operates. In this system the control wires do not carry the current that actually

runs the switch motor; the switch circuit controller is a high-resistance instrument and the control wires may be as small as mechanical strength will allow. It is customary to use No. 16 copper wire and to group them into cables for protection against mechanical injury. This reduces the amount of copper necessary in the plant, especially where the switches are located at a considerable distance from the tower.

The switch circuit controller used with 110-volt direct-current control, shown in Fig. 137, is called the "normally deenergized" controller because it automatically locks itself in place and then cuts off its controlling current. It contains a neutral

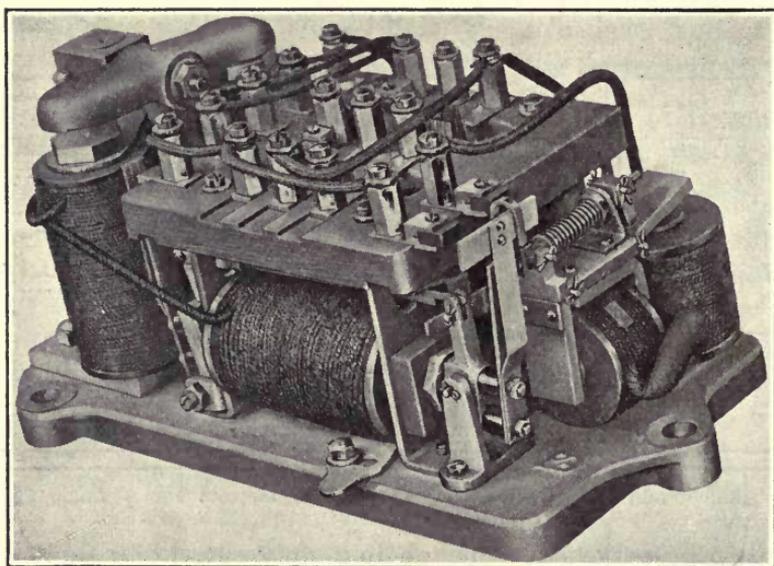


FIG. 137.—Switch circuit controller, direct current, normally deenergized type.

magnet of two coils, and a polarized magnet of three coils. The neutral magnet is energized by a reversal of the polarity in the control wires, current flowing from one of the control wires through the coils to the power main of opposite polarity.

When the neutral armature picks up, its contacts open the switch motor circuit and close the circuits to the polarized magnet. One coil of the polarized magnet then receives current of a definite polarity and from the power mains; the other two coils of the polarized magnet receive current from the two control wires. When the polarity of these wires has been reversed, the

polarized armature reverses. The polarized armature carries contacts which change the circuit for the neutral magnet from one of the power mains to the other. Thus the neutral magnet becomes deenergized, and its armature is released, mechanically locking the polarized armature in place. Its contacts open the two circuits to the polarized magnet, and close the switch motor circuits to throw the switch. All the magnets of the controller are thus deenergized until the next reversal of the polarity of the control wires by the switch lever.

This controller also contains an overload circuit breaker. Should the switch points be obstructed, the switch motor would be overloaded and the breaker would open as any circuit breaker would. It is so arranged, however, that it is reset by the neutral armature when the switch lever is moved to the other indicating position. Thus the switch motor is protected without the use of fuses which require replacement; and the operator can move the switch back and forth in an effort to dislodge or crush the obstruction. A separate set of contacts on the switch movement opens the motor circuit when the switch has been thrown and locked. Figure 136 shows the complete operating and indication circuits for alternating current to operate a single switch.

The control of signals in the Type "F" system is accomplished very much as it is done in the electro-pneumatic system, except that an electrical device must replace the air valve. Two small wires connect the signal lever with a relay or its equivalent at the signal. That relay when picked up closes the signal motor circuit from the power mains. When the signal lever is restored to its normal indicating position, it breaks the connection to the control wires, the relay drops and the signal falls to the stop position by gravity.

**80. The Indicating System.**—The indicating system is essentially the same as that described for the electro-pneumatic system with only such changes as are necessitated by the difference in voltage. Obviously, the indicating system which is independent of the control system may be of a different voltage, may be operated from a different source of power, or may be alternating current when the control system is direct current. Each switch movement embodies a pole-changing indication circuit controller that controls a polarized relay in the tower. Each signal when in the stop position completes a circuit for its indication just the same as in the electro-pneumatic system.

81. Style "M" Switch Movement.—Figure 139 shows a Style "M" switch and lock movement used for throwing switches and derails. It consists essentially of motor, clutch, reduction gears, mechanical movement arranged to operate in the usual order to unlock, throw and lock a switch, and circuit controller that does the double duty of opening the motor circuit after the switch is thrown and locked, and of controlling the indication circuit. The purpose of the clutch is to absorb shocks due to the momentum stored up in the rotating armature, and to limit the load that may be imposed upon the motor by an obstructed switch.

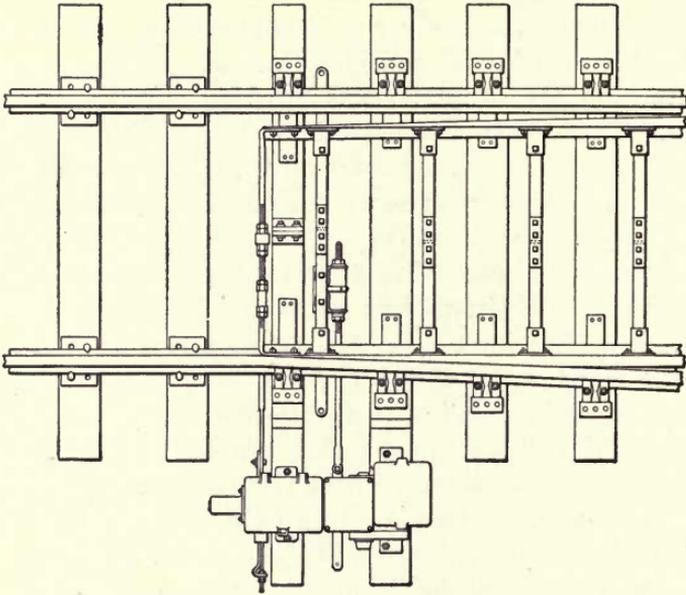
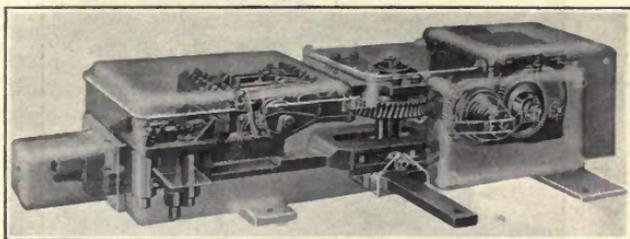


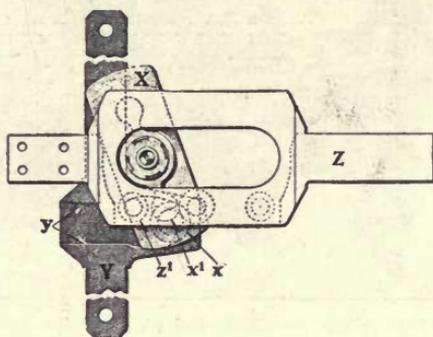
FIG. 138.—Style "M" switch layout.

(B) illustrates the normal positions of the immediate parts instrumental in throwing and locking the switch points. Starting from this position a reverse movement is begun by the clockwise rotation of combined shaft and crank arm *X*. Lug *x'* on the top of crank *X* acting against roller *z'* on motion plate *Z*, effects the unlocking of the switch points. Meanwhile, roller *x* on the underside of crank *X* has moved through an arc of 40 degrees in groove *y* in switch operating bar *Y*, thus freeing the bar for the reverse stroke. During the next 140-degree revolution of crank *X*, roller *x* engages the reverse operating face of groove *y* and throws switch operating bar *Y* to the reverse position.

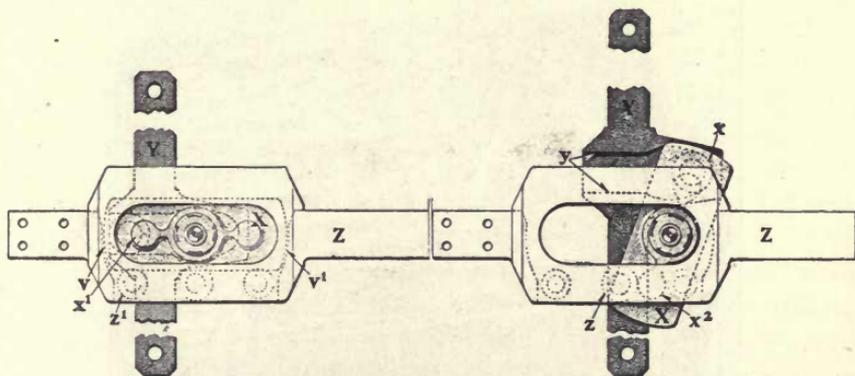
(C) shows the relative mid-stroke positions of the switch operating bar *Y* and lock bar *Z*; the crank *X* is still rotating clock-wise; but is not transmitting motion to the lock bar, as



(A) Switch and lock movement assembled.



(B) Diagram of driving parts in normal position.



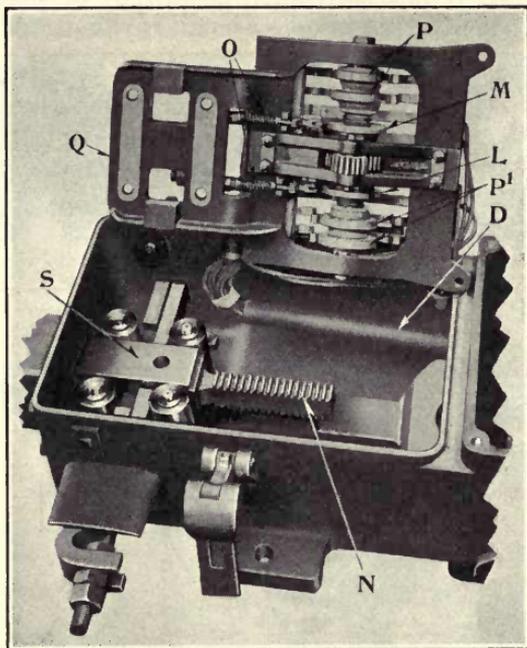
(C) Diagram of driving parts in middle position.

(D) Diagram of driving parts in reverse position.

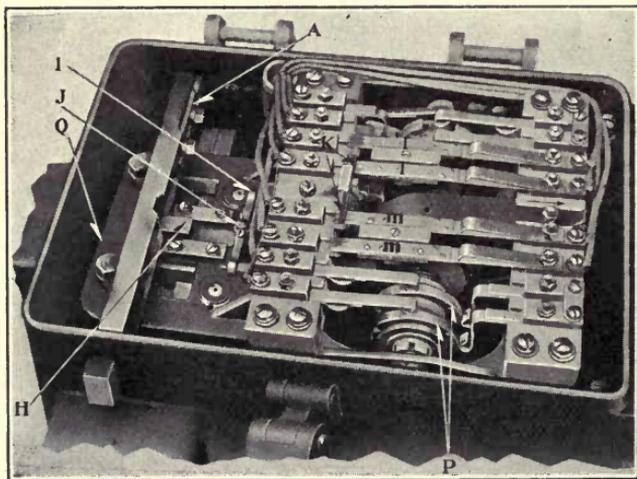
FIG. 139.—Style "M" switch and lock movement.

lug  $x'$  has become disengaged from roller  $c'$  and the arcs of contact at  $v$  and  $v'$  between the crank *X* and lock bar *Z* are radial to the center of the crank shaft.

The complete reverse position is shown in (D). Roller  $x$  on crank  $X$  acting in groove  $y$  has pulled operating bar  $Y$  in and



Style "M" lock box and inverted view of circuit controller.



Style "M" circuit controller with point detector.

FIG. 140.—Style "M" indication circuit controller.

secured it; lug  $x^2$  has come into contact with roller  $z$ , thus driving locking bar  $Z$  to the full reverse position.

Starting from the normal position of the main crank, which is 20 degrees beyond dead center, the consecutive events and respective angular positions of the crank are as follows:

## Degrees

0	Normal position.
5	Indication supply opened and relay shunted.
10	Normal motor circuit closed.
15	Detector bar even with top of rail.
20	Dead center.
40	Points unlocked.
40—180	Degrees—Throwing switch points.
200	(Dead center) points locked full width of lock bar.
210	Reverse motor circuit opened.
215	Shunt removed and indication circuit completed.
220	Reverse position.

**82. "SS" Control.**—In this system, as in the electro-pneumatic system, it is customary to operate more than one switch, for example, the two switches of a crossover, from one switch lever, and to control several signals governing converging or diverging routes from one signal lever; also it is customary to employ the "L" position of a signal lever for one signal or group governing train movements in a corresponding direction on the track, and the "R" position for train movements in the opposite direction over the same track. The ability to accomplish this multiple control makes it possible to employ a comparatively small machine for a large number of switches and signals. Where several tracks lead onto a common track, and each of these tracks has its own signal, these signals may all be controlled by one signal lever. The circuits for these signals, however, must be arranged so that only the proper signal will clear. This is known as the selective control of converging signals. In considering the control of several signals from one lever it must be remembered that each signal governs a definite route over switches and derails set a definite way. Each switch or crossover controls a corresponding polarized relay in the tower, as previously described. Each relay must correspond in the position of its polarized armature with the controlling lever in order that the indication be received. Therefore, each switch must have been setting in accordance with its lever when the indication was received. The control wire for a given signal is not only controlled by its signal lever, but is also carried over neutral and polar contacts on the indication or "SS" relays, and over

contacts on the levers of all switches and derails in the route governed by that signal; and these contacts are arranged so that they are closed only when all the relays and levers are properly set for movement over that route. Thus, when a

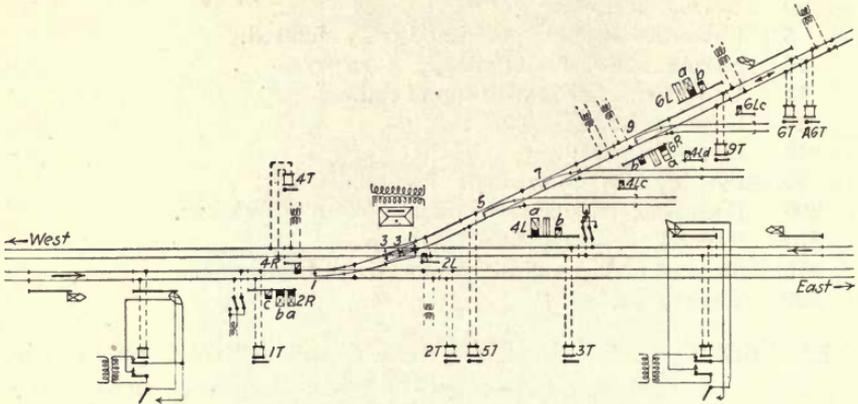


FIG. 141.—Track and signal layout. Alternating current used in interlocking.

signal is cleared, a check is provided that the switches are properly set, that the switches correspond with their levers, and that no switch is manually operated or even unlocked after the indication is received. The route to be properly set for one signal must be

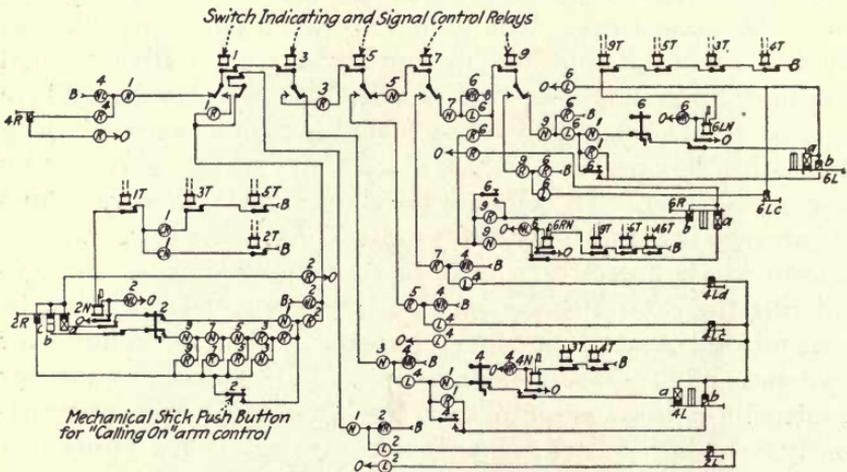


FIG. 142.—Signal control circuits for Fig. 141.

wrong for all others; hence all the other signal control wires must be open at certain lever contacts and relay contacts, preventing all other signals from clearing. This method of controlling signal circuits through switch lever contacts and relays is known

as "SS" control. A sample track layout and the corresponding signal control circuit are shown on Figs. 141 and 142. Its advantages lie in the high degree of safety accomplished and in avoiding the interruption of the signal control wires at the switches with the possibilities of crosses and grounds. Each signal control wire runs direct from the tower to the signal.

**83. Auxiliary Features.**—In connection with the semi-automatic control of signals, the push button, a device sometimes used with the signal levers, as shown in Fig. 98, should be mentioned. Its purpose is to close the circuit for a calling-on arm when conditions such as an occupied track circuit prevent clearing the semi-automatic arms of a signal. After the signal lever is reversed, the button is pushed in, carrying with it a vertical pin that closes the contacts below and engages with a hole in the spring above, retaining it in the pushed-in position. When the signal lever is restored to its normal position, the lever latch raises a cam which, in turn, raises the spring out of engagement with the pin and allows the button to snap out into normal position.

The interlocking machine is designed to mount a row of lever lights when desired. These lights indicate by being illuminated or dark, which switches may be operated and which signals may be cleared.

**84. Union "S-7" and "S-8" Electro-mechanical Interlocking Machines.**—The Union "S-7" electro-mechanical interlocking machine consists of a standard Saxby and Farmer mechanical machine above the locking bed of which is a frame supporting one or more electric lever units, as shown in Fig. 143. The electric lever units are spaced five inches from center to center, the same as the mechanical levers; and the number of electric lever units may be equal to, but no greater than, the number of mechanical levers and spaces.

Each electric lever moves forward and back through a total angle of  $60^\circ$ , and by means of bevel gears rotates a horizontal shaft which carries the segment for the single lock magnet, and an insulating roller with contact bands very similar to that in an electro-pneumatic machine. This shaft also carries a crank to which is attached the vertical rod extending down to the locking bed, described in the following paragraph.

The mechanical locking between all of the levers, mechanical and electric, is accomplished in the regular Saxby and Farmer

locking bed. Electric levers are connected to the locking bed by adjustable vertical connecting rods which extend through the locking bed and operate loose sleeve driving pieces. These driving pieces rotate on split journals clamped to the locking shafts of mechanical levers, thus permitting an electric lever to drive its locking bar without interfering with the operation of the locking shaft which supports the driving piece. The driving pieces are made in various lengths so that a selection of locking bars may be available,

It will be noted that a longitudinal locking bar is required for each electric lever as well as for each mechanical lever, thus necessitating a wider locking bed than would be required for the mechanical levers alone.

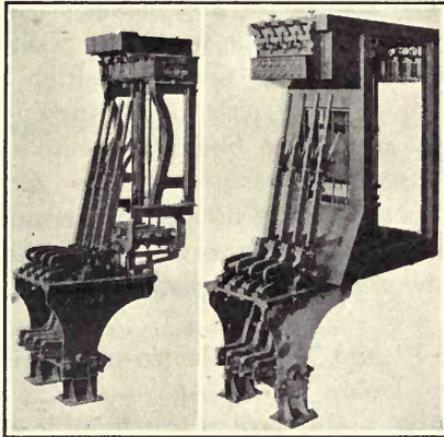


FIG. 143.—“S-7” Electro-mechanical interlocking machine.

FIG. 144.—“P-5” Electro-mechanical interlocking machine.

The “S-8” interlocking machine is a modification of the “S-7” machine and may have as many as three lock magnets on each electric lever. It may also have its contact rollers arranged vertically below the electric units, where more space will permit a greater number of contacts. Either machine may be equipped with quick switch, lever indicator lights, latch contacts, or stick push button, thus incorporating practically all of the features of the electro-pneumatic or Type “F” machines.

The “S-7” and “S-8” machines find their application at mechanical interlocking plants where some of the functions are electric, such as signals, or remote switches, or where it is desired to employ electric detector locking, route locking, check locking between towers, or electric indication of mechanical switches.

In many cases the electric units are added to an existing Saxby and Farmer machine, where the plant is being enlarged by adding switches and signals; in such cases existing mechanical signals can be converted to electric, operated by the electric levers, thus making the former signal levers available for switches. The number of operated functions can thus be materially increased without adding to the length of the mechanical machine, which would not infrequently require enlargement of the interlocking tower.

**85. Union "P-5" Electro-mechanical Machine.**—Another development in electro-mechanical interlocking machines is represented by the Union "P-5" machine, one of which is shown in Fig. 144. This machine is made by combining the frame and levers of a Saxby and Farmer machine, with the electric levers, locks, spring combination board, and locking bed of a Type "F" electric machine. In this arrangement each mechanical lever is locked full normal or full reverse by the corresponding electric lever directly above it, by means of horizontal locking bars and vertical tappets connected respectively to the rocker-links of the mechanical levers and to cranks on the electric levers. In order to reverse a mechanical lever, the electric lever is first moved to the center position, thus unlocking the mechanical lever, which can then be reversed; finally, the electric lever is moved to full reverse, thus locking the mechanical lever in the reversed position.

The locking of mechanical levers by electric levers provides for detector locking and electric indication of mechanically operated switches the same as if the switches were power operated. Electric levers are interlocked the same as in the Type "F" machine. Mechanical levers are not interlocked except through their respective electric levers. The electric levers are spaced  $2\frac{1}{2}$ " between centers, and the mechanical levers 5"; the intermediate or alternate electric levers which do not come directly above mechanical levers are used for strictly electrical purposes, such as the control of signals.

#### FEDERAL SIGNAL COMPANY SYSTEM

**86. Interlocking Machine.**—The Federal interlocking machine is built with short levers and with quadrants and rocker-links similar to those in the Saxby and Farmer mechanical plant. The machine is made in sections of eight levers, spaced 3 in. center to center. It has a horizontal locking bed of miniature

Style A type placed directly behind the levers, and this may be enlarged to suit requirements in proportion to the number of levers grouped in a machine by adding plates to increase the depth of the locking bed. Figure 146 shows a section of a two-plate machine. The latch block roller travels in the rocker-link slot when the lever is moved from the normal to the reverse position, and the lifting of the lever latch operates the rocker-link just as previously described in the mechanical plant.

The tappet bars are connected to the rocker-link by a tappet link. On the extreme outer end of the tappet is a driver that operates the contact button shaft of an auxiliary circuit controller.

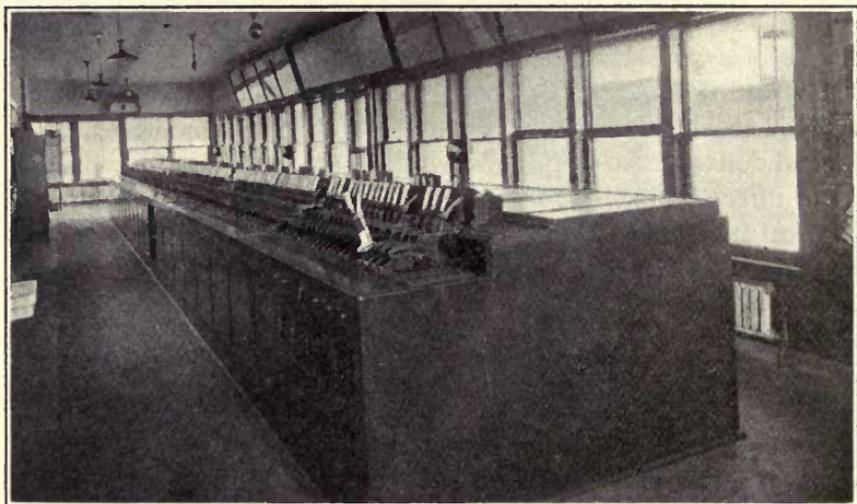


FIG. 145.—Federal interlocking machine.

This controller furnishes a means whereby electric checking of the position of each lever in the machine becomes feasible. On the front of the machine is another vertical controller connected by a rod to the tail of the lever. This controller moves simultaneously with the lever itself. The auxiliary controller in the back moves simultaneously with the lever latch and hence becomes a factor in the lever locking.

The front circuit controller is provided with a rod having three bearings. Between the top bearing and the intermediate one is a double pole, double throw, heel and toe type of knife switch. This switch is operated by the roller on the controller rod and functions to make and break circuits to the switch and signal mechanisms. Between the intermediate bearing and the

bottom one are located insulated contact buttons which are adjustable on the controller rod in relation to the fixed contact springs, so that the contact may be timed to make and break with desired positions of the controller rod and thus control auxiliary circuits as may be required by different conditions of the interlocking plant. These contacts are in general used for the control of route locking circuits wherever these may be employed.

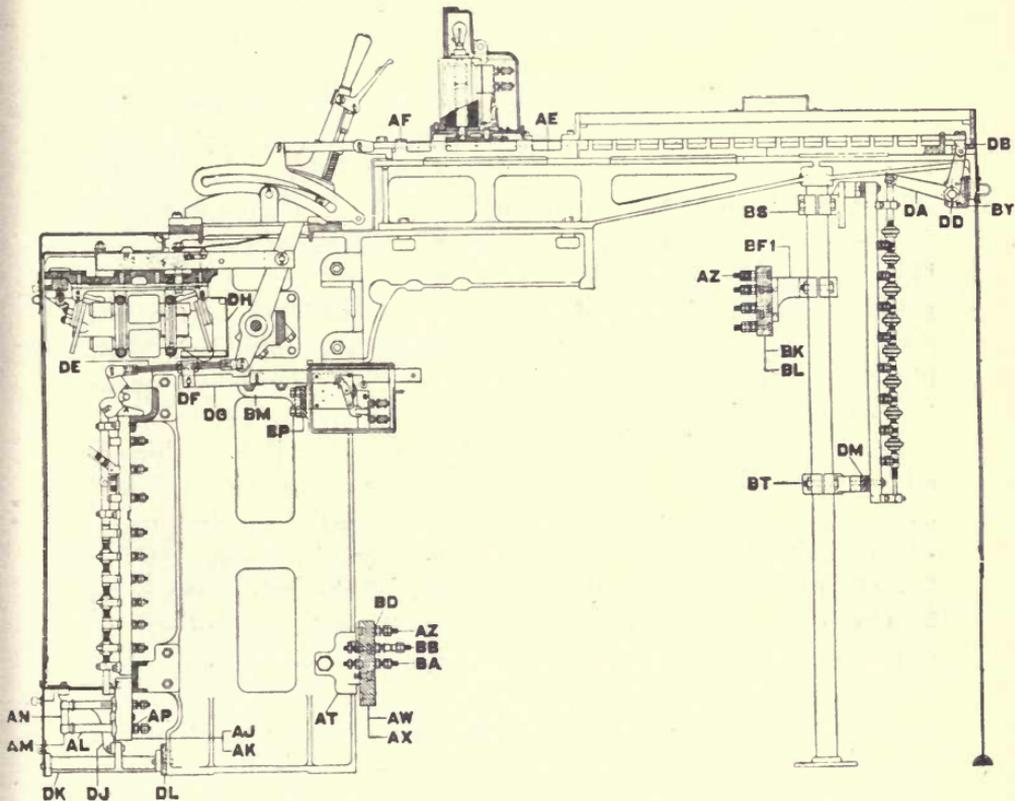


FIG. 146.—Section through Federal interlocking machine.

Each lever may also be equipped with an electric lock mounted directly above the tappet bars and immediately behind the levers. These locks are of the solenoid type and are wound to a resistance of 8 ohms. They are arranged to check or hold the movement of the latch by means of notching a plate on the tappet in various portions of the cycle of operation. The most common cuttings for the electric lock are the "normal and reverse" and the "half reverse." When the lock is cut "normal and reverse," a notch is provided in the plate riveted to the tappet wherein the solenoid

plunger may drop and prevent the lifting of the latch from the normal or reverse position of the lever except when the lock has been preliminarily energized and the solenoid core lifted from the notch in the locking plate attached to the tappet. When the lock is cut "half reverse," the notch is so situated that the lever may be returned to its normal position, but the latch will be prevented from dropping unless the lock has been energized and the conditions requisite to the placing of the latch normal have been fulfilled. The half reverse cutting is generally found on signal levers.

Each lock is provided with an auxiliary contact that holds the circuit to the coil open until it is desired to move the lever to which the lock is attached. This effects the saving of electricity inasmuch as the circuits are closed only when it is desired to use them. The levers are provided either with or without lights as may be desired. The light, however, furnishes a ready means of indicating the condition of the track over which a switch lever might govern; and in general, the light will when illuminated, indicate that conditions are right for the energization of the electric lock.

**87. Type 41 Switch Machine.**—The Type 41 switch machine is adapted for circuits of 100-volt and 20-volt potential direct current as well as for circuits of varying potential and frequency when provided with suitable alternating current motors. Figure 147 shows an assembly and part section of the switch machine. The motor, in the case of the direct-current operation is of bipolar construction. Each field pole is furnished with two field windings, one for each direction of rotation. Since the control of the motor is effected by means of three wires, one for reverse operation and the other for normal operation, the double sets of field coils furnish a means of reversing the direction of rotation by merely energizing one or the other of the two control wires in combination with the common or return which is connected to one of the brushes. The other brush is connected to a point common to both field windings.

By means of a train of gears the motor drives a main cam gear, *GP*, which, in turn, drives the circuit controller rods *KB* and the connecting rod *FV* attached to the stud *HB*. Through the medium of this stud *HB*, the rotary motion is changed to a reciprocating one. The rod *FV* operates the locking plunger *FX*. The escapement cam, pivoted on stud *GY*, is provided with a stud

*HA* that engages operating connections *KK* so that when stud *HA* is rotated around *GY*, *KK* will be given a motion transverse to the mechanism case, and being connected to the switch points will move them from one position to the other. The escapement cam *FT* is provided with cam surfaces machined to be concentric with the main stud *GZ* in the extreme positions of the operating connections *KK*; therefore, when rotation of the main gear *GP* takes place, no movement of cam *FT* occurs until the operating

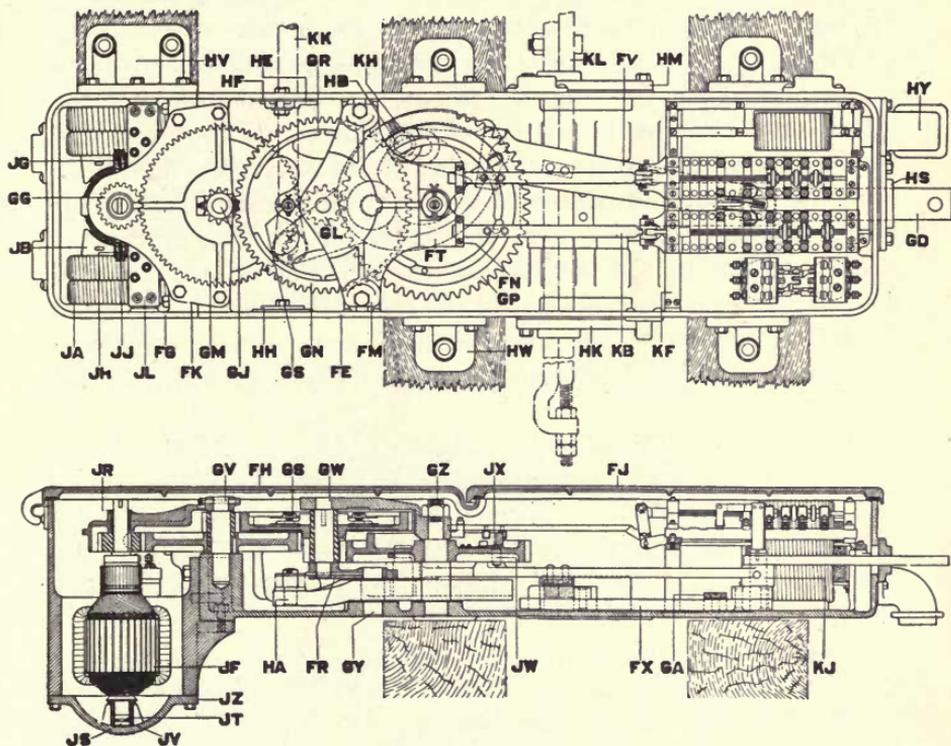


FIG. 147.—Type 41 switch machine.

stud *HB* reaches a position where it engages the end of the concentric cam surface opposite stud *HA* from the center stud *GY*. This movement of *HB* engages connecting rod *FV*, however, putting it in operation and moving it towards the right-hand end of the mechanism case. Such movement withdraws lock plunger *FX* from notches cut in the lock rod *KL* and thus unlocks the switch points. Continued rotation of *HB* around the center *GZ* moves the escapement cam *FT* to a position opposite to the one shown in the figure, while the second concentric cam surface

goes to a position concentric with the stud *GZ*. The operating connection *KK* and the lock rod *KL* move to their reverse positions from that shown in the figure and another locking notch in *KL* comes to register with the locking plunger *FX*. Still further rotation of stud *HB* puts the operating rod *FV* in tension drawing it forward and thereby plunging the lock rod in its reverse position from that shown in the figure.

After the lock plunger has entered through the lock rod, continued rotation of the gear *GP* causes the cam surface provided on its top to engage the roller studs on the lower sides of controller operating rods *KB* and shifts the insulated contact buttons from engagement with the contact springs and thus disconnects the motor from the operating circuits. The connecting rod *FV* stands at an angle to the center line of the switch mechanism in both the normal and reverse positions. This change in angular position occurs simultaneously and coincident with the movement of the switch points, thus enabling the selection of an indication contact to the right or the left of the center line closed only when the lock plunger advances towards the motor a sufficient distance to insure its passage through the proper notch provided in the lock rod.

Sixty two revolutions of the motor are required to throw the switch. The first 16 are necessary to move the detector bar and unlock the switch. The next 30 throw the switch; and the last 16 lock the switch and throw the detector bar again. The last revolution of the motor disconnects it from the operating circuit.

In order to prevent the mechanism from damage when it meets a serious obstruction in the switch points, a friction clutch is provided in the transmission between the motor and the main gear. The rotation of this clutch, *GR*, is caused by the rotation of gear *GN* due to the friction of their engaging surfaces.

A dynamic brake is used to control the operation of the switch mechanism between its final normal and reverse positions and also to control the application of the dynamic braking or regenerative circuit required at the end of each switch operation in order to prevent shock or damage due to the sudden stopping of the parts at their extreme positions of operation. This device is used also to control the excitation of the indication transformers. It is a compact electro-magnet device comprising two coils and a swinging armature. The armature is used to close contacts in accord-

ance with its attraction to the right or left, and this, in turn, is controlled by the energizing of the right- or left-hand windings.

**88. Switch Machine Control and Indication Circuits.**—The following description of the switch machine control and indication circuits is taken from the January, 1920, issue of the *Railway Signal Engineer*.<sup>1</sup>

“The control and indication of the switches is illustrated by the typical circuit shown in the diagram. When a lever is operated to move a switch, direct current flows through the double-pole double-throw switch actuated by the movement of the lever, and then over either the normal or reverse control wire (depending on the position of the lever), then through the circuit controller in the switch machine, and one of the coils of the circuit controller known as the ‘dynamic breaker,’ which is housed in the switch machine. During the initial movement of the switch machine and while the dynamic breaker is energized there is a bi-circuit set up through which direct current is supplied to the motor of the switch machine.

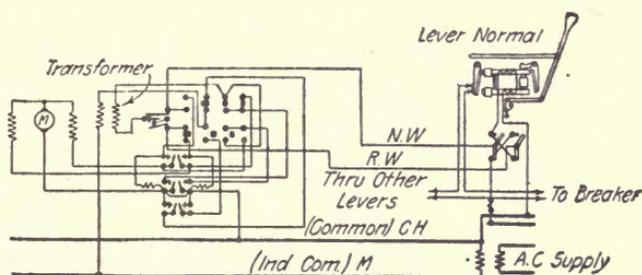


FIG. 148.—Typical control circuit diagram for switch. (*Railway Signal Engineer*.)

“When the operation of throwing and locking up the switch has been completed, alternating current is transmitted over the main direct-current common wire and the alternating-current indication common wire. Each section of the plant has a branch of these two common wires. The alternating current transmitted over these two common wires is stepped up to 220 volts when it reaches the indication transformer located in the switch machine. This secondary current, at 220 volts, is transmitted to the ‘safety and indication magnet’ on the lever controlling the function, over the idle control wire and the main direct-current common, which releases the lever so it may be placed in either the full normal or full reverse position, depending on the position of the function. The coils on the dynamic breaker located in the switch machine housing are of the slow releasing type, and hold the controller in

<sup>1</sup> Page 61. Electric Interlocking at Winchester, Ky., by F. H. BAGLEY.

the energized position for a sufficient length of time after the direct current which operated the mechanism has discontinued to allow the alternating indication current to perform its function.

“The ‘safety and indication magnet,’ referred to in the previous paragraph and shown in the illustration, is equipped with an armature at each end and automatically selects or attracts either one or the other of these armatures, depending upon whether alternating or direct current is passing through the magnet coils. This is accomplished as follows:

“With the alternating current scheme of indication, the magnetic lines of force will be set up through the path indicated by the dotted line, since the copper ferrules *A*, *B*, and *C* will effectively choke the

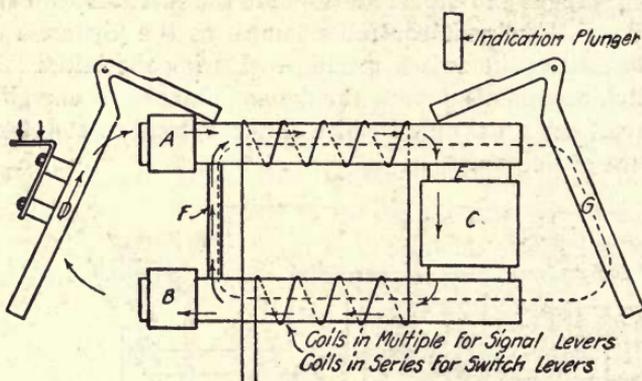


FIG. 149.—The safety and indication magnet. (*Railway Signal Engineer.*)

magnetic field, set up by the alternating current, from going through that part of the iron core enclosed by them. This will cause armature *G* to be attracted, which delivers the indication. The iron path *F* is of small cross-section and consequently high reluctance, forming part of the magnetic path for the magnetic flux set up by the alternating current. If a direct current is caused to flow through the indication magnet, the indication mechanism will not be operated by this direct current, since the magnetic lines of force will then take the path shown by the arrows, because the copper ferrules at *A*, *B* and *C* have no choking effect on the magnetic flux set up by a direct current. The path *F* carries part of this magnetic flux, but on account of the great reluctance of path *F* it cannot carry all of this flux so that part flows around through armature *D*. Armature *G* is not attracted, since the large cross-section of *E* provides ample path for the magnetic flux. Armature *D* is attracted, which opens the circuit energizing the main circuit breaker on the operating switchboard, causing this circuit breaker to release and thereby cutting power from the section of the plant affected.

“It is evident that if direct-current energy should by some chance be applied to the idle control wire, it might have a tendency to cause the switch mechanism to assume an opposite position to the control lever. Since the idle control wire forms a part of the indication circuit, and the safety and indication magnet is connected at all times between the idle control wire and common, a portion of any direct-current energy applied to the idle control wire will flow through the safety and indication magnet, attracting the armature that opens the cross protection circuit, and thus causing the main circuit breaker in that section of the plant to open. This provides an effective means of cross protection.

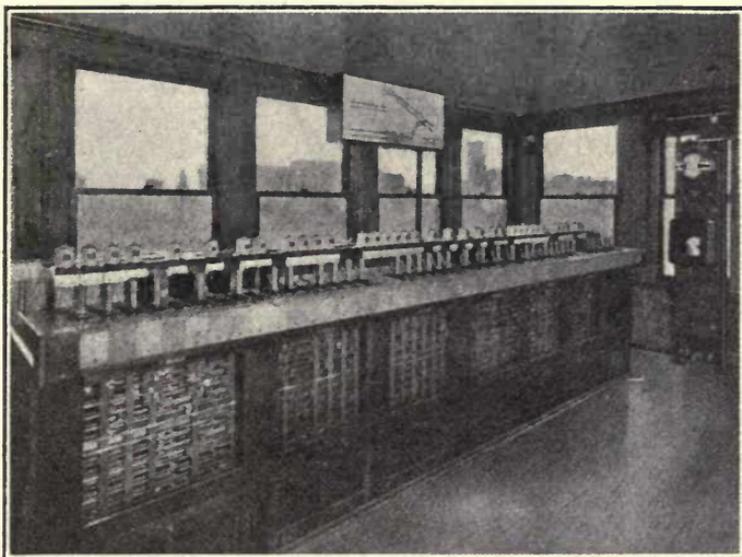


FIG. 150.—Hall interlocking machine.

“This indication mechanism is applied in exactly the same form to interlocking machines equipped for alternating-current control, direct-current indication, by merely turning the iron core around. Then armature *D* is attracted by the magnetic flux set up by the direct-current indication. Armature *G* then becomes the cross protection armature, being energized when the indication wires are crossed with the control wires carrying alternating current, and opening the main cross protection circuit.”

**89. Federal Electro-mechanical Interlocking Machine.**—A row of miniature levers similar to those on the electric machine is located above the mechanical levers and is provided with the same spacing. Mechanical locking between both sets of levers is accomplished in the vertical locking bed placed just behind the

mechanical levers. Circuit controllers can be applied to the rear of the machine and operated by either the mechanical or electric levers.

### HALL SWITCH AND SIGNAL COMPANY SYSTEM

**90. Interlocking Machine.**—Each lever is connected to a slide that moves in a horizontal plane making and breaking the circuit

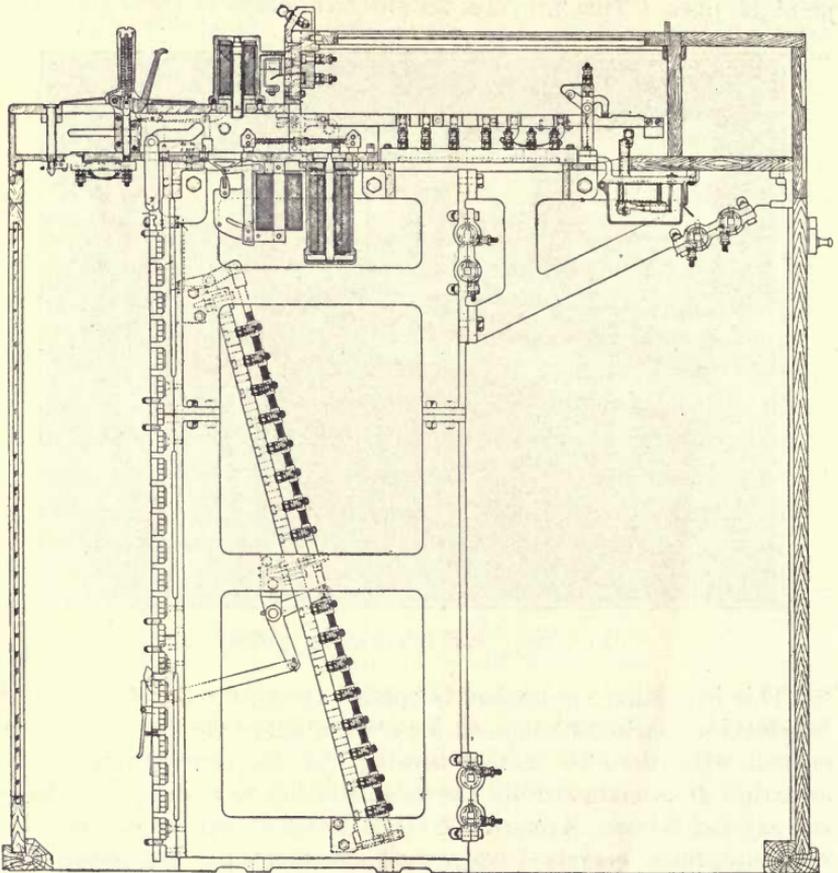


FIG. 151.—Section through Hall interlocking machine.

by means of the controllers attached to the rear of the slide. The mechanical locking is of the vertical type operating in practically the same manner as that in the Style A machine. The levers are equipped with latch pins actuated by the latch handle to serve

the purpose of latch locking. The levers are also provided with stop dogs to relieve the indication and safety dogs and to leave them free to move regardless of the pressure exerted on the lever handle. Electric locks are located above the lever slides with notches cut in the side to give the desired lever locking according to requirements.

To prevent the movement of a switch lever to full normal or reversed position before a proper indication is received, two mechanical locking dogs are arranged in each lever slide. The dogs are mechanically forced down into a slot in the bed plate on which the lever slide rests, and can be forced out of the slot only by the action of the indication and safety magnet armatures. The armature of the safety magnet has two vertical lugs projecting up from the face of the armature plate which engage with two horizontal lugs attached to the lever slide. The function of these lugs is to lock the lever in the full normal, reverse and operating positions with the safety coil energized. All the current for operating the switch must pass through the safety magnet, which has two windings, one a low-resistance winding of 0.4 ohm, and the other a high-resistance winding of 350 ohms. The high-resistance winding is connected in parallel with a fuse, which makes the safety magnet effective with or without the fuse in circuit. To make a complete movement of the switch lever, it is obvious that the safety magnet armature must be energized and then deenergized in addition to the energization of the alternating-current indication magnet.

**91. Switch Movement.**—The switch is thrown by an electric motor operating through a train of gears. It is provided with a normal and reverse controller, an indication selector, an indication transformer, lock rod, throw rod and locking plunger. The motor is connected to the gearing by a friction clutch to eliminate the strain that would arise if the gears should be brought to a sudden stop. The controllers are actuated by a cam plate rigidly attached to the locking plunger. This makes their action positive and becomes dependent upon the actual locking of the switch. The plungers are staggered in a horizontal plane so as to make it impossible for the normal plunger to enter the reversed notch in the lock rod, or *vice versa*. The throw rod, itself, is locked in both normal and reverse positions by a peculiar arrangement of the gearing, so that the switch cannot be forced over by taking off the lock rod.

The indication selector is composed of two magnets, one in multiple with the reverse operating circuit, and the other in multiple with the normal operating circuit. Each of these magnets, when energized, operates a set of contacts corresponding to the contacts of its respective locking plunger controller so that the selector contacts and the locking plunger controlling contacts must operate in conjunction.

**92. Switch Operating Circuits.**—The circuit for a switch consists of a normal operating wire shown on the plan as *NO*, a reverse operating wire shown on plan as *RO*, and a negative shown as *Neg.*, Fig. 152.

The operation is as follows: Operating the lever latch handle, closing the lever latch contact *LL* energizing the lever lock *L*, permits the lever to be moved to the reverse operating position, which closes contacts 7-8 and 11-12. Current will now flow from 110-volt positive bus over wire 20, 10-amp. fuse, wire 21, through low winding *SL* of safety magnet, wire 22, contacts 8-7, wire 23, over *RO* wire, to *RO* contact on plunger circuit controller, over wire 24 through coil *RIS* on reverse indication selector to negative. This will energize the selector and close contacts *RO*, *RI*, *RP* and *RD*. When these contacts close, current will flow through the *RO* contact on *RIS* over wire 25, through fields *RF* and motor armature *A* to negative. Immediately the motor starts, the contactors *NO*, *ND*, *NI* and *NS* on normal plunger circuit controller will shift to the right closing the *NO* contact and opening contacts *ND*, *NI* and *NS*. When the switch has completed its full movement, the contactors of the reverse plunger circuit controller will shift to the left and open the *RO* contact and close the *RD*, *RI* and *RS* contacts. When the *RD* contact is closed, it completes a local dynamic brake circuit over wires 36 and 34, through the *NF* winding, through *A* to negative, to the *RD* contact on selector, through *D* winding, to *RD* on plunger circuit controller. This snubs the motor and holds the indication selector magnet closed for a predetermined interval of time, which is sufficient to allow the indication magnet on lever to operate. When the dynamic or snubbing current ceases, the selector becomes deenergized and automatically opens its contacts.

**93. Signal Operating Circuits.**—The operation for a signal is as follows: The lever is moved to the full reverse position (no reverse indication being required), closing contacts 3-4 and 7-8;

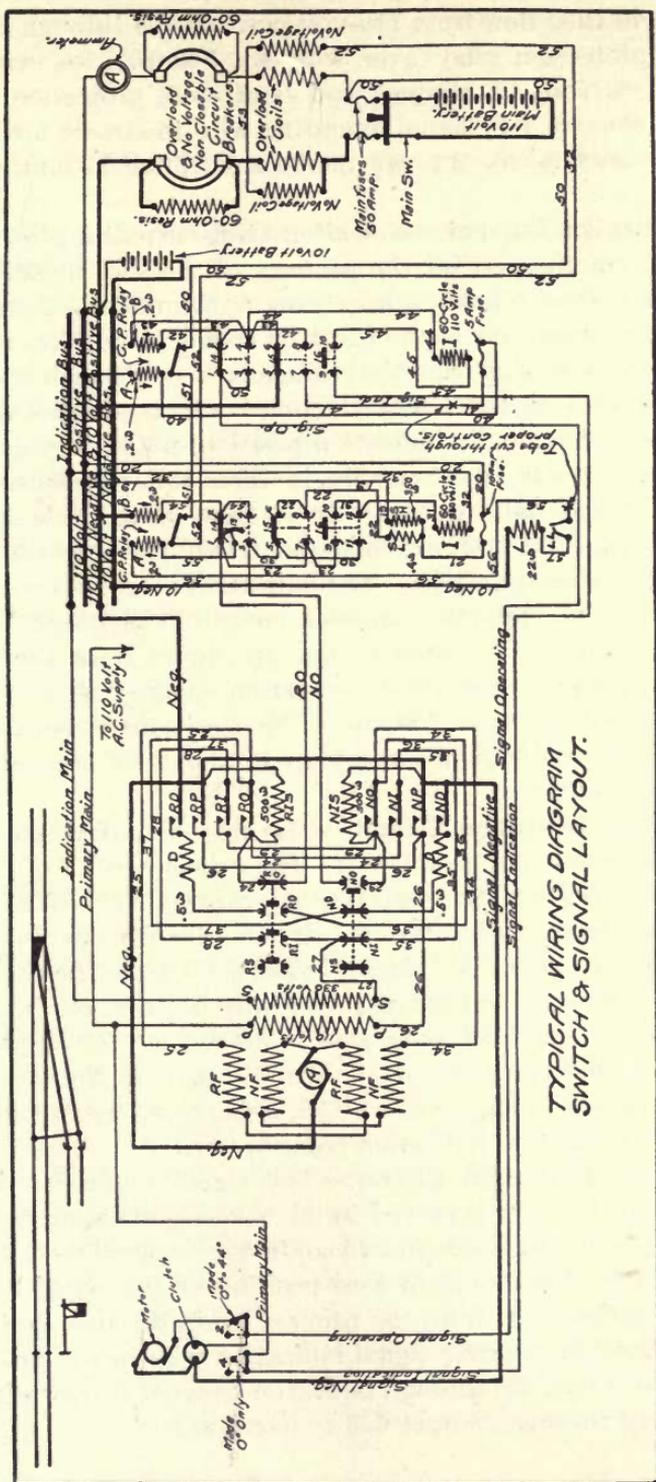


Fig. 152.—Typical wiring diagram for switch and signal layout.

current will then flow from 110-volt positive bus through coil *A* of cross protection relay over wire 40, 5-amp. fuse, wire 41, contact 7-8, wire 42, through coil *B* of cross protection relay, wire 43, contact 4-3, signal operating wire to circuit breaker 2 on signal mechanism, through motor and clutch in multiple to negative.

**94. Indication Current.**—The alternating current for the signal indication circuits and for the primary of the switch indication transformer is obtained either from a commercial source of supply or is generated at the plant by means of a  $\frac{1}{4}$ -kw. motor-generator set operated from the storage battery through contacts on each lever. As the motor starting contacts are closed only when the lever is in the indication position, no battery current is consumed when all levers are in their full positions. The primary of the indication circuit is from alternating-current supply through the various coils and transformers returning to supply on 110-volt negative. The indication magnets are designed so as to be immune to direct current. The signal lever indication magnet is wound to operate direct from the primary main. The switch lever indication magnet is wound to operate on not less than 250 volts. A one-to-three transformer that steps the indication current up to 330 volts is located at each switch function.

**95. Switch Indication Circuit.**—The normal indication is received from the switch as follows: The primary coil *P* of indication transformer was energized through contact *NP* of *NIS* when switch movement was started. When plunger operated circuit controller contact *NI* closed, indication current flowed from coil *S* of indication transformer over wire 27, contact *NI*, wire 35, contact *NI* on *NIS*, over wire 24 to contact *RO* on plunger operated circuit controller, over wire *RO*, wire 23, contact 9-10 wire 31, indication magnet *I*, wire 32, indication bus and indication main to coil *S* of indication transformer.

**96. Signal Indication Circuit.**—The signal indication is received when the lever is moved to the normal indication position closing contacts 5-6 and 9-10 and contact 4 on signal mechanism. (Contact 4 is closed only in zero position of the signal.) The current will then flow from the primary main through contact 4 on signal mechanism over signal indication wire to contact 9-10 on lever, over wire 45, through indication magnet *I*, over wire 44, wire 43, and through contact 6-5 to negative.

## CHAPTER VIII

### DIRECT-CURRENT TRACK CIRCUITS

97. **Track Circuits.**—The direct-current track circuits used in power interlocking and in automatic block signaling are operated by local batteries. A portion of the track is set apart as a block, which has a low-voltage circuit of its own traveling through the rails, as indicated in Fig. 153. The blocks are separated by insulated joints, while the rails within the blocks are all bonded to insure the continuity of the circuit. At the end of the block is an electro-magnet known as a relay, *A*, that governs the operations of the lock or signal, or whatever function is to be controlled. When the coils are energized, the armature, *B*, of the relay picks up, making what is termed front contact. When they are de-energized, the armature drops away by gravity, making back con-

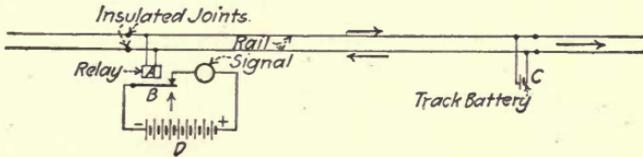


FIG. 153.—Track circuit diagram.

tact. These track relays are usually wound to a resistance of from 2 to 4 ohms. If it is any less, the armature may not drop away when a train comes into the track; if any more, it may not hold when the track circuit is temporarily weakened by rain or snow, even though there be no train in the block.

At the opposite end of the block is the track battery, *C*, for which in the plan indicated, the track circuit is always closed. When there is no train in the block, the relay is energized, holding up the armature which completes the circuit to the signal motor and to the mechanism that retains the arm in the proceed position. When a train comes into the block, much of the current flows across the axles shunting the relay and releasing the armature. This breaks the circuit to the motor or holding device, and the signal arm goes to the stop position of its own accord. The battery and relay should be placed at the extreme ends of the block to get the full benefit of broken rail protection.

The voltage of the track circuit varies from  $\frac{1}{2}$  to 2 volts. It is made low in order to avoid as much leakage as possible from rail to rail across the ballast. It must not be too low, however, or it will not operate the relay especially during periods of rain or snow, when the leakage is the greatest. If the ballast touches the rail, the leakage is considerably increased. As the track currents are flowing continuously and as the signal batteries are active except when a train is in the block, some kind of battery should be chosen that will not become exhausted quickly. For this purpose, the primary batteries most commonly used in practice are the gravity and the Leland types. Two or three cells of either kind are sufficient for a track circuit. Storage batteries are used to some extent on account of the greater output per cell. One such cell is generally sufficient for a track circuit.

The amount of current to operate a 4-ohm track relay alone is less than  $\frac{1}{4}$  watt. As 50 per cent. of the current in the track circuit is lost by leakage and 10 per cent. by overcoming resistance of the rails, the battery, and the relay, the battery output should be about  $\frac{1}{2}$  watt. In most cases, the batteries must be protected by inserting some kind of resistance in series with the track to reduce the amount of current flowing when a train is in the block.

**98. Cut Sections.**—Where the blocks become too long for a battery to operate the relay successfully, cut sections are em-

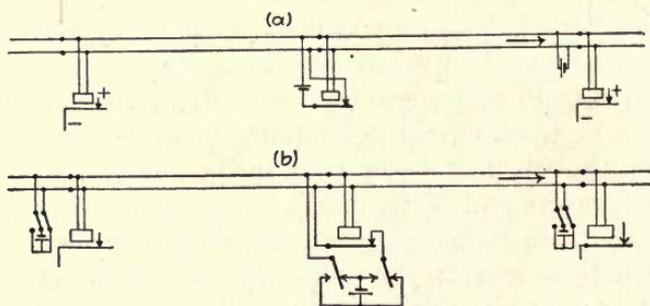


FIG. 154.—Cut section track circuits.

ployed. The block is divided into two or more sections with a relay and track battery in each. The battery of one section is connected through the armature and front contact of the relay in the adjacent section so that when the relay of any section is deenergized the circuits for all sections in the rear in that block are broken. Figure 154a shows a cut section in an ordinary

track circuit and 154*b* a cut section in a polarized track circuit. The direction that the current flows through the polarized track circuit is controlled by a pole-changer on the home signal.

**99. Fouling Circuits.**—Fouling circuits are used for protection at turnouts or crossings where there is a possibility of a car standing on one track interfering with those moving on another track. For example, a car standing too near the frog in a turnout may endanger the movements of trains on the main line. The fouling

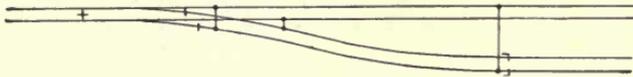


FIG. 155.—Fouling circuits at a turnout.

circuits generally extend to the clearance point of the siding, which is frequently marked by a derail.

Figure 155 shows a wiring plan for an insulated switch protected to the clearance point of the siding. A pair of wheels standing at any point on the turnout up to the clearance post will give to the block signal a stop indication just as if a train were occupying the main track.

Figure 156*a* shows a wiring diagram for a crossover between two main tracks controlled by block signals. Figure 156*b* repre-

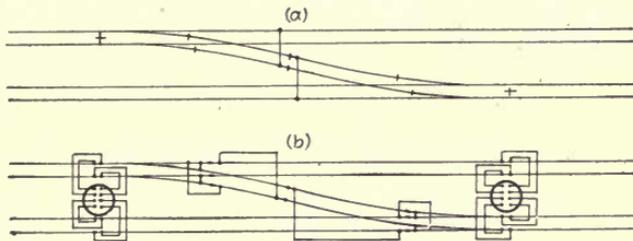


FIG. 156.—Fouling protection at crossovers.

sents another form of track circuit so connected through the switch controller that the opening of the switch on either track will operate to throw the approaching signals to the stop position on both tracks.

**100. Insulated Rail Joints.**—In order to separate the rails electrically at the ends of a block, some kind of vulcanized fiber is ordinarily used, placed between the ends of the rails, between the splice bars and the rails, and around the bolts that hold the splice bars in place. Occasionally on low-speed tracks, wooden-block

splice bars are used on each side of the rail instead of metal bars, in which case the only fiber necessary is that between the ends of the rails. Figure 157 shows some of the different types of joints commonly found in practice.

**101. Rail Bonds for Track Circuits.**—As the construction of the rail joint itself is an uncertain factor in the continuity of the track circuit; and as a scale of rust, which is a poor conductor of electricity, is likely to form between the splice bar and the rail, the intermediate rail joints in the block are all bonded. Where there is no return propulsion current to carry, two No. 8 B.W.G. galvanized iron wires are generally used. One wire is

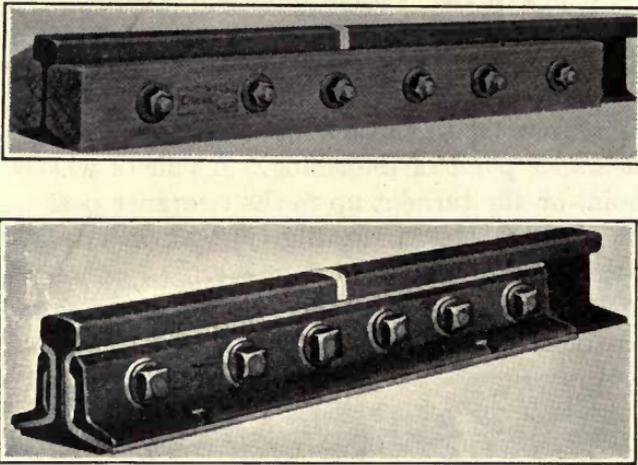
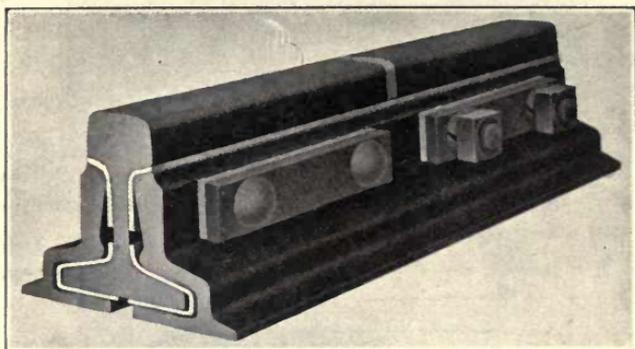


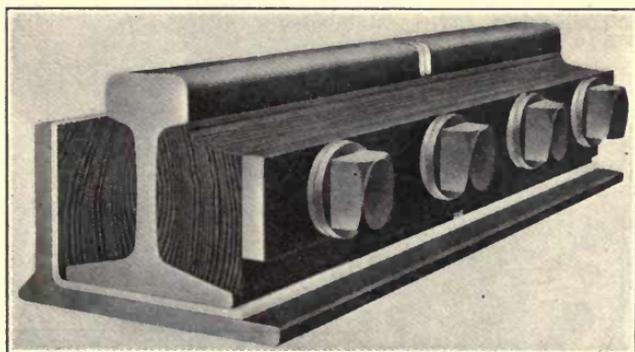
FIG. 157, PART 1.—Insulated rail joints.

sufficient to carry the track current, but an additional one is used to provide for breakage or other failure. Holes are drilled through the web of the rail near the end of the splice bar, and the iron wires are held in place in these holes by copper-plated steel channel pins driven in around the wire. The bonds are generally placed outside of the angle bars to permit an easy inspection for broken wires. Where there is a propulsion current to consider, however, heavy copper bonds are required at each joint, adding a considerable item of expense.

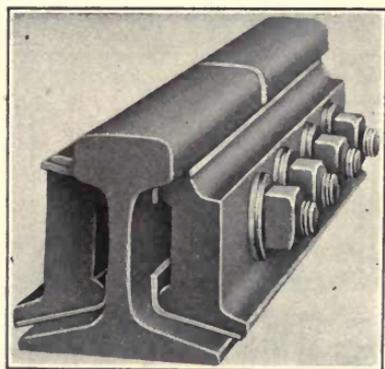
**102. Neutral Relay.**—The two coils of the relay shown in section in Fig. 159, are protected from mechanical injury by hard rubber shells, *M*, or by insulating varnish. The wires that energize the coils are connected to the two binding posts, *P*. The armature, *A*, is hinged at the back of the poles and very



Continuous.

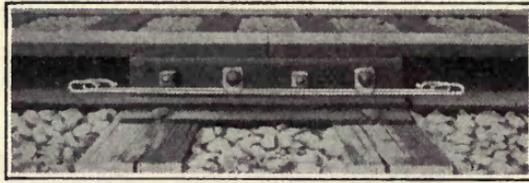


Weber.

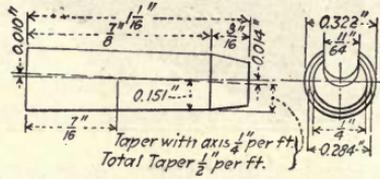


Keystone.

FIG. 157, PART 2.—Insulated rail joints.



Rail bond for track circuit. P. & M. bond protector.



R. S. A. channel pin, plan 1086.

FIG. 158.—Rail bonds for track circuits.

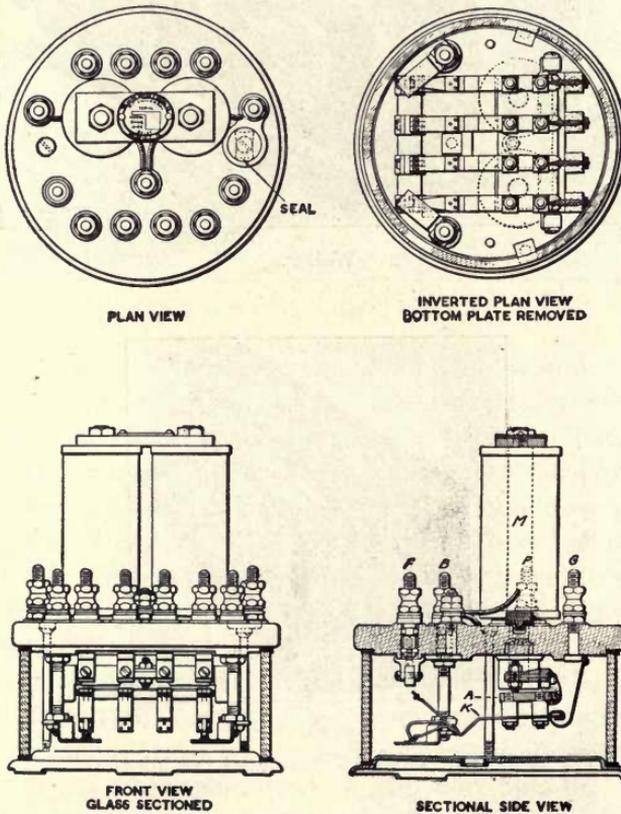


FIG. 159.—Neutral relay.

little movement is necessary to make and break contact. Two small non-magnetic stops attached to the lower end of the pole pieces provide a slight air gap between the pole pieces and the armature, thereby eliminating the possibility of the armature's sticking on account of residual magnetism in the cores. The contact fingers, *K*, are fastened to the armature by bakelite studs so as to insulate them electrically. The tips of the fingers where they touch the front and back contacts are made of silver or platinum. The circuit for front contact is made through the

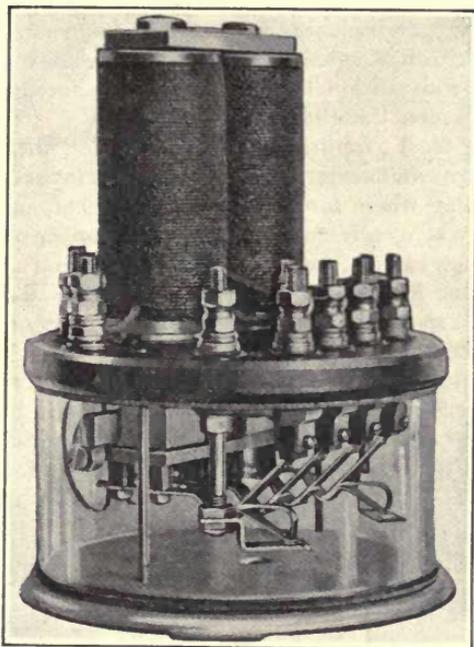


FIG. 160.—Neutral relay. (*Union Switch & Signal Co.*)

binding post *F* and back contact through the post *B*. One terminal of the control circuit is fastened to the binding post *G* and the other to *F* or *B* according to whether front or back contact is required. The armature and contact fingers are enclosed in a transparent dustproof case to protect them from dust and moisture and from mechanical injury. While the windings for practically all track relays vary from 2 to 4 ohms, the resistance for line relays runs much higher, even up to 1,000 ohms.

A comparison of the 2- and 4-ohm relays printed in the *Proceedings* of the Railway Signal Association presents the following points for consideration:<sup>1</sup>

<sup>1</sup> Page 5, 1918.

1. Because of its lower operating voltage, the 2-ohm relay will operate with a lower ballast resistance.

2. The 2-ohm relay is less susceptible to leakage current from adjacent battery entering track circuit through insulated joints.

3. The energy consumption for the 2-ohm relay on equal track circuits is approximately 50 per cent. less when the track is occupied. When the track is not occupied the energy consumption will be less when the ballast resistance is less than 5 ohms per 1,000 ft.

4. The length of track circuit may be increased with the use of the 2-ohm relay if no foreign current is present and the resistance between the battery and track is not less than the recommended limiting resistance.

5. On track circuits of equal length the 2-ohm relay gives equally as good protection against broken rails where no foreign current is present.

6. On track circuits of equal length, the 2-ohm relay will release with a higher shunting resistance across the rails when foreign current entering the track circuit is less than 350 amp.

7. Considering track circuits of equal length and with other conditions equal, no definite recommendations can be made in favor of either the 2-ohm or the 4-ohm relay where foreign current is present, on account of there being conditions where each has its advantages over the other.

8. With a foreign current present, the 2-ohm relay on a track circuit of its maximum operable length will receive more combined foreign and track battery current than will be received by a 4-ohm relay on a track circuit of its maximum operable length.

9. When a battery lead or a rail is broken and the track circuit between the break and the relay is shunted, the 2-ohm relay will be more susceptible to foreign current than the 4-ohm relay. With the track circuit not shunted, the 2-ohm relay will be more readily picked up by foreign current only when that current enters the track circuit through a resistance less than 5 ohms.

In view of the above statements, your Committee recommends the use of the 2-ohm relay with caustic soda battery, provided the recommended limiting resistance is used in series with the battery. The recommended limiting resistance should also be used in series with the battery wherever the 4-ohm relay is used with caustic soda battery.

**103. Polarized Relays.**—In addition to the two coils found in the neutral relay, there is a steel bar, *P*, that is permanently magnetized in the polarized relay, Fig. 161. The polarized armature, *PA*, rotates in a horizontal plane about a vertical axis through *X*. The armature is supported between the lower end of *P* and the bracket *S*. The top of the permanent magnet is generally the north pole and the bottom the south pole. The entire polarized armature then becomes a south pole by induction. The polarized armature can operate only when the neutral relay is energized, at which time one of the pole pieces of the coils becomes a north pole and one a south pole. The north pole

will attract the polarized armature while the south pole will repel it, causing a slight rotation. The fingers, *K*, connected to the armature by insulators, make contact connections with the binding posts *B*.

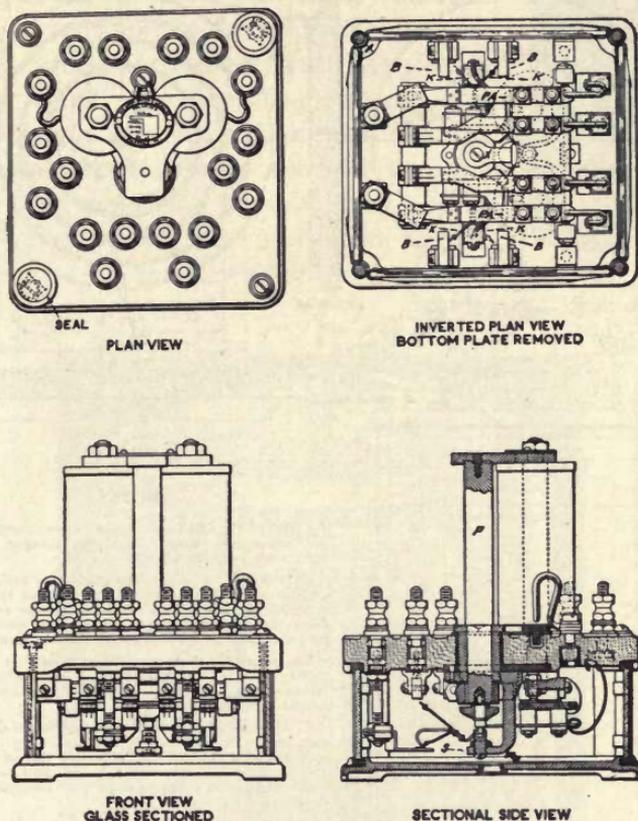


FIG. 161.—Polarized relay.

**104. Track and Signal Batteries.**—The electrolyte of the gravity cell is made up of two liquids that separate themselves by gravity. A saturated solution of copper sulphate is used in the lower half of the jar and a dilute solution of zinc sulphate in the upper half. The copper element rests on the bottom of the jar in the copper sulphate solution and the zinc element is supported at the top in the zinc sulphate solution. The gravity cell finds its best service where the current demand is practically continuous as it is in the case of the track circuit. Where the current is broken for some time a chemical change takes place that practically destroys the efficiency of the cell. As the cell

must be renewed about once a month, it involves considerable expense for maintenance. The internal resistance of the cell is very high.

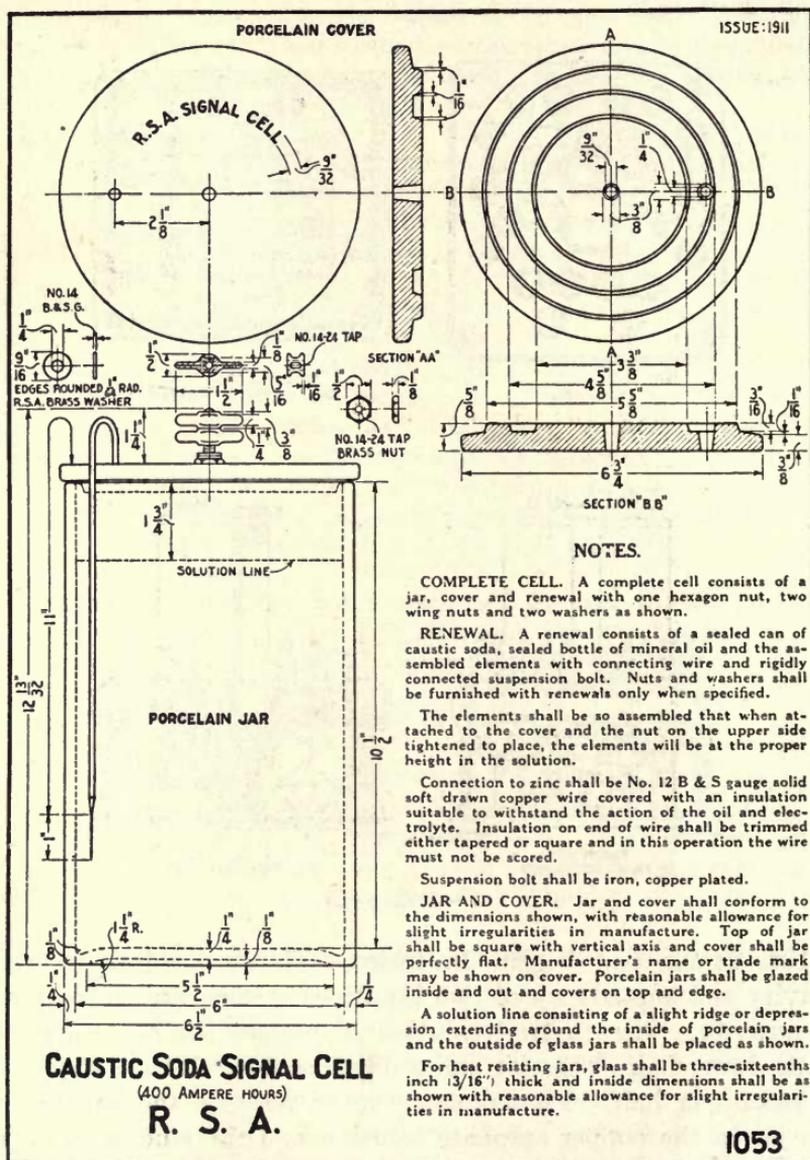


FIG. 162.—R. S. A. standard caustic soda signal cell.

The Lelande type covers a number of patented cells, among which are the Edison, Columbia, Waterbury, and Gordon, varying only in the method of construction. The electrolyte

is a strong solution of caustic soda, while the elements used are zinc and copper oxide. The cells do not deteriorate when not in service and may be used on either open or closed circuits. As the total output of the cell is practically constant, a heavy current may be drawn for a short time or a low current for a long time. As used in ordinary signal practice, the cell must be renewed about every eight or nine months. The internal resistance of the cell is so low as to require some kind of resistance in series with the battery to prevent it from becoming exhausted too quickly when used on track circuits.



FIG. 163.—Edison primary cell.

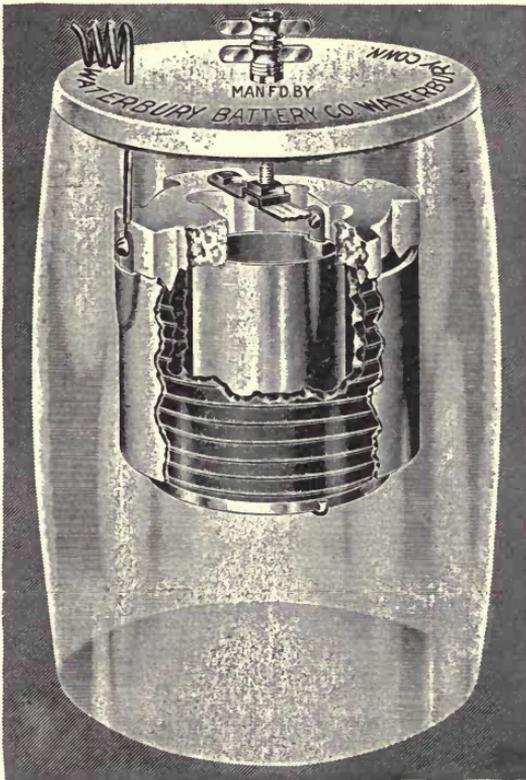


FIG. 164.—Waterbury signal cell.

The storage cell is formed of two lead plates with an electrolyte of dilute sulphuric acid. The plates of themselves will not

form a current as the primary batteries do, but must be charged by the current from a generator or from a mercury rectifier. Once so charged, they will give out current, but they must be recharged rather frequently. They possess the advantage, however, of having a higher voltage, each cell having an electromotive force of 2 volts.



FIG. 165.—  
Columbia signal  
cell.

#### 105. Battery Wells and Battery Chutes.—

The batteries used to operate the signals are generally housed in battery wells, located near the base of signals. Most of these wells are now made of concrete, as illustrated by Fig. 166. They are built in a material yard, and shipped to the place where they are to be used. Some are set into the ground to within a foot of the top, while others are set with their tops flush with the surface of the ground. This not only provides a safe place where the batteries will not be disturbed, but also protects them against freezing temperatures. The well is usually 4 or 5 ft. in diameter and from 4 to 8 ft. in depth over all.

Tiers of wooden shelves are provided around the wall of the well to support the battery cells.

The two or three cells required for the track battery when housed alone are generally placed in a battery chute, the greater portion of which extends below the ground. The chutes are usually made of cast iron, just large enough in diameter to contain the cells when they are supported one above another. The length of the chute varies from 5 to 7 ft.; but even longer ones are used where the temperature gets low enough to require the cells to be placed at greater depths to prevent freezing or to maintain the proper efficiency. About a foot of the chute remains above the ground; and some proper construction is utilized to so connect it with the trunking that the wires will not be exposed to the weather. In order that they may be easily removed for repairs or renewals, the battery cells are supported in wooden elevators raised and lowered by a rope.

**106. Cable and Relay Posts.**—Cable posts are used to house and support wires where connections are made between lines and relays. At points where it becomes necessary to install a relay in its own housing, the relay box is generally attached to

the cable post, as shown in Fig. 167. Figure 168 represents a battery chute with a relay box attached.

**107. Trunking.**—The trunking used to carry the wires from the track connections to the battery wells and battery chutes, to the track relays and the signal towers, is generally made of wood, frequently treated with some chemical agent to protect it against

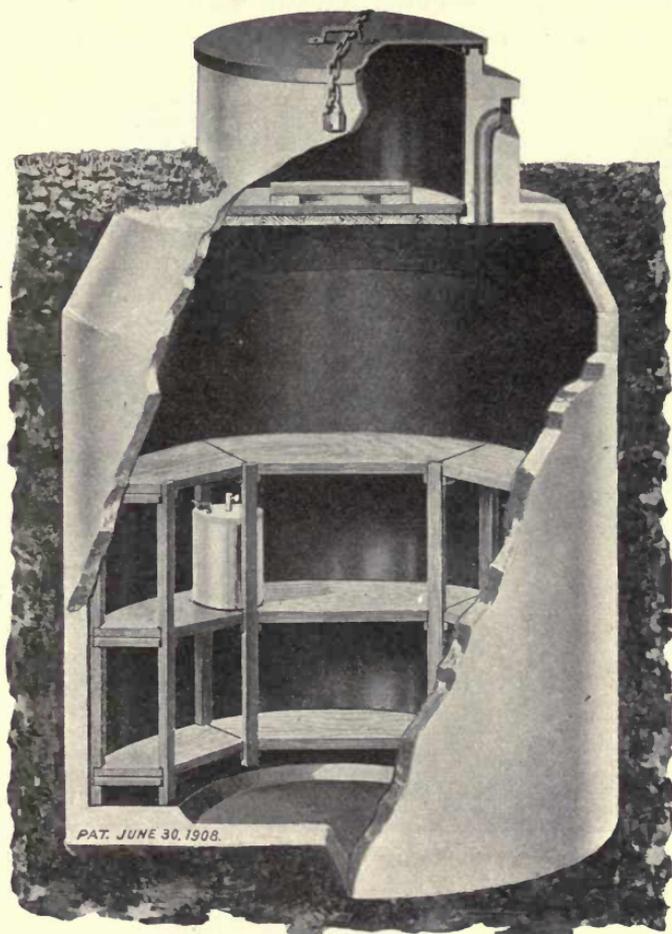


FIG. 166.—Massey 80-cell battery well.

decay. As shown in Fig. 169, it may be either grooved or built-up depending upon the size of the opening required. The trunking is buried flush with the surface of the ballast when used within the roadbed, and is supported on substantial tasks when carried along the ground. Conduits of fiber and other materials are sometimes used, but they are laid underground and are generally

encased in concrete. Reinforced concrete makes a practical trunking where it becomes desirable to install a more permanent type.

**108. Insulated Head, Front, and Tie Rods.**—In order to maintain the track circuit intact through the turnout, all connections between the two rails, such as head, front, and tie rods, and the head plate where it is used, must be insulated. The common method of doing this is to make these rods and plates in two

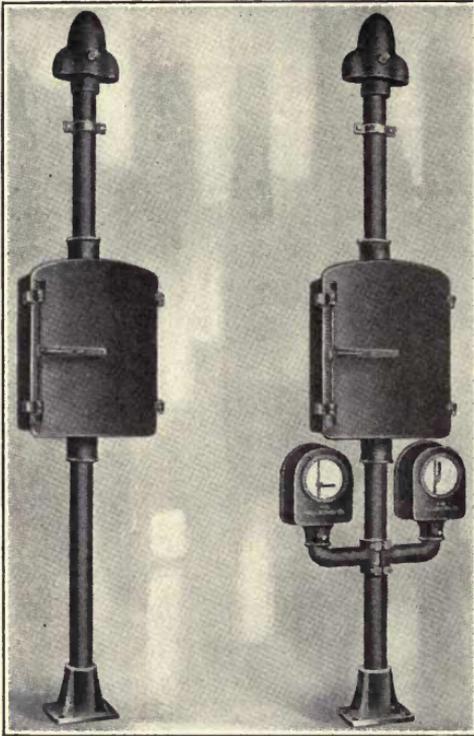


FIG. 167.—Cable and relay post. Switch indicators.

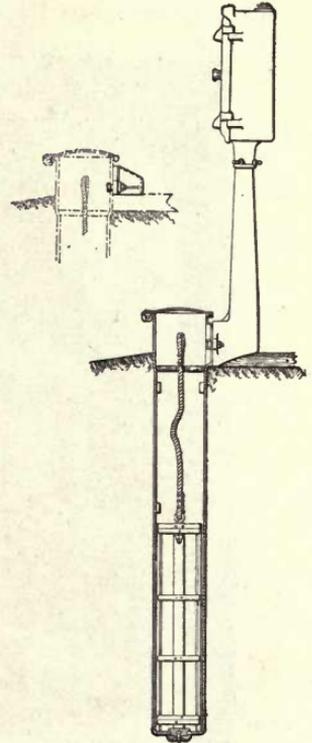


FIG. 168.—Battery chute and relay box.

pieces and bolt them together with a fiber insulator between, as shown in Fig. 171.

**109. Lightning Arresters.**—In order to protect the relays and other equipment in track and signal circuits against damage by lightning, two different appliances have been devised to insert in the circuit—the spark gap arrester and the choke coil. One type of spark gap arrester frequently used is made of five brass plates arranged as shown in Fig. 172, with a short air gap between

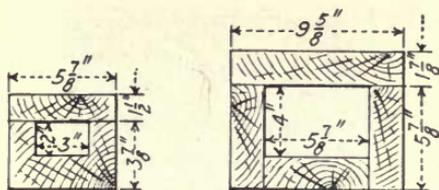


FIG. 169.—Trunking and capping.

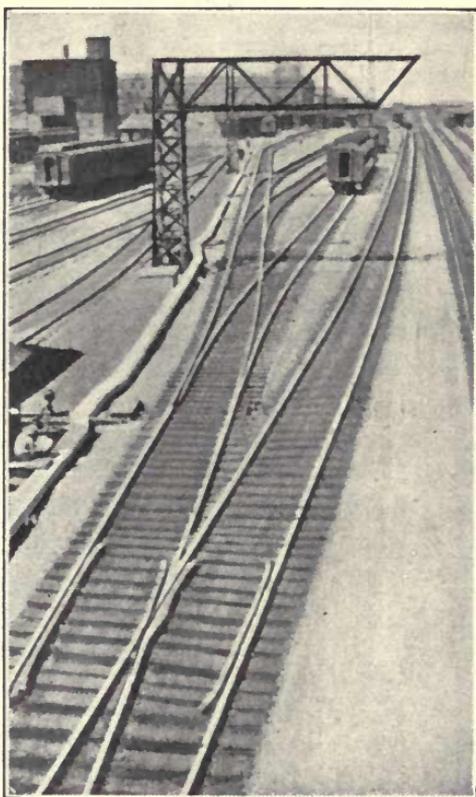


FIG. 170.—Reinforced concrete trunking on New York Central R. R. at Utica, N. Y.

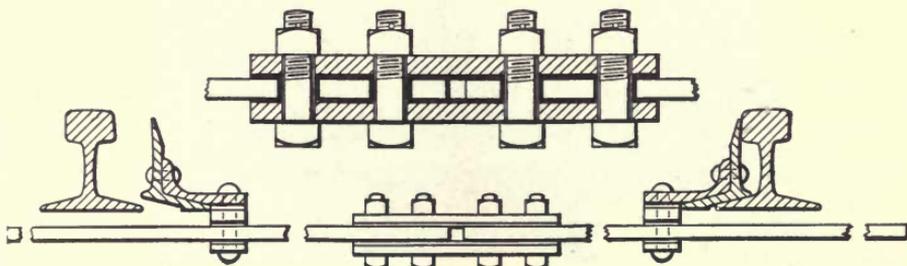


FIG. 171.—Insulated switch rod.

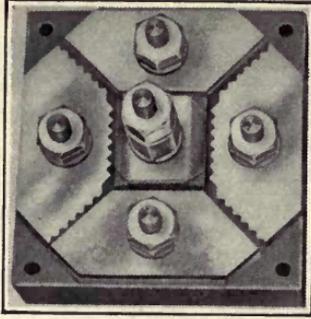


FIG. 172.—Hall lightning arrester.

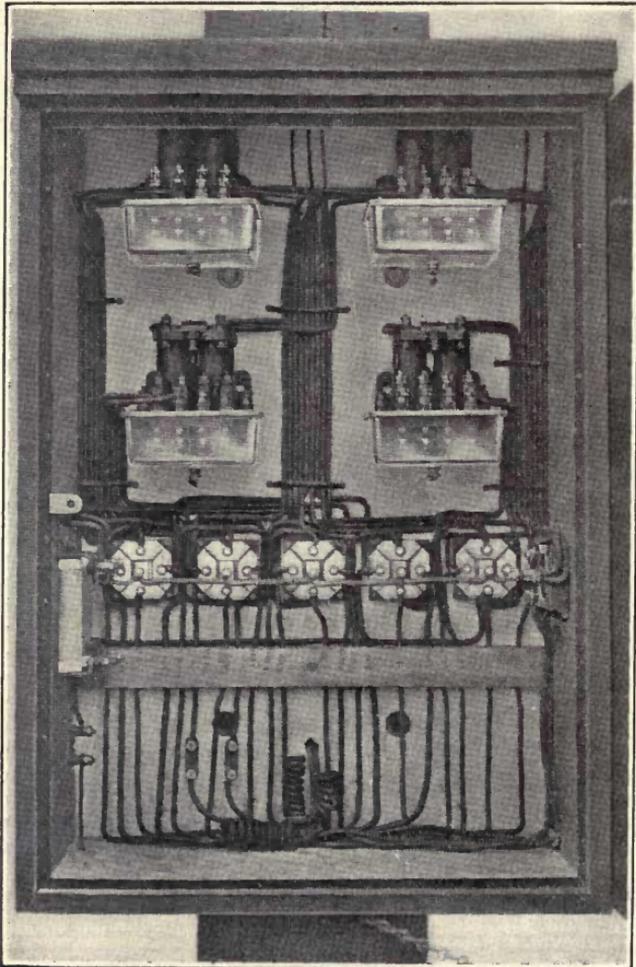


FIG. 173.—Lightning arresters in relay box.

them. The center plate is grounded; the other four are connected to the track and other circuits. As the lightning has a high voltage, it will tend to jump the gap rather than follow the wires, and the notches on the edges of the plates will aid the discharge,

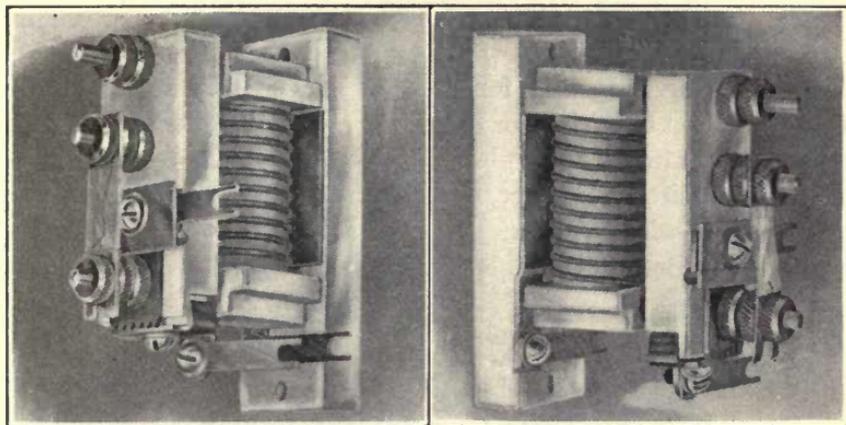


FIG. 174.—Hall choke coil lightning arrester.

The choke coil is generally made by winding a bare copper wire into a coil around a porcelain core. The direct current of the track or signal circuit will meet with practically no resistance in the coil; but the lightning, being a high-frequency alternating current, will meet with an impedance due to the self induction of the coil.

## CHAPTER IX

### ELECTRIC LOCKING

**110. Wiring Diagrams for Electric Locks.**—Figure 175 is the Union method of wiring for operating a power distant signal in a mechanical interlocking plant. When the home signal, 2, is cleared, its circuit breaker, *C*, is closed so that when lever 1 is reversed, the circuit is complete to relay *D* picking up its armature and closing the local battery circuit to clear distant signal 1.

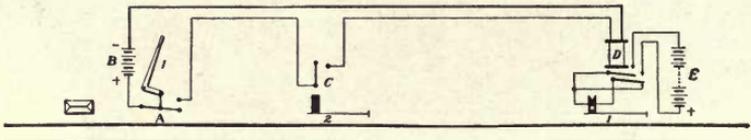


FIG. 175.—Wiring for power distant signal.

The signal will remain cleared until lever 1 is returned to its normal position.

Figure 176 is an indication wiring so arranged as to make certain that the distant signal is returned to its full normal position before the lever latch can be released. When lever 1 is reversed after signal 2 is cleared, the distant blade will go to clear. Levers

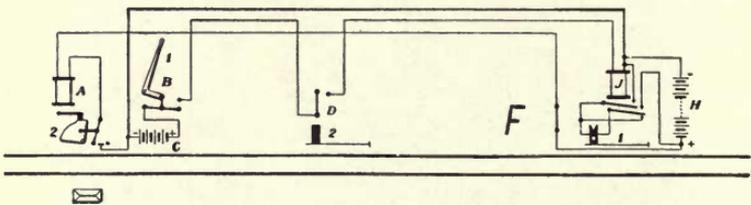


FIG. 176.—Wiring for electric lock.

1 and 2 may be returned to their normal positions, but the latch on lever 2 will not be released until the distant blade goes to its full normal position closing circuit breaker *F*, thereby energizing lock *A* on lever 2 and unlocking its segment 2. The latch will then be dropped into its full normal position. If *F* is not closed however, *A* will not be energized and the latch will remain locked.

Figure 177 shows a form of an electric lock to control the lever latch on a Saxby and Farmer machine. In Fig. 178 an arm

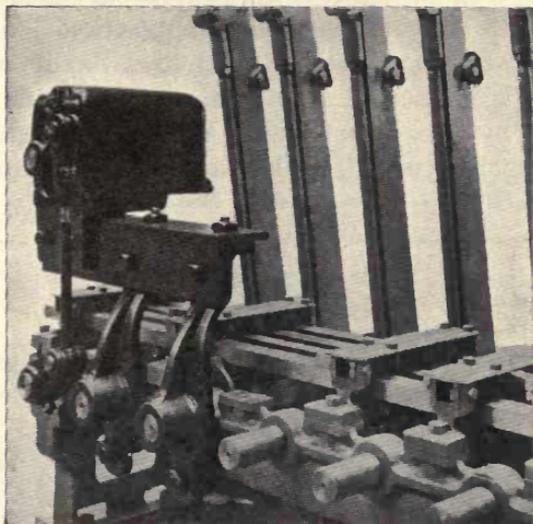


FIG. 177.—Electric lock.

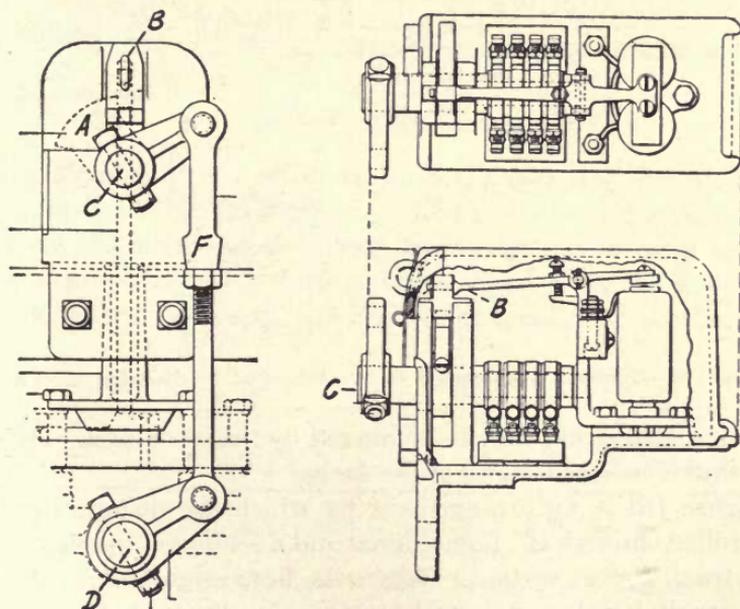


FIG. 178.—Electric lock.

fastened to the locking shaft *D* operated by the latch, is connected by means of link *F* to a segment *A* that rotates about its center *C*.

The edge of this disc engages a bar, *B*, controlled by the electromagnet. When this lock magnet becomes energized, the bar, *B*, is raised clear of the notch allowing the locking shaft to be turned and the latch to be seated in its normal position.

Figure 179 shows a lock applied to a Saxby and Farmer machine. It is connected by a rod directly to the rocker-link manipulated by the lever latch. When the magnet becomes energized, its armature lifts the dog from the segment notch

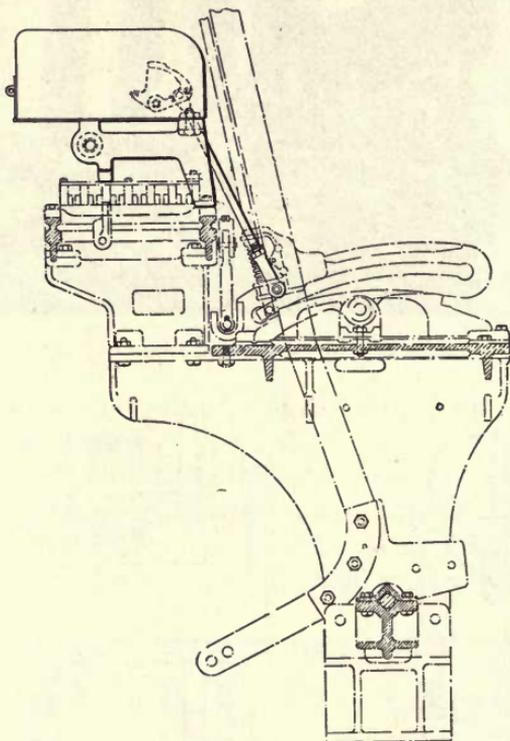


FIG. 179.—Electric lock applied to a mechanical interlocking machine.

allowing the rocker-link to be moved by the lever latch. Figure 180 shows enlarged views of the lock.

Figure 181 is an arrangement by which the distant signal is controlled through the home signal and a section of bonded track, or a track circuit section. When the home signal, 2, is cleared, the circuit breaker *A* completes the circuit through the track battery *C*, energizing the track relay *E*, thereby completing the local battery circuit through signal *F* causing it to go to the clear position. As soon as a train enters the controlling track section,

relay *E* is deenergized causing the signal *F* to go to the caution position. When signal 2 returns to the normal position, circuit breaker *A* opens the circuit that controls the relay *E*, and signal *F* will continue in the normal position. Signal *F*, brought to the clear position by power controlled by the towerman in the inter-

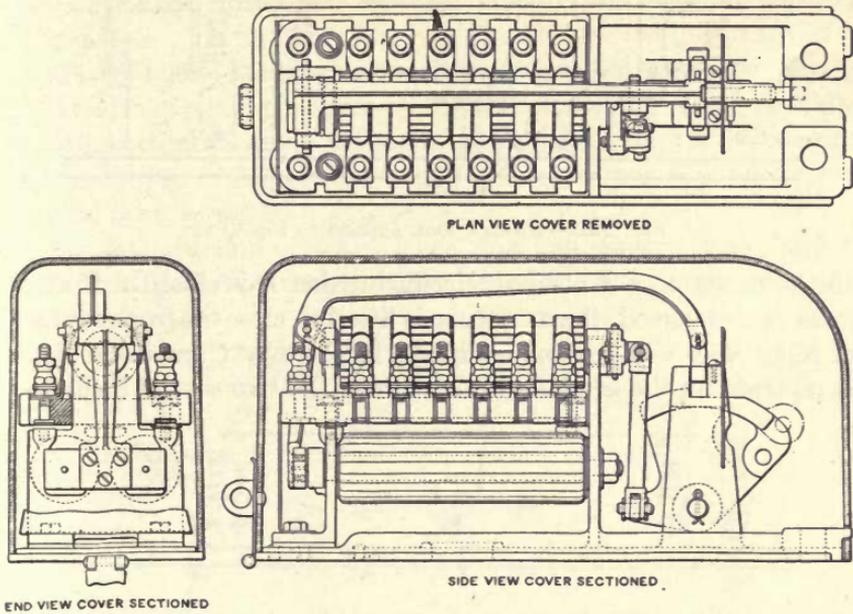


FIG. 180.—Details of electric lock.

locking plant, but returned to its normal position by the presence of a train in its track section, is called a semi-automatic signal.

Figure 182 is an elaboration of the wiring arrangement shown in Fig. 181 whereby the lever to home signal 2 may be locked in the half reversed position. *D* is a circuit breaker on the drum of

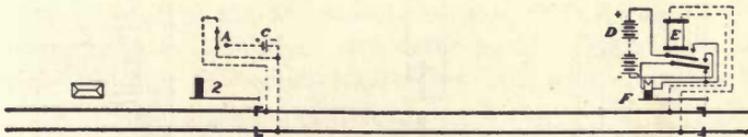


FIG. 181.—Distant signal controlled by track circuit.

the electric lock that is closed when lever 2 is returned to its normal position; but *A* will not become energized until the distant signal has gone to the full caution position, closing the circuit breaker *J*. As soon as *A* becomes energized, the latch is unlocked and may be placed in its normal position.

Figure 183 is an arrangement whereby the distant signal and the tower indicator *B* are controlled by a short track section known as a "setting section." The section may be made as long as desired, but a few rail lengths will answer the purpose. When

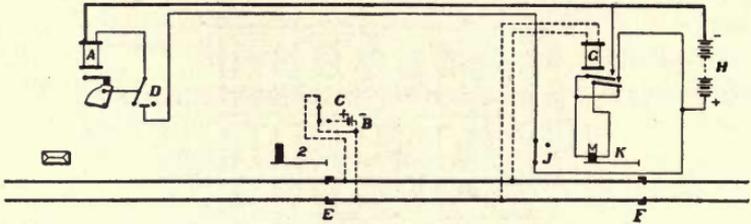


FIG. 182.—Electric lock applied to Fig. 181.

the home signal *E* is cleared, circuit breaker *D* is closed. If after lever *A* is reversed, the armature is lifted to close the front contact of relay *B*, *B* will become energized by battery *C* provided there is no train on the track section between the two sets of insulated

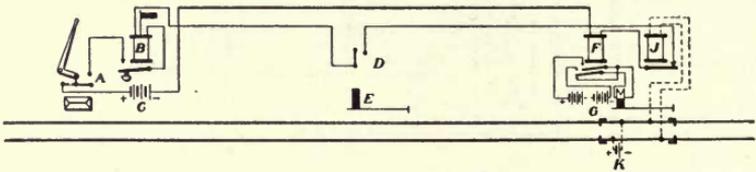


FIG. 183.—Distant signal controlled by setting section.

rail joints, and the armature of *B* will stick. As soon as *F* becomes energized by battery *C*, the distant signal goes to clear. Should a train come into the block, the signal would return to caution and would remain in that position after the

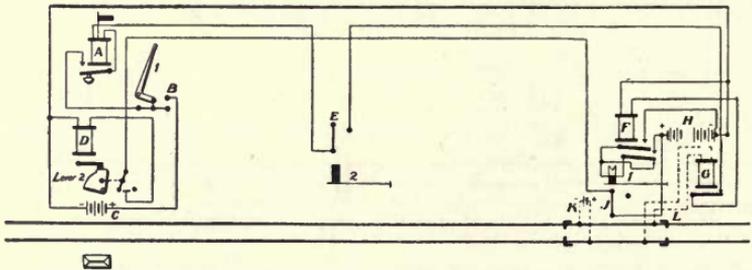


FIG. 184.—Setting section and electric lock.

train goes through. As soon as *J* becomes deenergized, *B* becomes deenergized and its indicator goes to the stop position, opening the circuit until restored by hand.

Figure 184 is an elaboration of the wiring arrangement shown in Fig. 183 and provides for a separate lever to operate the distant signal in connection with the track section and an electric lock *D* to insure that the distant signal blade returns to its full normal position. Levers 1 and 2 may be returned to normal, but 2 will remain locked in the half reversed position until circuit breaker *J* is closed.

**111. Section Locking.**—As defined by the Railway Signal Association, section locking is: “Electric locking effective while a train occupies a given section of a route and adapted to prevent manipulation of levers that would endanger the train while it is within that section.”

The introduction of heavy track rails has rendered more or less uncertain the effectiveness of the detector bar in preventing the

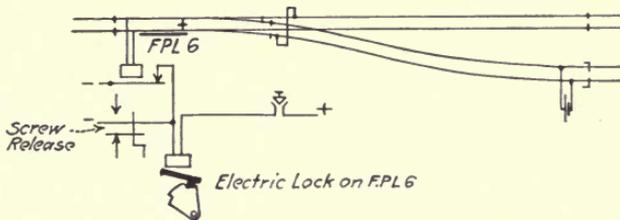


FIG. 185.—Section locking.

signalman from throwing a derail or switch under a train. With the wide rail, there is a possibility that the detector bar would miss the tread of the wheel entirely if an attempt should be made to throw the switch under a train, and thus it would fail to perform the only function it had to serve. Furthermore, the clips sometimes fail either from continual wear or from the force of the drive by power equipment.

As a measure of greater safety, section, or detector locking, is used sometimes instead of the detector bar and sometimes in addition to it. It becomes effective by having electric locks attached to the facing point locks or to the switch levers and controlled by the track relays. The track section used for this purpose may vary from 100 to 300 ft. in length. Figure 185 shows circuits for section locking.

As the lock is controlled by the track relay, the lever to which the lock is attached is locked positively in both the normal and reverse positions as long as the track section is occupied by a train. On certain occasions while a train is standing in a portion

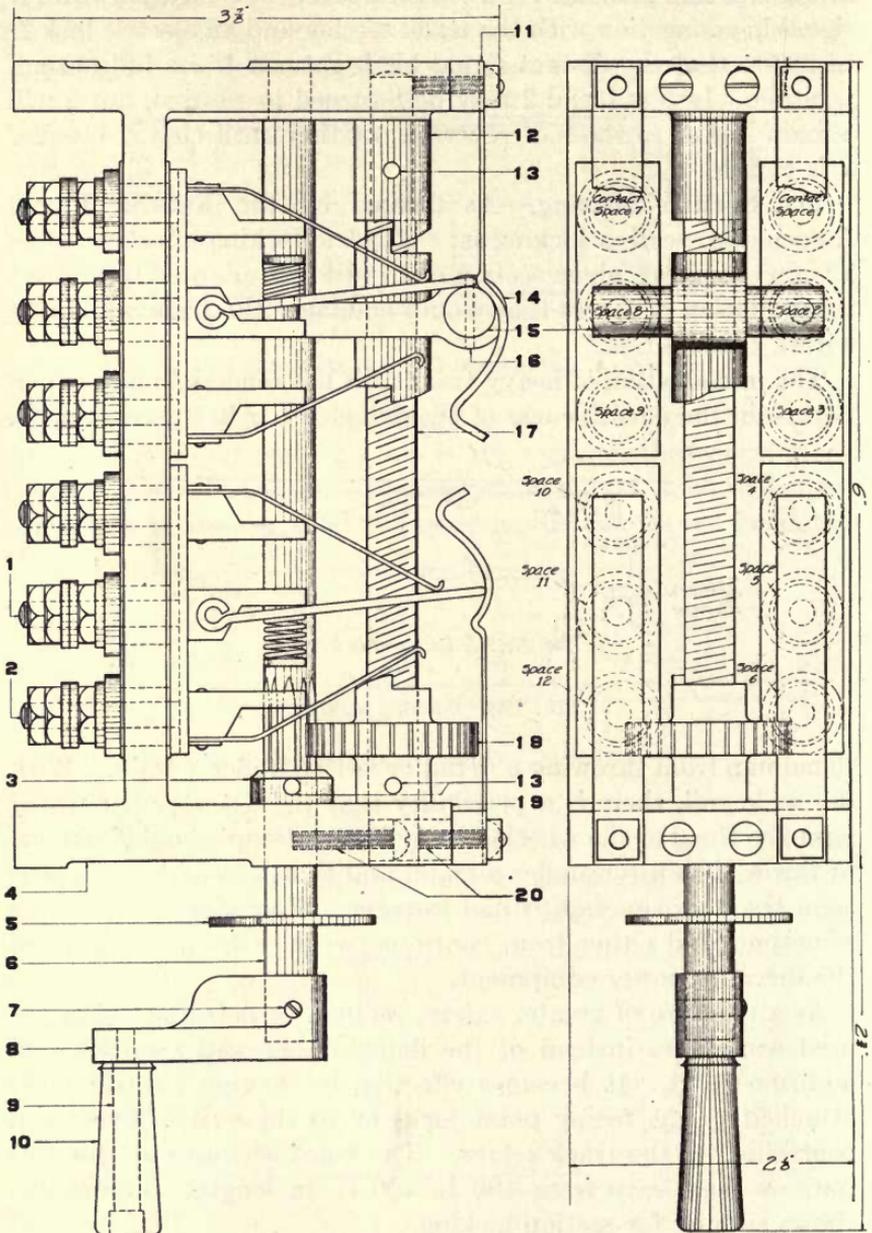


FIG. 186.—Electrical screw hand release. (General Railway Signal Co.)

of this section, it might become desirable to energize the electric lock in order to change the route. To accomplish this, a screw release is inserted to energize the lock magnet independently of the track section. A floor push is installed in the locking circuit as a matter of economy in current consumption.

**112. Screw Release.**—A screw release is a device for mechanically releasing the electric lock on a lever in a mechanical interlocking plant in order to restore the levers to their normal position with or without the section having been occupied by a train, depending upon the particular case in hand. It intentionally involves an element of time either to prevent hasty action on

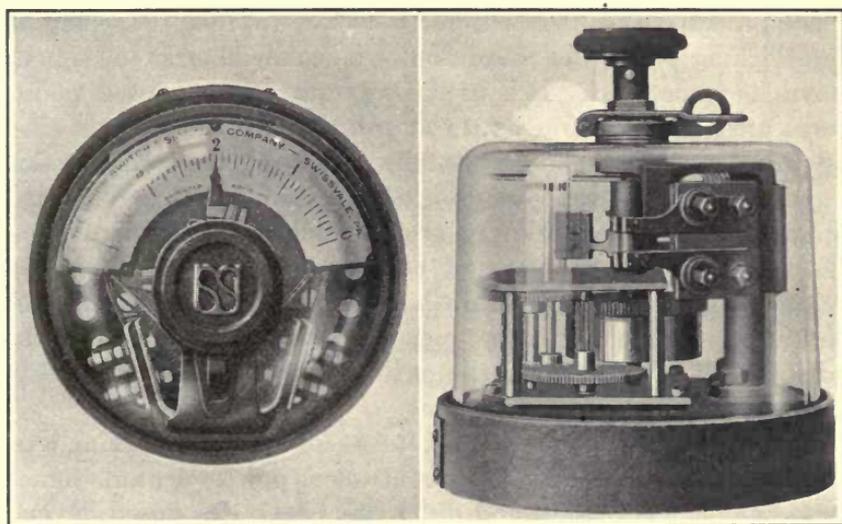


FIG. 187.—Clock-work time release.

part of the towerman in some cases or to penalize him for negligence in other cases.

An electrical screw hand release is shown in Fig. 186. In its normal position, the contact block is as far to the upper end of the screw as it is possible to go. To manipulate the electric lock, the contact must move the full length of the screw, requiring from one to two minutes of time for the operation. It is known also as a hand release, time release, and slow release.

**113. Clock-work Time Release.**—The clock-work time release, shown in Fig. 187, serves the same purpose as the hand release, but requires very little of the signalman's time for actual manipulation. To apply the release, he turns the knob as far to

the right as it will go. This winds up a mechanism of clock-work, which when released slowly unwinds, returning the pointer to its stop position. The time interval is usually from one to two minutes, but may be as much as four. When there are many movements of trains, however, the interval must be comparatively short.

**114. Approach Locking.**—As defined by the Railway Signal Association, it is: “Electric locking effective while a train is approaching a signal that has been set for it to proceed and adapted to prevent manipulation of levers or devices that would endanger that train.”

Approach locking is an arrangement whereby, after a train has passed a certain point or entered a certain route approaching an interlocking plant, the route cannot be changed after the signals have been accepted. It is used essentially at high-speed points for a greater protection than the ordinary crossing signals give. In this connection, there is usually a preliminary track section outside of the section governing the distant signal. When the train enters this preliminary section and the home signal has been cleared the route cannot be changed except by the hand release. As soon as the train has passed the home signal, the locking is released. Some type of indicator controlled by the preliminary section or by the entire route is generally used in connection with approach locking.

Figure 188 is the Union arrangement for approach locking used in connection with the lever controlled power distant signal. After signal 2 is cleared and its circuit breaker is closed, lever 1 may be reversed placing distant signal 1 in the clear position. When a train enters the preliminary section *Y-Z*, it deenergizes the lock magnet *B*. Levers 1 and 2 can be returned to the full normal position, but the latch on lever 2 will be locked half reversed until the train passes *X*. When both track sections are cleared, the lock *B* becomes energized, unlocks the latch and allows it to be seated in its full normal position.

It sometimes becomes desirable to change the line-up of the signals after a train has stopped between *X* and *Z* in Fig. 188. To do this, a screw release or time lock is provided. Figure 189 shows a hand release, also an approach indicator added to the arrangement in Fig. 188. When the train occupies the track between *X* and *Z* in Fig. 189, the tower indicator *A* becomes deenergized thereby locking signal lever 2 in the half reversed position. To

change the line-up in any way, the latch on lever 2 must be returned to the full normal position. This is done by means of the screw release. The lock magnet is a relay, which becomes energized when the lower contact of the screw release is closed through a circuit not controlled by the indicator. As soon as the lower contact is made, the latch on lever 2 may be returned to the

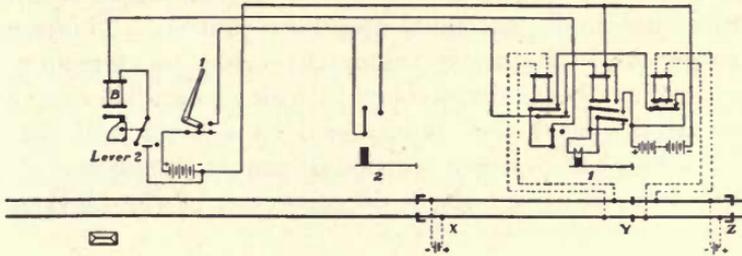


FIG. 188.—Approach locking.

full normal position, allowing for a change in line-up of the tracks. When the lower contact is made, the upper contact is broken. The upper contact must be closed again by the screw release before the distant signal can be cleared.

Figure 190 is a form of approach locking with semi-automatic control of the power distant signal through the contact of the tower indicator with relief for changing the line-up by means of

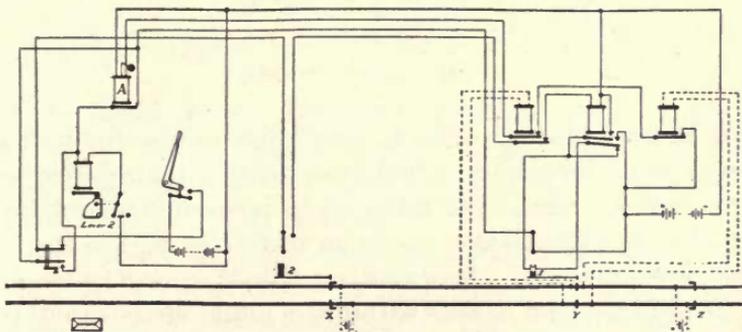


FIG. 189.—Approach locking.

the screw release. Distant signal *D* is cleared as soon as home signal 2 is cleared by a current from battery *A* through upper contact of screw release *R*, contact on hard rubber drum of lock *N*, front contact of second armature *J*, circuit breaker *M*, line relay *L*, and return to *A*, energizing line relay *L*. When the relay *L* becomes energized, the local circuit through battery *B* is complete

to operate signal *D* to clear. The distant signal goes to caution as soon as a train enters the section *G-H*. When there is no train in this section, the track indicator *J* will indicate clear only provided the towerman has placed signal lever 2 in its normal position after the passage of the last train.

The signal lever 2 may be returned to its normal position at any time, but its latch cannot be released until the block *G-K* is unoccupied and the distant signal is placed at caution. This prevents the towerman from quickly taking the signals away from a train after they have been accepted and throwing a derail in front of the train. If the block *G-K* is occupied by a train and the lever latch 2 is in a half reversed position, it cannot be restored to a full normal position except the train move out of the block or the towerman use his screw release.

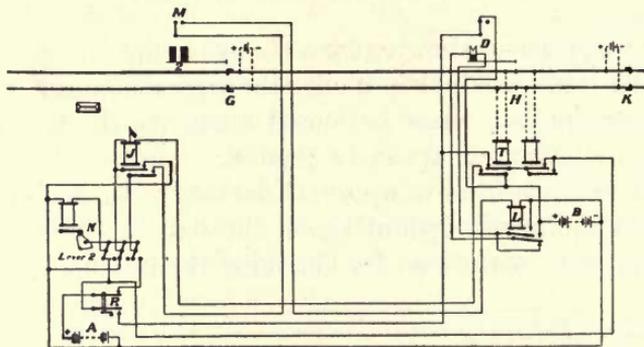


FIG. 190.—Approach locking.

**115. Route Locking.**—The Railway Signal Association's definition of route locking is: "Electric locking taking effect when a train passes a signal and adapted to prevent manipulation of levers that would endanger the train while it is within the limits of the route entered." It is an extension of section locking such that all switches and derails within the limits of the track to be protected by route locking are locked automatically by a train entering the route and remain so locked until the train leaves the route. It should take effect when the train passes the first signal on the route. Some means should be provided that the route line-up may be changed should a train stop in the route, but it must be a slow process requiring a time element for protection. A hand or time release is used in such instances. Figure 191 shows an example of both approach and route locking.

In this figure signal 3 in a proceed position presupposes that *F.P.L.5* and switches 4 and 6 are in proper position for main line movement from *A* towards *D*. Before either 4 and 6 can be changed for a different line-up, it is necessary to place lever 3 and then 5 in the full normal position. As soon as the train enters section *A* the approach indicator *AB* becomes deenergized, deenergizing, in turn, the lock magnet on lever 3. The towerman may return lever 3 as far as it will go towards its normal position, but he cannot release the latch until *AB* becomes energized again, which will be when the train passes out of *B* into *C*. He cannot move 4 and 6 until the latch on 3 is released. Furthermore, he can not change either switch while a train is in *C* because of section locking.

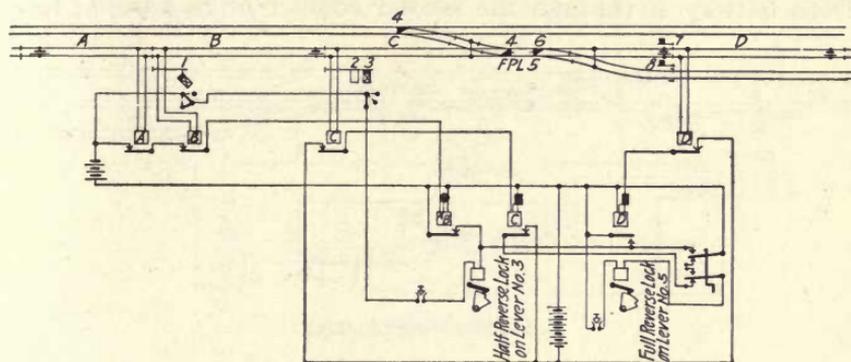


FIG. 191.—Approach and route locking. R. S. A. plan 1149.

**116. Sectional Route Locking.**—Sectional route locking is defined by the Railway Signal Association as: “Route locking so arranged that a train in clearing each section of the route releases the locking affecting that section.”

By this system as soon as the train enters the route, all the signals, switches, and derails on that route are locked as before; but as soon as each section is cleared by the train, the locks in that section are released. This finds its best service in busy terminals, where extraordinary protection is required, but where the train movements are so frequent as to prohibit the long time intervals.

**117. Stick Locking.**—The Railway Signal Association defines stick locking as: “Electric locking taking effect upon the setting of the signal for a train to proceed, released by a passing train, and adapted to prevent manipulation of levers that would endanger an approaching train.”

Stick locking does not depend upon the presence of a train, but becomes effective upon the reversal of the home signal lever. It remains effective until the train passes the home signal into the releasing section; and unless the towerman returns the lever to its normal position while the train occupies this releasing section, he must use his hand or time release to do so. Figure 192 is an example of stick locking, which involves the use of a stick relay. This is Railway Signal Association plan 1151 with some lettering added to assist in the explanation, and the floor push substituted for the latch.

When the home signal lever 3 of this plan is reversed, the circuit is broken by circuit breaker *F* on signal 3 and the stick relay *K* becomes deenergized. This, in turn, breaks the circuit from battery *E* through the second contact of *R*, wire *T*, lock

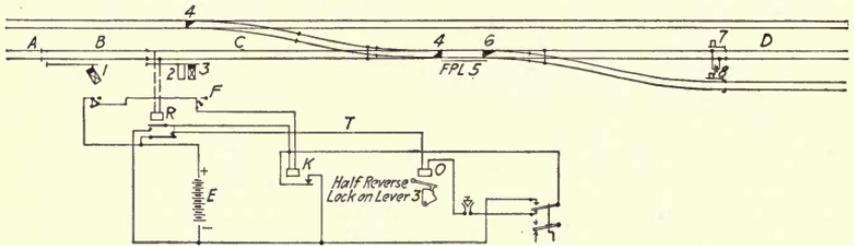


FIG. 192.—Stick locking.

magnet *O*, floor push, contact of time release, contact on relay *K* to battery *E*, deenergizing *O*. When the train enters the block *C*, track relay *R* becomes deenergized, and if the signal lever is restored to normal before the train leaves the section *C*, relay *K* will be reenergized through the back contact of *R*. While the lever may be restored to the normal position, its latch cannot be released until unlocked by *O*. *R* will become energized as soon as the train leaves the section *C*, and immediately the lock *O* becomes energized unlocking the latch and allowing it to fall to its normal position. The fact to be observed is, however, that the latch cannot be released in this manner unless the lever is placed in its normal position while a train is in section *C*. If the signalman neglects to restore the lever to normal while the section is occupied by the train, or if he lines up a route and the train for some reason or another does not come into the interlocked section, or if he lines up a route and decides to change it to another, he must use his hand release to do so. In the first instance, this

penalizes him for his negligence, and in the last instance it prevents him from throwing a derail in front of a train after it has passed the distant signal giving a clear indication. The time element involved should be enough to allow the train to be over the crossing and gone or to allow the train to come to a stop before it reaches the home signal.

**118. Stick Relay.**—A stick relay, represented by Fig. 193, is so connected that its armature and front contact are used to complete the circuit that energizes its own coils. A circuit from battery *B* through wires 1, 2, and 5, must be provided originally to energize the relay *R*. When *A* is picked up another route formed is from battery *B* through wires 3, 4, and 5; and the current will continue to flow through it even though the original circuit be broken at *C*. If the "stick" circuit is broken at any point,

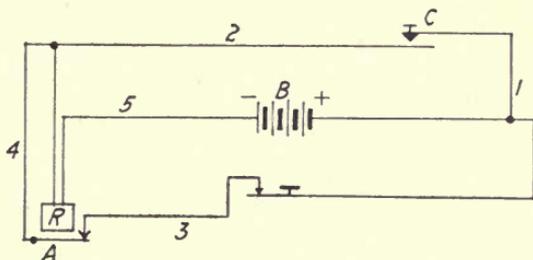


FIG. 193.—Stick relay.

as by the deenergizing of a track relay where its armature forms a part of the stick circuit, the relay *R* becomes deenergized and the armature *A* will not pick up until the original circuit is closed.

**119. Check Locking.**—Where two interlocking plants are located a comparatively short distance apart on a single-track road, it becomes necessary at times to so interlock levers in the two towers that conflicting movements of trains will be impossible. Such an arrangement is called check locking. Figure 194 shows such a check locking circuit where there is no preference as to the direction of traffic. There is a check lock lever in each plant *A* and *Z* so interlocked with the signal levers that the signal levers cannot be placed in the proceed position until their respective check lock levers have been moved to the full reverse position. By referring to Fig. 194 it will be seen that as only one of the check lock levers can be placed in the full reverse position at a time, it will be impossible to clear but one signal at a time; that is,

20 cannot be cleared while 1 is cleared. As the signal lever at both *A* and *Z* when reversed, locks its check lever reversed, the check lock lever must be fully reversed before the signal lever can be reversed. The two check lock levers are each equipped with a half reverse lever lock that can be energized only when the two sets of devices are in a certain position. The signalman in tower *A* may reverse his check lever lock to the reverse indication point, but he cannot move it any farther until the lever lock becomes energized in the following manner.

Current from the battery at *Z* flows through the normal circuit controller of the check lock lever at *Z*, then through the front contact of the track relay *X*, and on through the reverse circuit

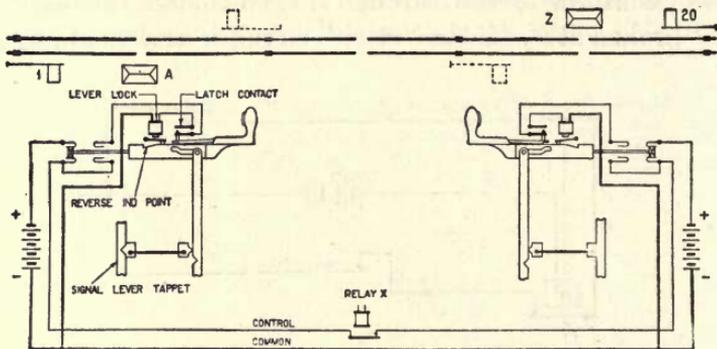


FIG. 194.—Check locking circuit. For use where there is no preference as to direction of traffic. (*General Railway Signal Co.*)

controller of the check lock lever at *A*, and to the lever lock itself. After the lock becomes energized, the lever may be placed in the full reverse position, whence the signal lever 1 may be cleared. The check lock lever at *Z* may be reversed to the indication point, but it cannot be reversed beyond that point because its lock magnet cannot be energized. Thus signal 20 must remain at the stop indication until 1 is restored to normal. As only one of the signals can be cleared at a time, traffic can be given a proceed indication in only one direction at a time. On account of the fact that the relay *X*, operated by the track circuit between the two towers, controls the check lever lock circuits, it is impossible to reverse the signal indications while a train occupies the track between *A* and *Z*.

**120. Union Electro-mechanical Slot.**—The up-and-down rod, which is pushed upward to clear the signal, is made in two parts, *A*, and *B*, Fig. 195, and is so connected by the electro-mechanical

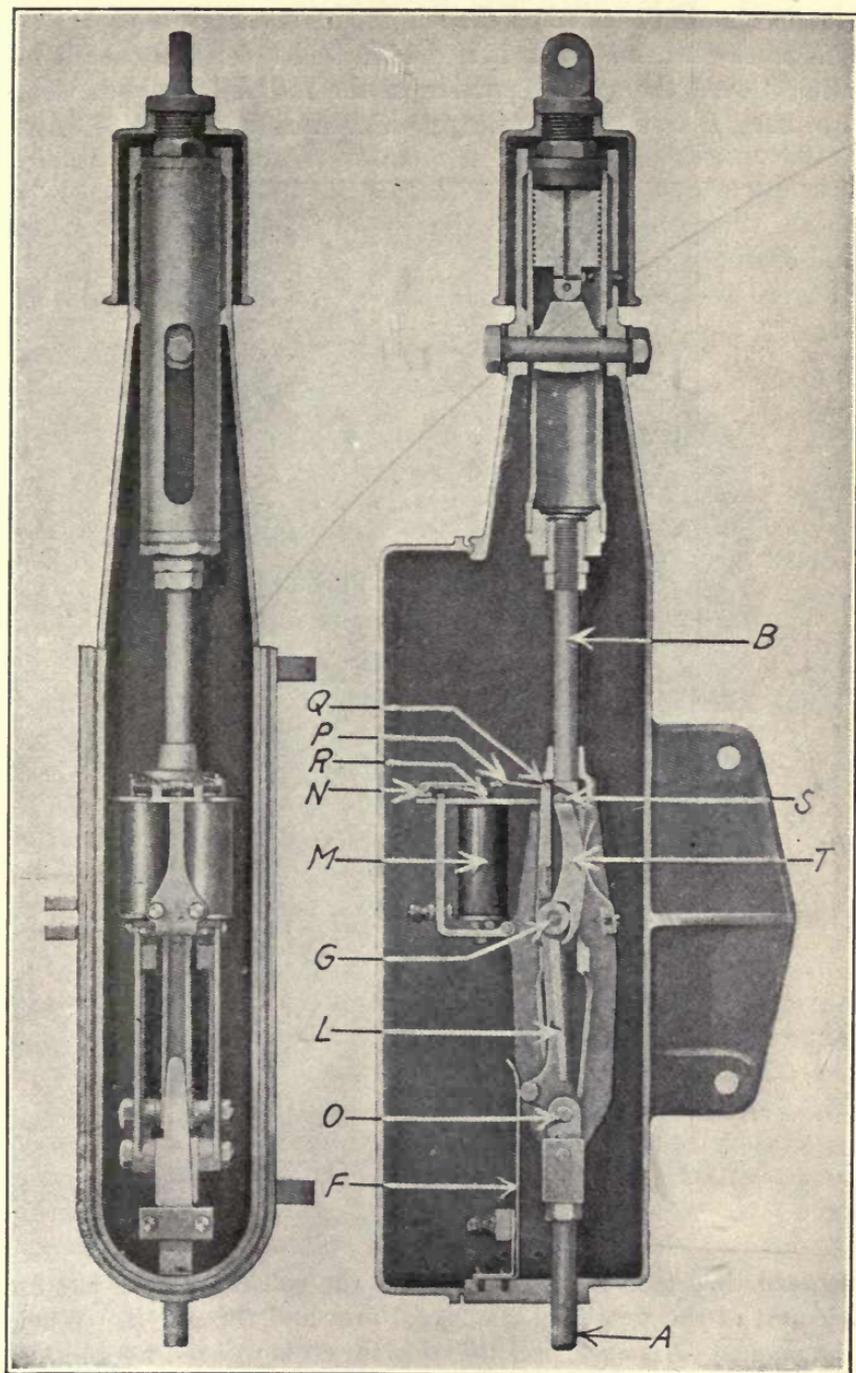


FIG. 195.—Union electro-mechanical slot.

slot mechanism that when the magnet *M* is energized the signal can be cleared, but when it is deenergized the signal cannot be cleared even though the portion of the rod *A* be raised. The two bars, *L* and *T*, form a toggle hinged at *O*, *G*, and *S*. Any

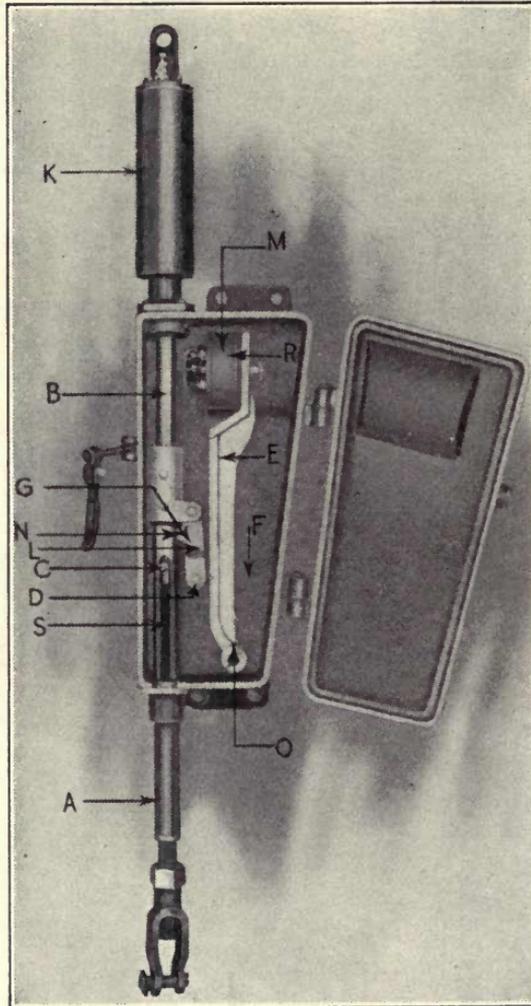


FIG. 196.—Hall electro-mechanical slot.

upward thrust on *A* tends to throw the roller *G* to the left on account of the weight of the signal arm and the rod *B*. When the magnet *M* is energized this side thrust is resisted by another toggle hinged at *N*, *P*, and *Q* and held in position by the armature *R*. Thus, the up-and-down rod is made rigid and the signal

can be cleared. As the three points, *N*, *P*, and *Q*, are not in line, the two pieces *N-P* and *P-Q* will buckle as soon as the magnet becomes deenergized if there is any pressure applied, during which time the signal arm cannot be cleared.

At the top of the encasing iron box is a dashpot installed to relieve the force of the blow as the blade comes to the stop position. The magnet, *M*, is controlled by track circuits and is energized continuously except when the track section is occupied by a train. The spring *F* tends to hold the lever *L* in position

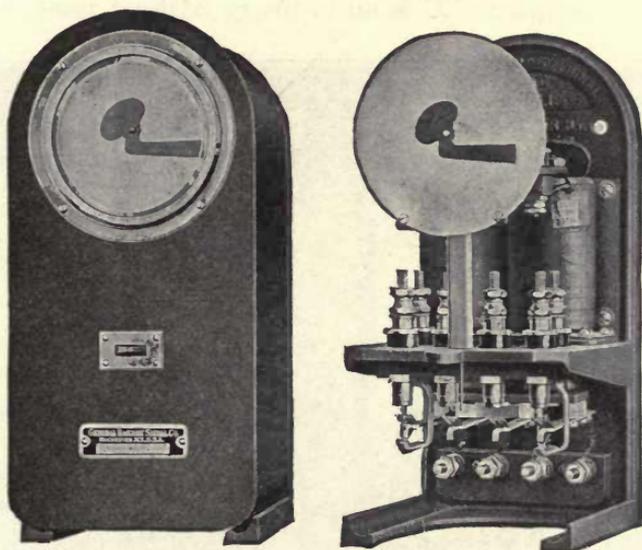


FIG. 197.—Tower indicator.

against *T* when the rod *A* is normal so that the magnet can get control of its armature *R*. The lever must be placed in its normal position again before the signal can be cleared.

**121. Hall Electro-mechanical Slot.**—In the Hall type of slot, shown in Fig. 196, *A* represents the lower portion of the up-and-down rod, or that portion that connects directly to the signal lever, and *B* the portion fastened to the signal arm. *A* is large enough to allow *B* to slide inside it. A pin *C* passes through the lower end of *B* and extends far enough out on each side to engage the outside rod at the top of the slot *S*. Both rods are notched at *N* to receive the point of the latch *L*. *M* is an electro-magnet with an armature, *R*, connected to the arm *E*. When the magnet is energized the arm *E* presses against the roller *D* on the

lower end of the latch and causes the point *G* to engage both *A* and *B* so that when *A* is raised to clear the signal, *B* moves also and the signal goes to clear. Should a train enter the block when the signal is clear, the magnet, *M*, would immediately become deenergized allowing *E* to move away from *D*, whereas the weight of the signal arm and rod *B* would force the point *G* out of the notch in rod *B* and the signal would go to the stop position. The spring *F* tends to keep the arm *E* and the armature *R* in contact with the magnet *M*. The signal cannot be cleared again until the lever is placed in the normal position and the magnet is energized. *K* is an ordinary dashpot used to relieve

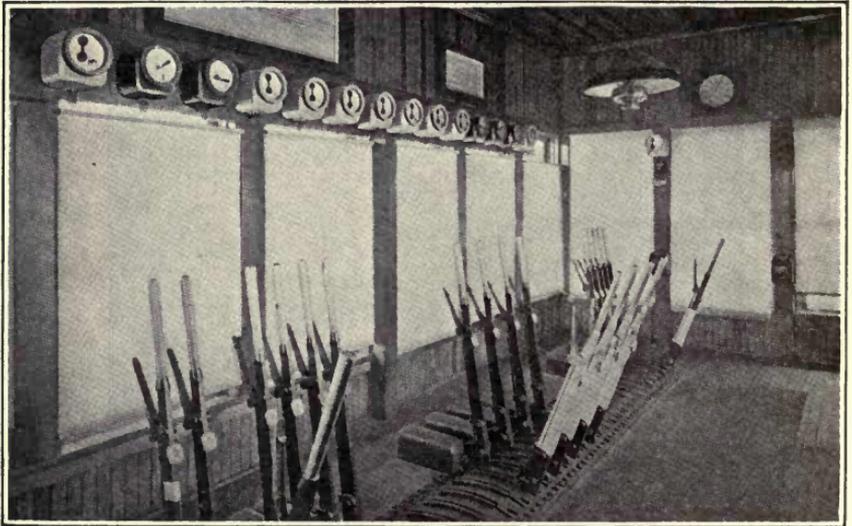


FIG. 198.—Tower indicators. (*Hall Switch and Signal Co.*)

the shock of the signal when the blade goes to stop. The magnet *M* is controlled by track circuits and is energized continuously except when the track section is occupied by a train.

The semi-automatic feature of these signals permits them to go to the stop position automatically even though the operator does not restore his lever to the normal position, an arrangement that operates on the side of safety to prevent a following train from entering the block until authorized to do so. The magnet is controlled by a short track section; and so long as the track circuit is not occupied by a train the signal can be cleared, but as soon as a train enters the section the slot magnet becomes deenergized allowing the signal to go to the stop position.

**122. Tower Indicators.**—Tower indicators are used to notify towermen of the approach of trains and to aid them in following more closely the movements of trains through interlocking plants where route and other locking is practiced. The information concerning the approach of trains is generally given by disc indicators; while that concerning the movements over track sections through interlocked territory is usually given by semaphore indicators. These are ordinarily located on the wall of the tower where they can be easily seen by towermen.

## CHAPTER X

### MANUAL BLOCK SYSTEM

A manual block system is one in which the signals or other devices governing the spacing of trains are operated by hand.

There are three ways of applying the system; Manual Block, Controlled-manual Block, and Electric Train Staff.

#### THE MANUAL BLOCK

##### 123. General Description.

The manual block is nothing more nor less than the ordinary telegraph or telephone block where an operator at one station is free to clear his signal at any time without electrical or mechanical check from any other station. Adjacent operators communicate by telegraph or telephone and clear or hold trains according to the rules in force on the particular road. The blocks are generally the distance between ordinary commercial stations, but occasionally on busy lines intermediate towers are built in order to shorten the blocks. The signals are given by train-order boards, which stand

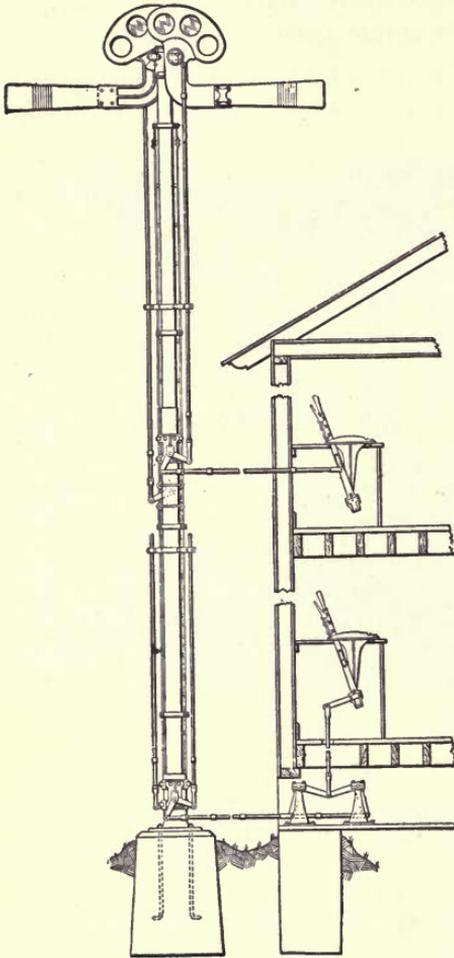


FIG. 199.—R. S. A. double-arm upper quadrant train-order signal.

in front of the station building or tower. One arm of the signal governs movements of trains in one direction and the other arm those in the opposite direction.

There are three roundels or glasses in each signal, and one lamp serves the purpose of all of them. Usually the signal indicates either stop or proceed, but a few roads use the 45-degree position for giving crews an indication for a 19 order. The positions of the blades and the colors of the lights correspond to those in use for ordinary signaling purposes. Figure 199 is the type recommended by the Railway Signal Association and operates in the upper quadrant.

The telegraph method of signaling has no check whatever on broken rails or open switches as some of the other methods have. Although the system is still in use on a great many branch lines and smaller roads, there are so many chances for accidents to trains through mistakes made by operators that other systems have been installed which have more checks to safeguard the train movements.

#### THE CONTROLLED-MANUAL BLOCK

**124. General Description.**—In the controlled-manual block system the signals are operated mechanically, but are so controlled electrically that the signal at one station cannot be cleared without the aid of the operator at an adjacent station. If operator *A* desires to clear his signal for an approaching train to pass into a block, he must communicate with the operator *B* at the other end of that block, and request him to assist in releasing the lock on his signal mechanism. If *B* is in position to permit the train to enter the block, he complies with the request, after which *A* may proceed to clear his signal.

Figure 200 shows a form of controlled-manual machine made by the General Railway Signal Company. To move a train from *A* to *B*, the operator at *A* signals *B* by means of a bell to close the circuit at 3, Fig. 201, in his controller by turning arm 12. At the same time, *A* closes 10 by operating his lever 13. The circuit being then complete, current will flow from battery 28 through wire 1, contacts 2-2 of the lock *L*, contacts 3, wires 4 and 5, contacts 6, wire 7, indicator magnet 29, wire 8, indicator magnet 30, wire 9, contacts 10, wire 11, electro-magnet 31, and to the ground. When magnet 31 becomes energized, the lock 14 is lifted and lever 15 may be withdrawn unlocking lever 19. When lever 19 is turned one-half a revolution the signal is cleared. It is restored to the stop position by completing the revolution. A ratchet wheel, 18, is provided to insure that the handle 19 be

turned only in one direction. The pipe that operates the signal is connected directly to the crank 21. There is a lug, 22, on the

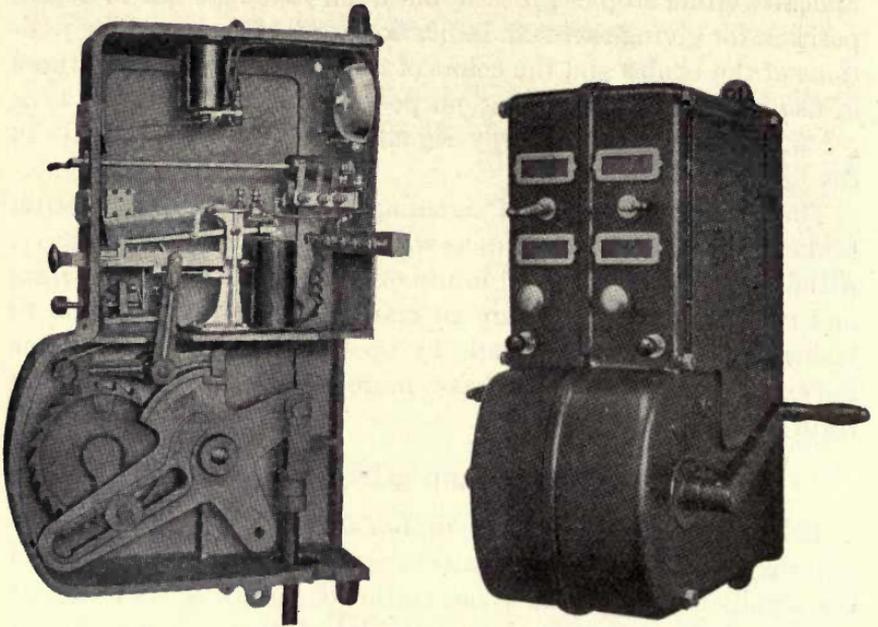


FIG. 200.—Controlled-manual station block instrument.

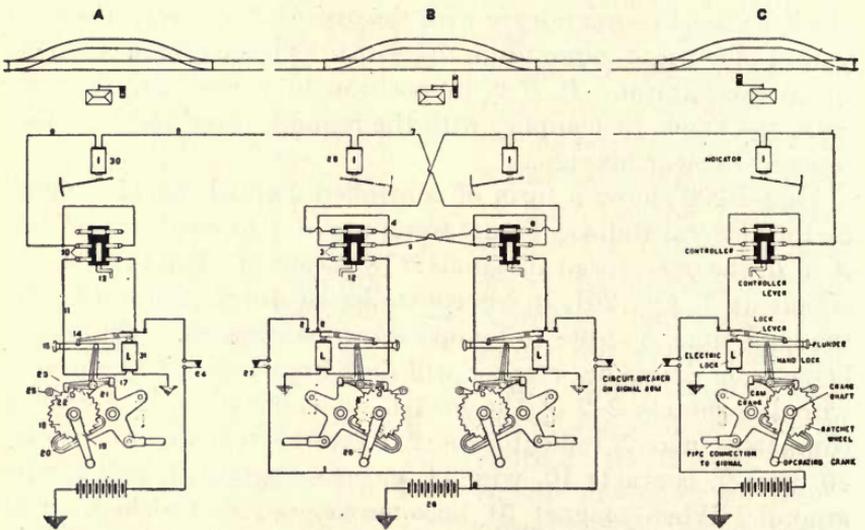


FIG V

FIG. 201.—Wiring diagram for controlled-manual system.

ratchet wheel 18, that when the signal is returned almost to the stop position engages the arm 23 and forces the lock 17 into its

seat requiring that the signal be again unlocked before it can be cleared.

Besides being a check on the operators, there are different degrees of track protection afforded by the controlled-manual system where track circuits are installed. The length of the track circuit may be, in some cases, merely enough to protect switches and to control semi-automatic signals at each end of the block; while it may extend entirely through the block, in other cases, giving better protection against broken rails. The ordinary train-order boards are used where there are no track circuits, and slotted signals where there are track circuits. A slotted, or semi-automatic signal, is one cleared by mechanical or other means, but is put to danger automatically by the train entering the block. These semi-automatic signals are equipped with electro-mechanical slots.

#### THE ELECTRIC TRAIN STAFF

**125. General.**—The staff system is one form of the controlled-manual system of block signaling and is applied only to single-track operation. The system finds its best application on roads with heavy traffic, being used principally in dangerous places, as at bridges and tunnels on non-electrified territory and at points where it is not feasible to install track-circuit signaling. The road is divided into blocks of 5 or 6 miles in length; usually the existing stations will suffice to form about the proper length of block when the staff system is installed, although occasionally an additional station will need to be supplied in order to expedite train movements. Two staff machines that are exactly alike are provided for each block, one stationed in the tower at each end of the block. The two machines are so connected by wires that they are interdependent in operation.

The train is given a metal staff and this eliminates the necessity of a written train order. No train is allowed to proceed into a block unless the engineman has a staff. Only one staff can be taken out of either instrument at a time; and when one is out, both instruments are automatically locked and remain locked until that staff is returned to one or the other of the two machines. The engineman must take a new staff at the beginning of each block and deliver it at the end of that same block. The staffs are made of steel rods,  $\frac{3}{4}$  in. in diameter and 6 in. in length, so cut with such a series of annular grooves that those used in one

block will not fit the instruments of the adjacent blocks. The instruments are duplicated, but the distance between duplicate pairs is great enough to prevent the staffs from being carried over.

**126. Operation of the Absolute Staff Instrument.**<sup>1</sup>—In the description of the staff equipment made by the Union Switch & Signal Company, a train is considered to move from station *X* to station *Y*, Fig. 202. The operator at *X* presses his bell key *A* the number of times prescribed in the bell code, and rings the bell *L* at *Y*, Fig. 204, from the positive side of the battery through the circuit 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and re-

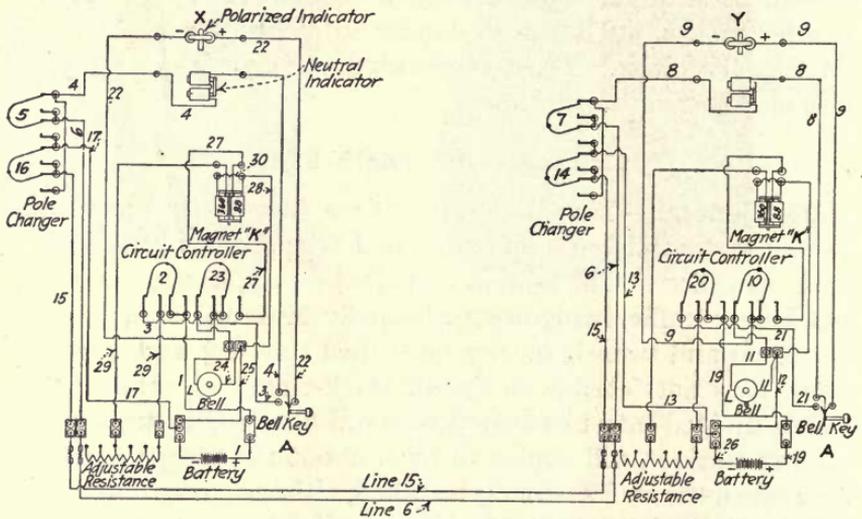


FIG. 202.—Wiring diagram for absolute train staff system. (Signal Dictionary.)

turn to the battery. The operator at *Y* acknowledges the call by closing his bell key *A*, thereby ringing the bell *L* at *X* through the circuit 19, 20, 21, 8, 7, 6, 5, 4, 22, 23, 24, 25, 17, 16, 15, 14, 13, 26; and as he continues to hold it closed, he deflects the "current indicating needle," *F*, Fig. 203, at *X* to the right. Thus informed that *Y* has furnished the necessary current, *X* proceeds to remove the staff by turning the preliminary spindle handle *B*, Fig. 203, to the right as far as it will go. This raises the armature *J*, Fig. 206 up to the magnets *K*, transferring the current from bell *L* to the magnet *K*-88 through the circuit 19, 20, 21, 8, 7, 6, 5, 4, 22, 23, 27, 28, 25, 17, 16, 15, 14, 13, 26, and at the same time closing the circuit on magnet *K*-360 through the circuit 1, 2, 29,

<sup>1</sup> From the Signal Dictionary, p. 38.

30, 28, 25, after which the preliminary spindle handle is permitted automatically to return to its normal position. This unlocks the revolving drum, *C*, Fig. 206, and indicates the fact by displaying a white instead of a red disc in the indicator, *H*, Fig. 205. The operator now moves the end staff, *E*, Fig. 203, up the vertical slot into engagement with the drum, *C*, Fig. 206, (the outer guard, *N*, Fig. 205, having first been turned to the right position), revolves the latter through a half turn, using the staff as a handle,

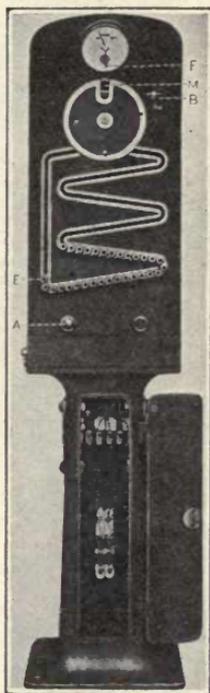


FIG. 203.—Absolute staff instrument.

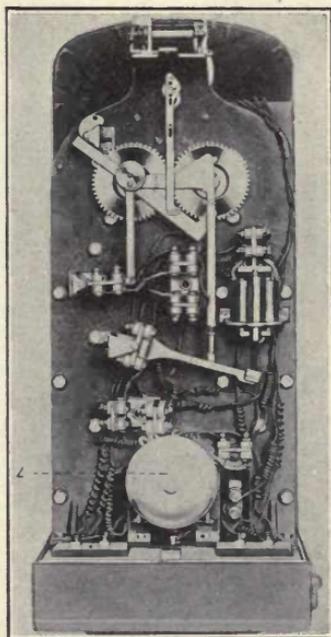


FIG. 204.—Rear view of absolute staff instrument.

and finally withdraws the staff through the opening at *M*, Fig. 203. In making the half turn, the drum, *C*, Fig. 206, has reversed the polarity of the operating current, thereby throwing the instruments at *X* and *Y* out of synchronism with each other and moving the "staff indicating needle," *G*, at *X*, Fig. 207 from "Staff In" to "Staff Out." Immediately on withdrawing the staff, the operator at *X* once more presses his bell key *A*, which indicates to the operator at *Y*, by moving his needle from "Staff In" to "Staff Out" that the operation is completed. He then prepares to deliver the staff to the train.

The magnet *K*, Fig. 202 has two separate coils, *K*-360 energized by the local battery and *K*-88 energized by the line battery. The polarity of the current through *K*-360 is never changed, but that through *K*-88 is changed every time a staff is put in or taken out of either instrument. When the currents in both coils have the same polarity, there is no attraction for the armature.

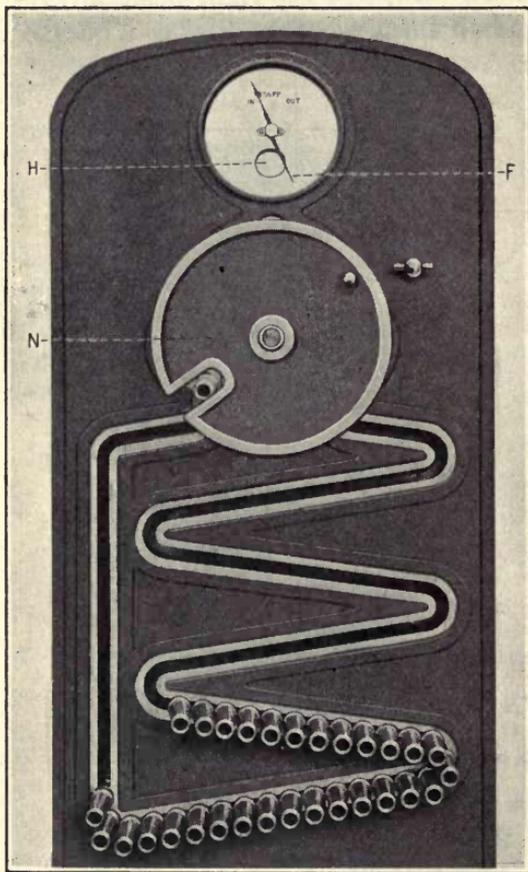


FIG. 205.—Front view of staff instrument in condition for removal of staff.

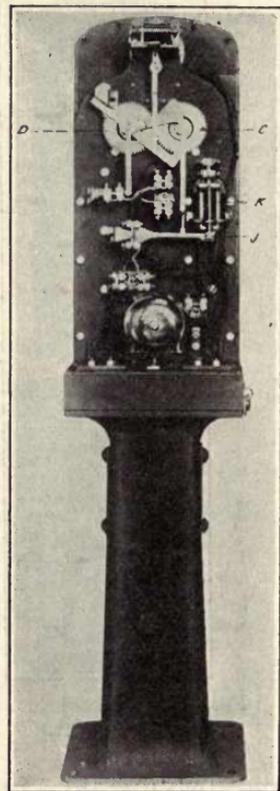


FIG. 206.—Staff instrument with armature up.

When the current is reversed in one coil, the lines of force oppose each other and the armature being brought to the point of attraction, is held there. With the staff out, if an attempt should be made to release another staff by turning the preliminary handle, the circuit closed would be from the positive side of the battery through 19, 20, 21, bell key *A* closed, 8, 7, 6, 5, 17, 25, 28, 27, 23, 22, 4, 16, 15, 14, 13, 26, to the negative side of the battery

at *Y*, with the polarity of the current flowing through magnet *K-88* reversed. By comparing this circuit with the one described for releasing the staff it will be seen that in the former the currents flowing through magnets *K-360* and *K-88* oppose each other, and in the latter they do not, which prevents the releasing of the second staff.

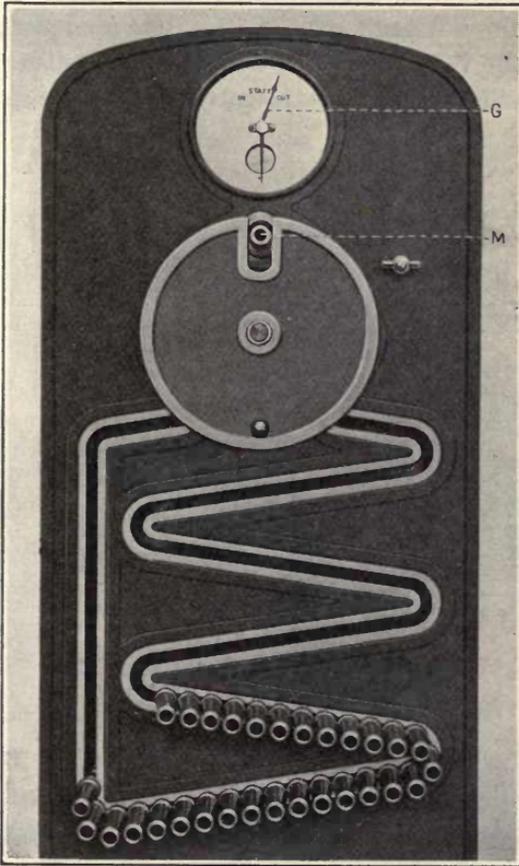


FIG. 207.—Front view when a staff is released or about to be replaced.

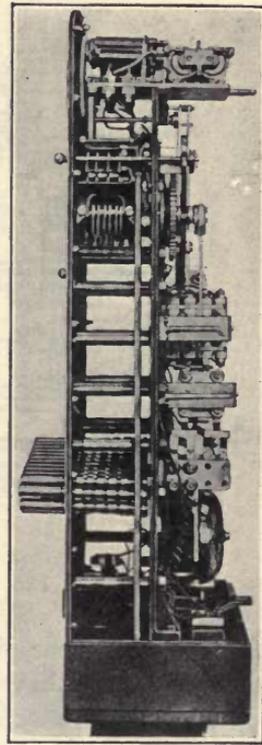


FIG. 208.—Side elevation of staff machine.

On arrival of the train at *Y* the crew delivers the staff to the operator, who places it in the opening *M*, Fig. 203, of his instrument, having first turned the outer guard, *N*, Fig. 205, to place. He moves the staff into engagement with the drum *D*, Fig. 206, revolves the drum through one-half turn to the right, using the staff as a handle, and allows the staff to roll down the spiral. He then presses his bell key the prescribed number of

times, thus notifying *X* that the train is out of the section, which operation also moves the "staff indicating needle" at *X* from "Staff Out" to "Staff In." The operator at *X* presses his bell key in acknowledgment, and by so doing moves the "staff indicating needle" at *Y* from "Staff Out" to "Staff In." The machines are now synchronized and another staff can be obtained from either in the manner outlined above.

If the speed of the train does not exceed 25 miles an hour, the staffs removed from the instruments by the block operators are delivered to the enginemen by hand by means of a small hoop

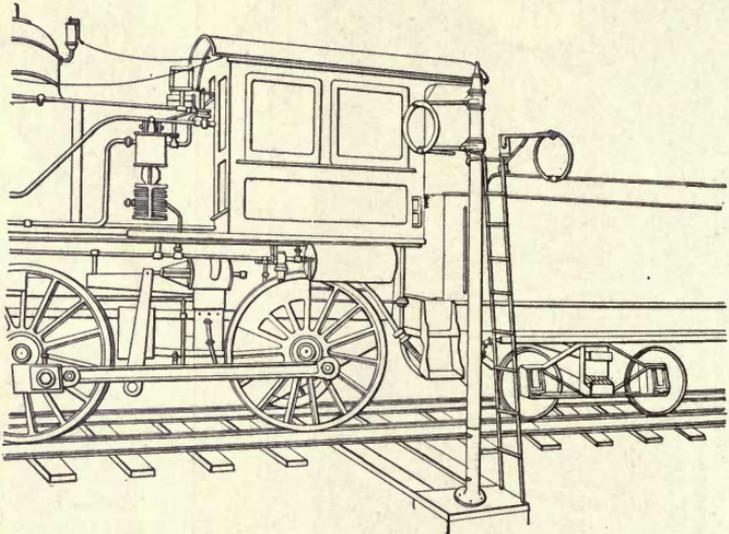


FIG. 209.—Staff catcher and deliverer.

formed of a piece of rubber hose. If the speed is more than 25 miles an hour, they are delivered by means of a staff catcher that operates something on the order of a mail crane, as shown in Fig. 209. The staffs are returned to the operators in a similar manner.

**127. The Permissive Staff.**—Where several trains are allowed to follow one another at short intervals through the block, they operate under what is termed the permissive system. A permissive attachment, shown in Fig. 210, is installed at each end of each block in connection with the absolute machine with only one permissive staff for the two instruments. To move a series of trains from *X* to *Y* this staff must be at *X*. The permissive staff, represented by Fig. 211*E*, is made by passing a double steel rod through 11 separate and removable discs, called tablets.

There is an additional disc fastened to the end of the rod making altogether 12 separate pieces in the staff. To operate the machine one of the regular staffs used in the absolute system is removed from the instrument at X and is used to unlock the permissive attachment. The withdrawal of the permissive staff locks the absolute staff in the permissive case and it cannot be removed until the permissive staff is returned to the case at one end or the other of the block.

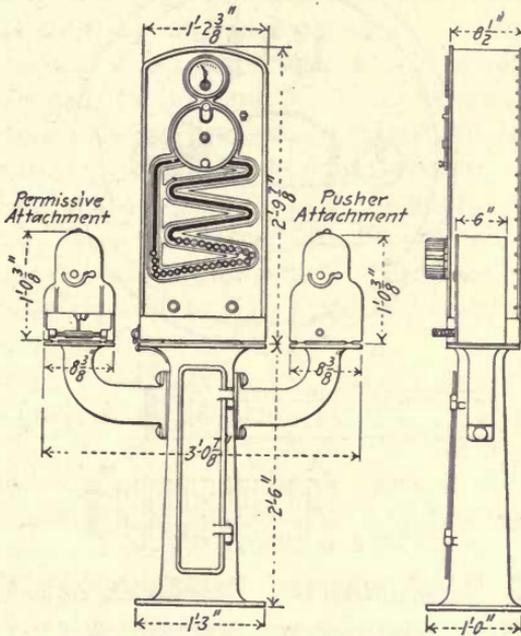


FIG. 210.—Permissive and pusher attachments.

As the trains enter the block, each one except the last takes one tablet, thus providing that as many as 12 trains may go in one direction should there not be occasion in the meantime to send one in the opposite direction. If there should be less than 12, the last one would take all that is left of the staff including the steel rod. These pieces are all delivered by the trains to the operator at Y, the leaving end of the block. He assembles them again into a single unit and places them in his permissive attachment. This allows the absolute staff to be released; and as soon as it is returned to the absolute machine, an absolute staff may be removed at either end of the block. A train may now move in either direction with an absolute staff

and from *Y* to *X* with the permissive staff. If it is anticipated that another series of trains will move from *X* to *Y*, the first engineman going from *Y* to *X* will use the permissive staff instead of an absolute, for the permissive staff, as a whole, confers the same rights as an absolute staff. The operator at *X* will then be prepared to handle the trains by the permissive system. An engineman having any part of the permissive staff is certain

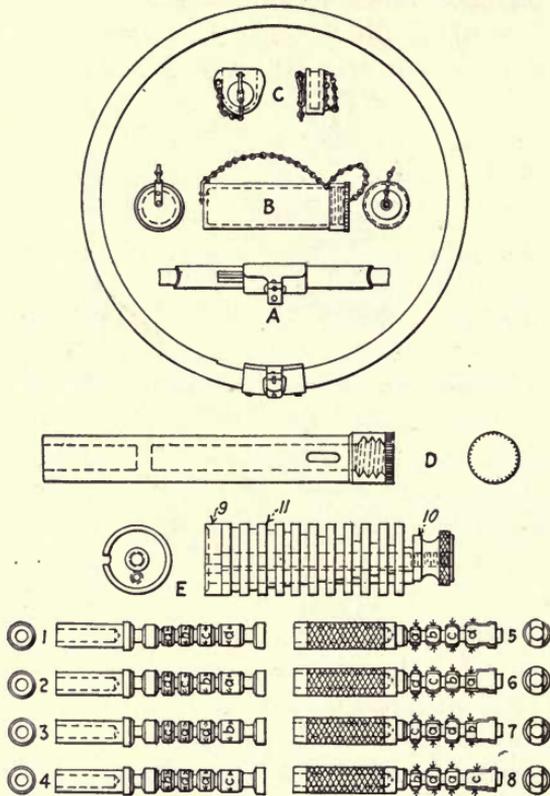


FIG. 211.—Staffs and staff pouches.

that he will not meet a train, but he will expect to find one preceding him unless he has the first tablet, or one following him unless he has the rod and possibly some remaining tablets.

**128. Intermediate Siding and Junction Instruments.**—At sidings between stations a special staff machine may be installed to govern movements of trains that meet there. If there is a train to leave *X* for the siding between *X* and *Y*, the operator at *Y* will unlock the instrument at *X* and allow a staff to be removed. This staff is handed to the engineman and when the train arrives

at the siding the staff is used to unlock the switch. After the train is entirely in the clear on the siding and the switch is locked, the staff is placed in the special staff instrument there, synchronizing the instruments at *X* and *Y*.

If there is a junction point between the two stations *X* and *Y*, a special junction instrument is often installed there when there is not enough traffic on the branch line to warrant a complete station and set of instruments. The movements from the point *X* or *Y* to the junction and into the branch line are made just as are those explained above.

When a train is to leave a branch line or siding for the main line, the crew calls both *X* and *Y*. The operators at these two stations acting together can release a staff in the junction or switch instrument. When this is removed every machine in that block is locked and remains so until the staff is returned to any one of them. After the crew unlocks the switch with this staff, the train pulls out on the main track. The crew locks the switch again and takes the staff to *X* or *Y*, depending upon the direction they are traveling.

**129. Pusher Attachment.**—In order to operate a pusher engine a portion of the distance between *X* and *Y* and let it return to *X*, a special pusher engine instrument is attached to the absolute instrument, Fig. 210. The pusher staff can be released only by a staff from the absolute machine. Both staffs, however, can be removed at one time. In order to proceed from *X* to *Y*, the operator at *X* signals *Y* to release the absolute staff. *X* removes this staff and uses it to unlock the pusher staff. The train takes the absolute staff and the pusher engine the pusher staff. After the pusher engine has gone as far as necessity requires, it returns to *X* while the train goes on to *Y*. Both deliver their staffs, the one at *X* and the other at *Y*. No other staff can be removed from either end of the block until they both are returned. In Fig. 211, numbers 1, 2, 3, and 4 represent absolute staffs and 5, 6, 7, and 8 represent pusher staffs.

## CHAPTER XI

### AUTOMATIC BLOCK SIGNALING ON DOUBLE TRACK

#### GENERAL

**130. Object.**—The purpose of automatic block signaling on double track is to provide automatically by the trains themselves such an interval between trains moving in the same direction over the same route as will secure safety and efficiency in operation. One of the factors that influence the efficiency of a block system is the length of its blocks. The manual and controlled-manual systems, where the length of block varies from 3 to 8 miles, provide for only one train between stations or towers, for there can be only one train in a block at one time. The automatic block system, where the average length of block is practically a mile, is much more effective. It permits a shorter interval between trains and an additional factor of safety. Closing a station or tower at night has the effect of rendering the manual system still more inefficient, but has no effect on the operation of the automatic system. By using automatic block signals, the trains can in many cases, operate without train orders. This tends to eliminate some of the expense of having operators to deliver the orders and of stopping and starting trains to receive them. The same analysis of the cost of starting and stopping trains could be made for automatic signals as for interlocking.

Running trains over a division in a shorter time will not only curtail the overtime wage for train crews, but will also give a more intense service for the train equipment. The same number of engines and cars will handle more business in an equal length of time. The detection of broken rails by means of track circuits is an item of great advantage.

Of the 99,360 miles of block signals installed in the United States up to 1919, 36,600 were automatic. In order to install a system of automatic block signals on single or double track, the road is divided into blocks varying in length from a few hundred feet to a few miles, depending upon the length of trains and the amount of traffic handled. The trains operate these automatic block signals by means of electric current flowing through the rails and through wires running along the right-of-way.

**131. Location of Signals.**—There are several factors that influence the spacing and location of automatic block signals. Whatever the kind of train service the road is giving, the spacing between the home and distant signals should exceed somewhat the maximum braking distance for the highest speed attained in that block. Since it is one of the functions of block signals to expedite train movements, the blocks on roads having dense traffic should necessarily be shorter than on those having light traffic. As trains run faster on down grades than on up grades, the blocks should be longer going down. Trains should be able to cover blocks in about equal spaces of time. Signals should be so placed as not to stop tonnage trains on heavy grades, if possible; for when they stop they will generally experience some difficulty in starting again. In terminals where trains are frequent, but where their movements are slow, the blocks should be shorter than they are in the open country. Signals should stand as near the beginning of curves as practicable in order to give the enginemen a chance to see them as far as possible. It is much easier to see them against an open-sky background than against trees or buildings or the side of an open cut. They should, however, stand in front of bridges, water-tanks, and tunnels and not immediately behind them. A signal near a station should stand beyond the depot where the engineman can see it when he makes the station stop. In such cases he would ordinarily not start his train until the signal should go to the proceed position.

From an article entitled "Automatic Signal Locations," by the late C. C. Rosenberg, and published in Volume II of the *Proceedings* of the Railway Signal Association, the following paragraphs have been selected:

"In making a survey for the installation of automatic signals, one of the greatest problems to be solved is that of location, and in order to get the best results, it is necessary that the subject be given careful study and thorough consideration from every standpoint.

"Signal Engineers and others in charge of signal construction on roads which have automatic signals, find that after signals are placed in service, some are to a great extent of little value owing to poor sight, stalling of trains, etc., and in some instances give confusing indications. In order to correct these, considerable expense is incurred which could to a large extent have been avoided if proper consideration had been given at the time of locating.

"In locating, the following conditions should be considered; the relative relation of the signal to sight, passing sidings, crossovers, interlocking plants, junction points, passenger stations and length of block.

"As all railroads are not fortunate enough to have long tangents, it is often a serious problem to get a good sight for a location on account of obstructions or being placed in a series of short curves; it is often necessary to lengthen or shorten the block in order to get even a fair sight.

"At a passing siding, the signal should be placed back of the fouling point of the outlet switch, so as to protect a train moving from the siding to the main track; while at the same time allow an approaching train on main track to advance one block farther than if placed ahead of the switch. No signal should be placed immediately ahead of an outlet switch, and used as a starting signal; but in order to give a train moving from a passing siding a starting signal, it should be placed at a distance far enough in advance of the outlet that it cannot be mistaken by a train approaching on the main track as its signal. The train moving from the siding to the main track should proceed cautiously and under full control until the next signal is reached. The proper location for a signal at the inlet of a passing siding is within 500 ft. of the switch points, and the next signal in rear should be placed not more than  $\frac{3}{4}$  mile from the switch, preferably less, if it can so be arranged.

"No location should be made immediately in advance of a crossover, but far enough in the rear to protect the same should the location be found to come in the vicinity of such crossover.

"Locating signals on the outside of curves should be avoided as far as possible; but if this is found necessary, then the masts should be high enough to place the signals so that they can be seen from approaching trains over the top of a train passing in the opposite direction, or a train standing on a siding.

"Telegraph pole lines should, wherever practicable, be moved as near the right-of-way as possible so as not to obstruct the sight of signals. All undergrowth and overhanging trees should be kept trimmed, so that a good view can always be obtained.

"In order to give extra protection to trains handling freight and passengers at stations, a signal should be located from one thousand to twelve hundred feet on either side of the station; this will allow an approaching train to advance, and often avoid making a stop at the signal in rear, should a train be standing within station limits.

"The length of block must be determined by traffic and track conditions. Where the traffic is not very heavy and the road bed practically level and not more than 0.5 per cent. grade, 1-mile blocks are considered very good practice. If traffic is congested this distance should be reduced to from  $\frac{1}{2}$  to  $\frac{3}{4}$  mile. On approaching ascending grades over 0.5 per cent., blocks should be gradually shortened until a uniform length

can be maintained; this should be done in order to avoid any unnecessary stops for following trains. On descending grades, blocks can be lengthened to conform to traffic and grade. In territory comparatively level and where traffic is not congested, 1½- to 2-mile blocks can be successfully operated.

“No location of a signal should be made just beyond a sag or apex, as a train obliged to stop at such a signal is likely to break in two in starting.

“Before making a final survey it is well to consult with the engineering and traffic departments relative to track changes, such as changing locations of crossovers and siding switches, and in some cases present sidings may be eliminated, thereby saving considerable expense if these changes can be made before signal work is begun.

“After locations have been made and considered from a signaling standpoint, the transportation department should be consulted, and the ground thoroughly canvassed, so as to determine definitely that the signals as located can be successfully operated from a traffic standpoint. It is also a good plan to get the views of competent enginemen as to locations, and ascertain from them if any are in localities liable to cause trouble.

“In some foreign countries, the practice of locating signals for sight, is to use a full-sized templet of a mast and blade and send out a locating party. After a sight has been selected, the templet is placed in position and viewed from an approaching train. If not seen to a good advantage, the templet is moved from place to place until the best sight is obtained; this accomplished for day signals, the same process is followed at night, except that a light is placed on the mast instead of the blade. Very frequently, in making both night and day tests, it is found that the location which gives the best sight for a day signal may not answer for a night signal, which necessitates the selection of a new location. While this method may at first glance seem to be unnecessary, it is certainly well worth considering.”

**132. Two-position Semaphore Signaling.**—Where the blocks are rather long, the home and distant signal arms are sometimes

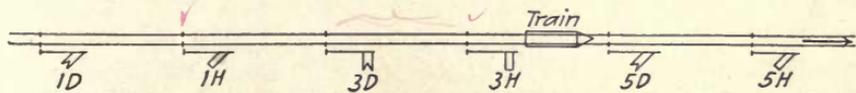


FIG. 212.—One-arm two-position signals.

mounted on separate posts, as shown in Fig. 212. These signals give only two indications, stop or caution, and proceed. The home signal stands at the beginning of the block and governs movements into the block. The distant signal, serving purely a

cautionary function, stands from 2,000 to 4,000 ft. in the rear and simply repeats the indications of the home signal. The train has caused the home signal 3H, to go to the stop position, and it, in turn, has caused distant signal 3D to remain in the caution position. Both signals will keep these positions until the train

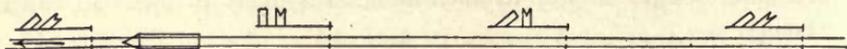


FIG. 213.—Two-arm two-position signals.

passes the next home signal, when they will both go to the proceed position again.

Where the blocks are shortened, the home and distant signals are usually placed on one mast, as shown in Fig. 213. In this case, the home signal governs not only the first distant signal in the rear, but also the one on its own mast. In the case of a four-

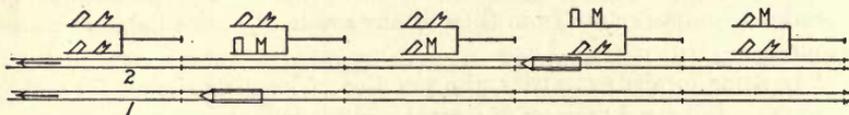


FIG. 214.—Two-position bracket post signals on a four track line.

track line, the signals are frequently mounted on the bracket type of post in a manner such as is indicated in Fig. 214. The inner signals govern track No. 1 and the outer ones track No. 2.

**133. Three-position Signaling.**—The three-position signal is a step in advance of the two-position, for it combines the home and distant signal in one, thereby saving about half of the posts,

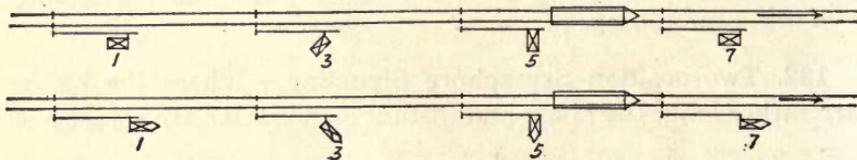


FIG. 215.—Three-position lower and upper quadrant signals.

motors, and lights. This reduces not only the rather serious first cost in the matter of construction, but also the heavy expense of maintenance. The 45-degree position signal 3, Fig. 215, indicates that there is a train in the block immediately in front of the one it governs, and warns enginemen to be prepared to stop when they reach the beginning of that block.

**134. Overlap Systems.**—As a measure of protection an overlap system was devised whereby a signal did not go to clear until the train had advanced a certain distance beyond the next home signal, the idea being to keep one full block and a portion of another between two trains going in the same direction. In Fig. 216 a train in section *A* of block 3 holds the home and distant

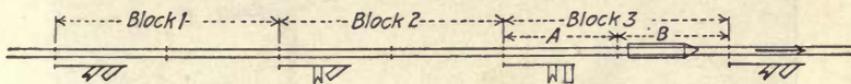


FIG. 216.—Partial block overlap.

signals at the beginning of block 2 in the stop and caution positions, but when it passes from section *A* into section *B* it allows the home signal to go to the proceed position.

This system is often criticised on the ground that as there are times when there are two home signals standing in the stop position between one train and another one following it as closely as

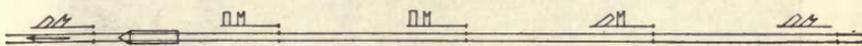


FIG. 217.—Full block overlap.

the signals will permit, the enginemen may on some occasions be inclined to pass one of these signals at high speed.

In some cases where the blocks are short, as in the New York Subway, a full block overlap has been provided in order to secure additional protection. In this case two full blocks are between two trains going in the same direction, as indicated in Fig. 217.

**135. Absolute and Permissive Signaling on Double Track.**—The common practice in double-track automatic block signaling on many roads is for a train to stop at a home signal that shows a stop indication, then after waiting one minute proceed at such a low speed as to be able to stop at any time. The stop indication may be due not to a train in the block, but to a break in the rail or to an obstruction on the track or to some failure of the signal apparatus; and if there should not be some method of procedure in such instances, traffic would be seriously delayed. Some roads require that a flagman proceed the train into the block in such cases to warn it of the danger. This plan of allowing one train to follow another into a block without receiving the proper indication from the home signal to do so is called permissive signaling. Many roads distinguish between absolute (stop and stay) and

permissive (stop and proceed) signals by making the blades of the absolute home signals with square ends and those of the permissive with pointed ends, as shown in Fig. 218 and Fig. 219.

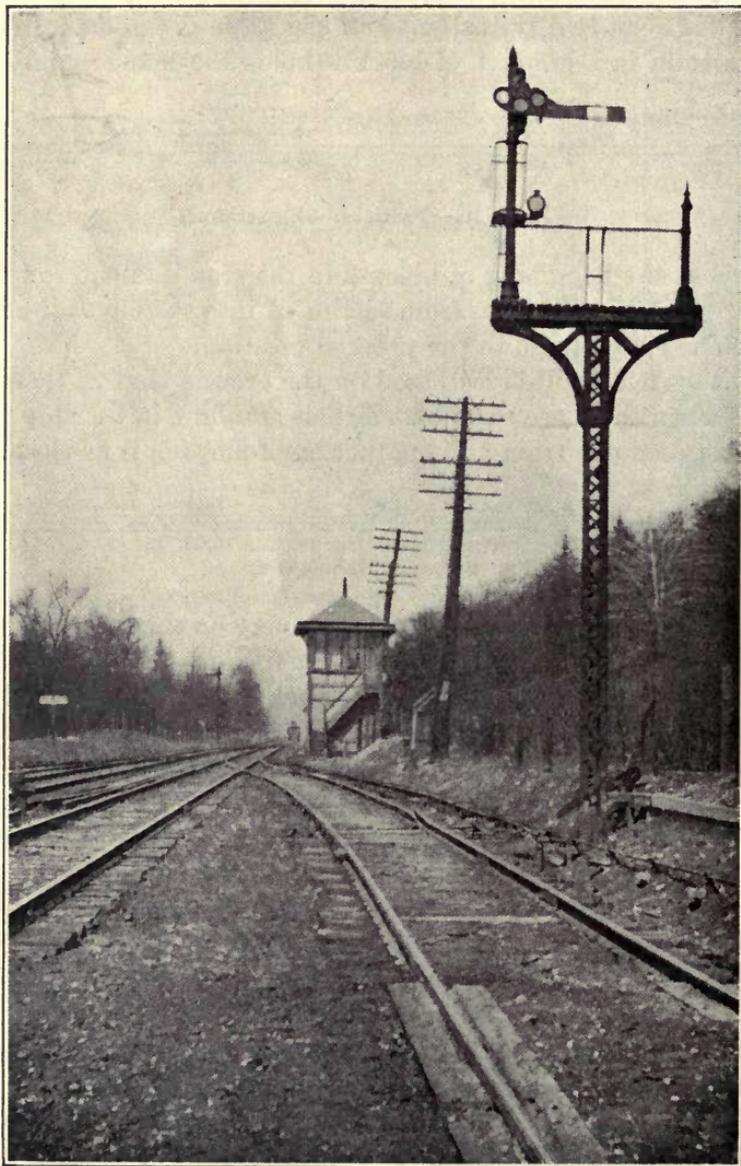


FIG. 218.—Absolute signal. (*Hall Switch and Signal Co.*)

The night indications as to whether a signal is absolute or permissive is shown by the position of the lamp, called a marker,

fastened to the signal post some distance below the signal lamp. A marker placed directly below the signal lamp, on the same side of the post, indicates an absolute signal; and on the opposite side



FIG. 219.—Permissive signal. (Hall Switch and Signal Co.)

of the post, a permissive signal. A marker may be either a red or a yellow light. All home signals at interlocking plants are absolute.

**136. Three-block Indication Scheme.**—Some roads have adopted the idea of using two-arm signals for giving information to trains as outlined in Fig. 220. The blades are made with pointed ends and operate in the upper quadrant. In the case of the upper blade, the signal light is on the right-hand side of side of

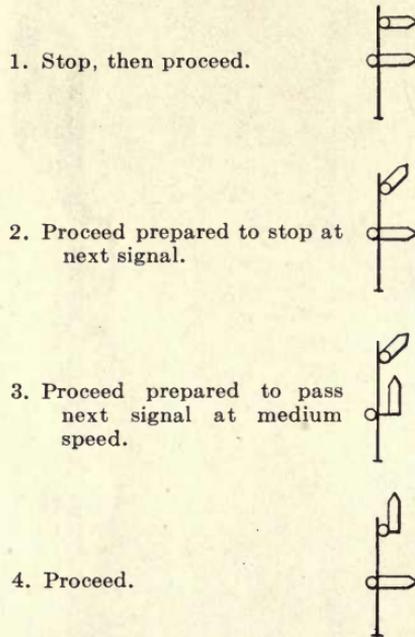


FIG. 220.—Three-block indication scheme.

the post and in the case of the lower one, on the left-hand side to act as a permissive marker. This combination of signals affords a much wider range of indications, the same really as would be displayed by a four-position signal, and is used to give indications for three blocks instead of two, as is ordinarily done in

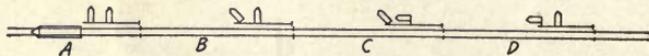


FIG. 221.—Three-block indications.

practice. A train in block A will cause the signal to display indications as shown in Fig. 221.

**137. Numbering Automatic Signal Posts.**—All automatic signal posts should be numbered, the even numbers governing trains going in one direction and the odd numbers those in the opposite

direction. There are two ways of designating them, one is to number them consecutively through the mile, and the other to use the nearest even or odd tenth of mile in addition to the mile-post number. By the first method, the signals running in one direction between mile posts 264 and 265 would be 2642, 2644, and so on if there should be more than two; and in the other direction 2641, 2643, and so on. By the other method the numbers would be, for example, 2646 for trains in one direction and 2649 for those in the other, depending upon the particular location that the signals should occupy in that mile. Branch lines may be numbered by a prefix letter, as *X*2641 and *X*2643. Figure 219 shows the method of numbering main line posts. Interlocking signals do not bear numbers except the distant signal used in connection with three-position automatic block signals.

## CHAPTER XII

### AUTOMATIC BLOCK SIGNALING ON DOUBLE TRACK DIRECT-CURRENT TRACK CIRCUITS

#### NORMAL CLEAR SIGNALS

**138. Two-position Signal Circuits.**—Figure 222 shows the wiring for two-position signals on double track where the home and distant signals are on separate posts. The home signal has a very simple motor control circuit. The distant signal is controlled by the front contact of a neutral relay for a train in its immediate section, and by a line relay and circuit breaker operated by the home signal for a train in the home signal section. A train in block *C* will deenergize its relay and cause signal *H-3* to go to the stop position. The circuit breaker *C-3* will then be opened, breaking the circuit to *S-3*, dropping its armature and allowing

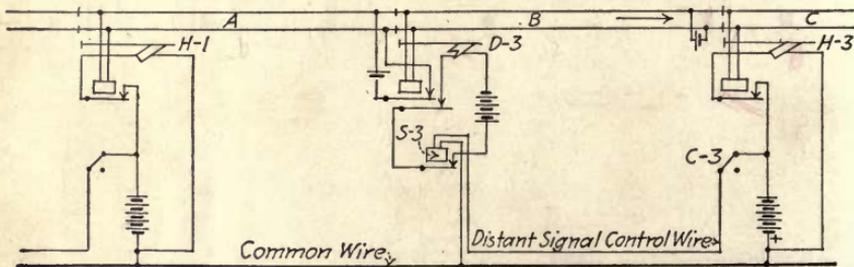


FIG. 222.—Wiring diagram for one-arm two-position signals.

*D-3* to go to the caution position. By means of the cut section, signal *H-1* will remain in the stop position while the train is in section *B*.

Figure 223 shows a series of two position automatic block signals on double track where the home and distant signals are on the same post. The home signal governs the distant signal on the same post, and also the one in the rear by means of circuit breakers. A train in block *C* shunts its track relay allowing the home and distant signals 5 to go to the stop and caution positions. As there is no train in block *B*, home signal 3 goes to the proceed position, but distant signal 3 remains in the caution position

held there by the circuit breaker *C-5*. The circuit that energizes *S-3*, the control relay of distant signal 3, is from battery, through second contact of track relay 5, circuit breaker *C-5*, relay *S-3*, and common return to battery. When this circuit is broken by circuit breaker *C-5*, the relay *S-3* is deenergized breaking the front

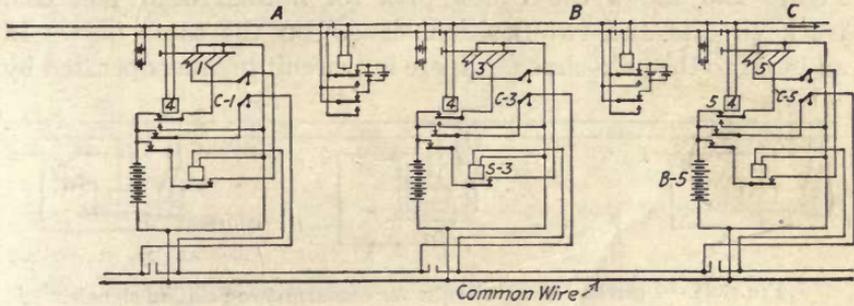


FIG. 223.—Two-arm two-position signal circuits.

contact to the distant signal 3. Both signals in block A are clear because the circuit breaker *C-3* is closed.

Figure 224 represents a wiring diagram for two-arm two-position signals prepared by Committee IV of the Railway Signal Association and printed in the 1910 issue of the *Proceedings*.<sup>1</sup>

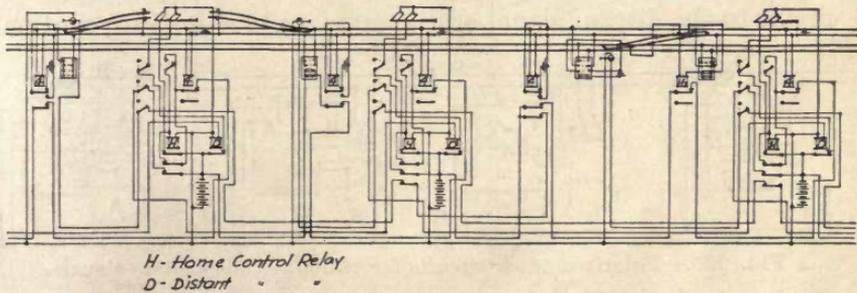


FIG. 224.—R. S. A. circuits for two-arm two-position signals. (Plan No. 1076A, page 367, *Proceedings* 1910.)

**139. Two-position Polarized Track Circuits.**—Figure 225 shows the plan for polarized track circuits for two-position signals where the home and distant signals are on separate posts. A train in block C will drop the armature and break the circuit to home signal 3. As it goes from the clear to the stop position, it shifts the pole changer, which in turn changes the direction of the track current in section B. This repels the polarized armature *P*

<sup>1</sup> Page 367.

and breaks the circuit to distant signal 2 allowing it to remain in the caution position. As home signal 1 is controlled only by a neutral relay, it will take the proceed position. This plan is used only where the traffic is light and the blocks are long, too long for a distant signal to be a full block from its governing home signal. Figure 226 shows the Union plan for normal clear polarized track circuits and two-position signals on the same post. In addition to the pole-changer, there is a circuit breaker operated by

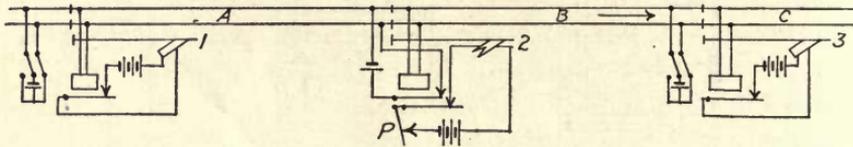


FIG. 225.—Polarized track circuits for one-arm two-position signals.

each home signal. The home signal is connected directly in circuit with the battery and neutral contact of the relay. The distant signal is in circuit with the battery and neutral contact of the neutral relay and also with the polarized contact of the relay. The distant signal is thus controlled entirely by the home signal. Whenever a train enters a block it shunts the relay and allows the home signal to go to stop, thereby breaking the circuit to the distant signal on the same post setting it to caution.

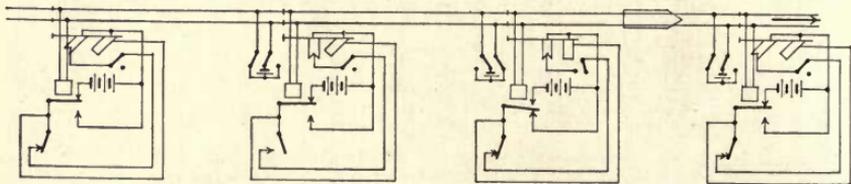


FIG. 226.—Polarized track circuits for two-arm two-position signals.

When the home signal is horizontal, it manipulates the pole-changer so as to send the current in one direction; when it is in the proceed position it causes the current to flow in the opposite direction. When the home signal goes to the proceed position the circuit is made through the polarized armature in the rear and the distant signal there goes to clear.

In the sketch, the train is deenergizing the first track relay in the rear and holding the signal in the stop position. In order that the home signal may not momentarily tend to drop the stop position while the pole-changer breaks the track circuit, shifting

from one contact to the other, a slow releasing magnet is frequently employed.

Figure 227 represents typical circuits for two-arm two-position polarized track circuits, while Fig.-228 represents typical circuits for two-arm two-position polarized line circuits.<sup>1</sup>

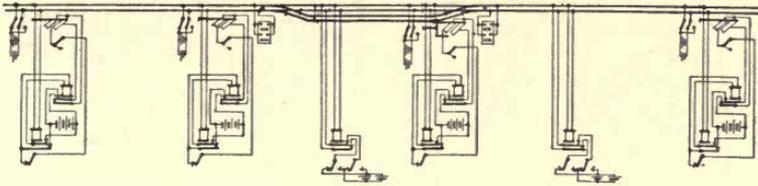


FIG. 227.—R. S. A. two-arm two-position signals, polarized track circuits. (Plan No. 1077A, Page 368, Proceedings 1910.)

**140. Three-position Signal Circuits.**—A sketch of the General Railway Signal wiring plan for three-position signals is shown in Fig. 229. The 45-degree position of signal 1 is controlled by a circuit through its local battery, third and fourth contacts of the track relay, and the common return. The 90-degree position is controlled by the circuit breaker and the battery of the signal in advance. If the block that is governed by signal 3 is occupied

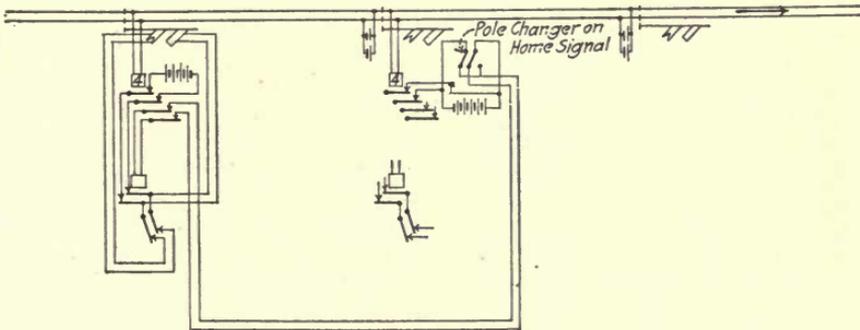


FIG. 228.—R. S. A. diagram for two-arm two-position signals. Polarized line circuits. (Plan 1078A, page 369, Proceedings 1910.)

by a train, its relay is deenergized and signal 3 goes to the stop position. As the block that is governed by signal 1 is not occupied, its relay becomes energized and signal 1 goes to the 45-degree position. As the train moves one block to the right, signal 3 goes to the 45-degree position and signal 1 goes to the 90-degree position because the 90-degree relay at signal 1 becomes energized from the battery at signal 3.

<sup>1</sup> Proceedings Railway Signal Association, pages 368 and 369, Volume 1910.

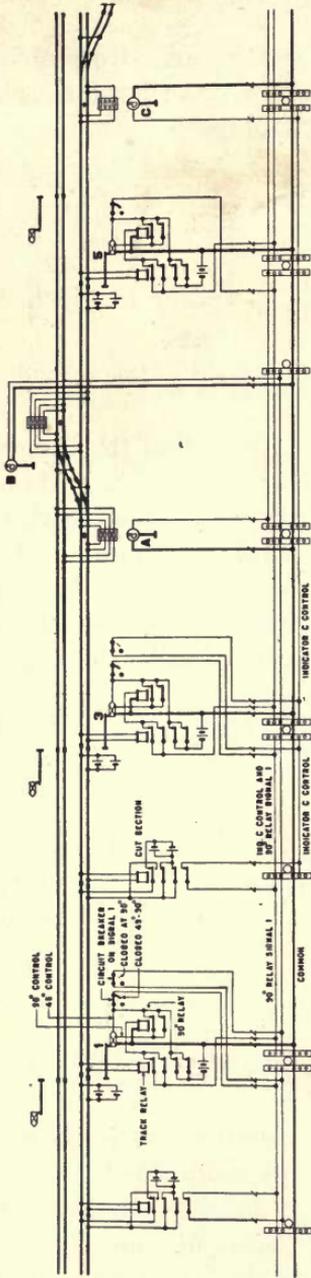


Fig. 229.—Wiring plan for three-position signals.

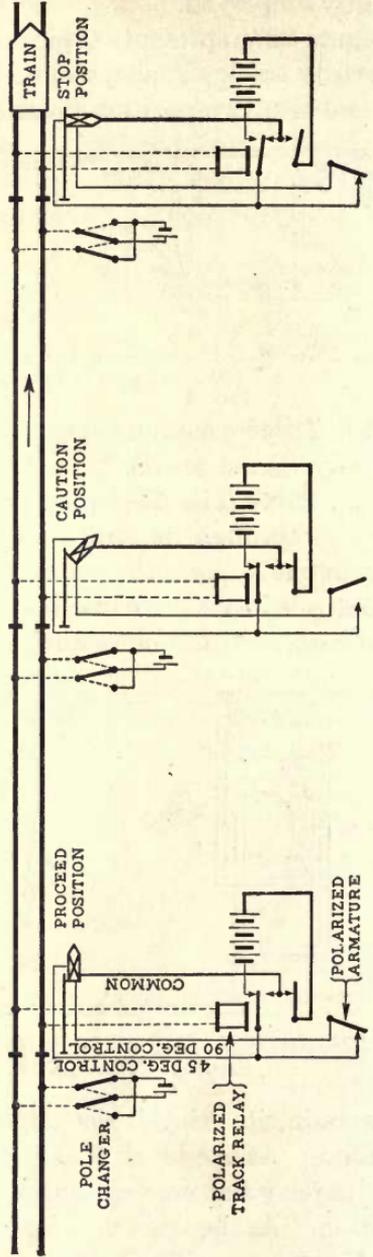


Fig. 230.—Polarized track circuits for three-position signals.

**141. Three-position Polarized Track Circuits.**—Figure 230 shows the Union design for a three-position signal system operated by polarized track circuits. The 45-degree position is controlled by the neutral contacts and the 90-degree position by the polarized contacts.

**NORMAL DANGER SIGNALS**

**142. Two-position Signal Circuits.**—Normal danger signals are those that stand normally at stop when the track is not occupied, but which go to the proceed position upon the approach of a train. They assume the stop position again as soon as the train enters the block they govern.

Figure 231 is plan 1,079A printed in the 1910 issue of the *Proceedings* of the Railway Signal Association, with some additional lettering to aid in explanation, and represents a two-arm two-position normal danger system. When a train enters the last section of block A, distant signal 3 and home signal 5 go to clear provided there is no train in either block B or C. The circuit for clearing these two signals is battery at signal 7, second contact of relay C-5, first contact relay T-5, relay H, relay A, middle circuit breaker at signal 3 closed by home signal 3 cleared, relay D, back

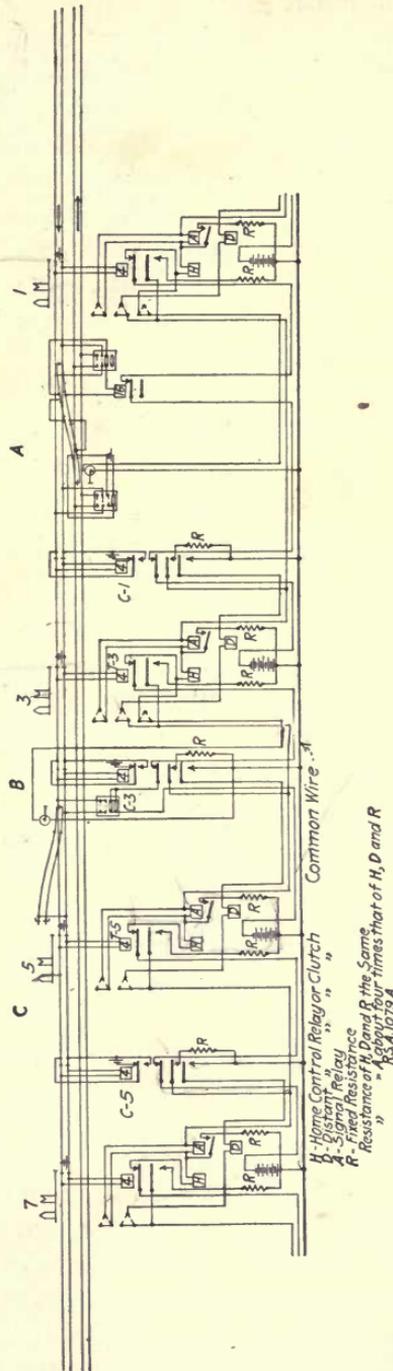


FIG. 231.—R. S. A. circuits for two-arm two-position normal danger signals. (Plan 1079A, page 370, *Proceedings* 1910.)

side fourth contact on relay *C-1*, and common return to battery at signal 7.

When the train enters block *B*, the home signal 3 goes to stop because the circuit is broken by the track relay. This, in turn, opens the middle circuit breaker operated by home signal 3 and allows the distant signal 3 to go to caution. Home signal 5 remains at clear, for the current has another route through the back side of the third contact of relay *C-3* and through the resistance to the common wire. Home signal 7 and distant signal 5 go to clear when the train enters the last section of block *B*.

The function of relay *A* is to allow relay *H* to pick up first, clearing home signal 5 before relay *D* can pick up to clear the distant arm of signal 3.

### SWITCH, CURVE, AND SIDING PROTECTION

**143. Switch Indicators.**—When the movements of a train are controlled by automatic block signals, switch indicators, as shown in Fig. 167, are usually provided at the switches, especially those in outlying districts. The indications may be either visible or audible, and are to inform a switchman whether or not a train is approaching, so that he can be governed intelligently concerning the opening of the switch. Visible signals are either miniature discs or semaphore arms actuated by electro-magnets energized by line wire circuits that extend through at least two full blocks in the rear of the switch. These wires are connected through the normally closed contacts of all the track relays or home signal arms in those two blocks so that the approach of a train will break the circuit and allow the indicator to come to stop. Thus the switchmen receive a warning that a train is immediately approaching and will not open the switch until the train has passed. The indicator is enclosed in an iron case with a glass front, and is placed in such a position near the switch stand that it can be easily seen by switchmen.

The audible warning is given by a bell placed in the immediate vicinity of the switch. The wiring for the bells is practically the same as it is for the visible indicators. In either case the wiring should extend back far enough so that the warning should occur, at least, by the time the train approaches the distant signal controlled by the first home signal in the rear of the switch.

144. **Switch Box.**—Located at each switch in a track with automatic block signals is a switch circuit controller, Fig. 232, so

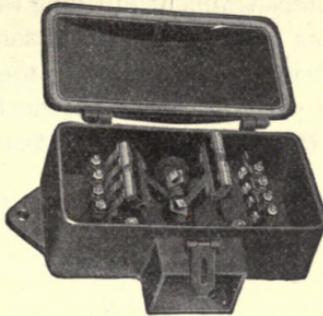


FIG. 232.—Switch circuit controller.

connected to the switch points by a rod that when the switch is open the circuit through the switch box is closed. They are

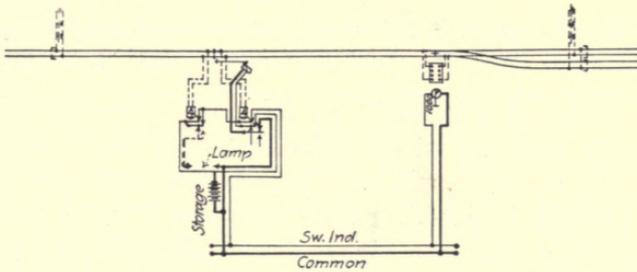


FIG. 233.—R. S. A. circuits for protection of facing switches. (Plan 1312.)

generally made with four contacts not all of which may be used at one time. The switch box is usually arranged to shunt the track

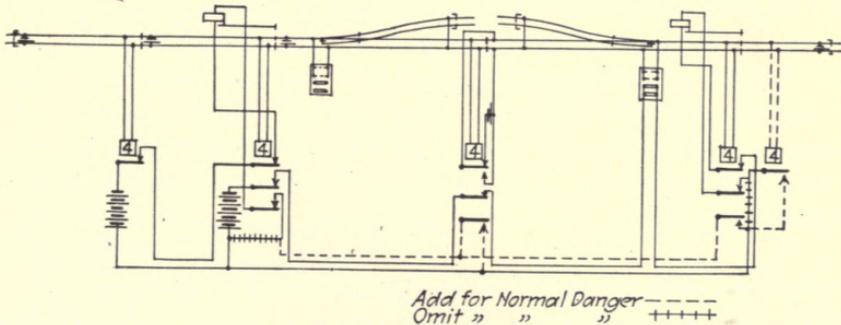


FIG. 234.—R. S. A. design for protecting obscure curves and switches. (Plan 1075A, page 366, Proceedings 1910.)

circuit, although sometimes it is placed in the circuit that controls, at least, the first home signal in the rear, so that when the switch is open the home signal will give the stop indication.

**145. Signals for Outlying Switches and Obscure Curves.**—Where the automatic block system is not in use, signals are sometimes installed to protect trains at outlying facing point switches and on obscure curves where the view is somewhat obstructed. In the case of the switch, the signal may be mechanically operated by wires connected directly to the switch mechanism or it may be operated by power, the Railway Signal Association diagram of

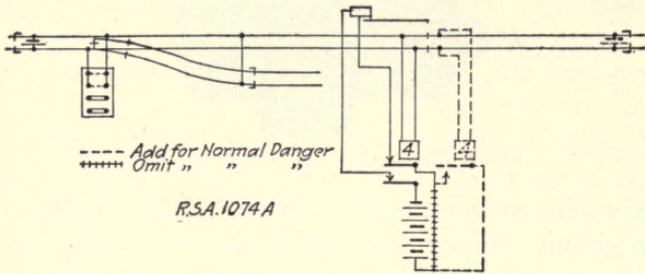


FIG. 235.—R. S. A. normal clear circuits for trailing switch and curve protection. Traffic in one direction. (Plan 1074A, page 365, *Proceedings* 1910.)

which is shown in Fig. 233. In this plan there are two block sections with independent track circuits, either one of which when occupied by a train will set the switch indicator to stop. When the switch is opened, or when the block in which it is located is occupied by a train, the signal will be placed in the stop position automatically. Figure 234 represents the Railway Signal Association circuit plan for protecting obscure curves and sidings.

## CHAPTER XIII

### AUTOMATIC BLOCK SIGNALING ON DOUBLE TRACK

#### ALTERNATING CURRENT

**146. Introductory.**—Alternating current is used for signaling purposes on electric lines whether the propulsion current be direct current or alternating. In the case of direct-current propulsion any commercial frequency of cycles may be used for the signal current, but in the case where alternating-current propulsion is used, the two cycles must be different. The signaling current is entirely independent of the propulsion current. It is obtained from a substation, is carried along the right-of-way on a separate set of poles, and has its voltage stepped down by means of transformers. As it is used for operating both track circuits and signals, it has the advantage of eliminating the expense of batteries, and of battery wells and battery chutes. It serves to avoid, also, the difficulties that arise from foreign currents carried by the rails. To a certain extent it eliminates the cut section so commonly used in direct-current signaling, for in many cases the track circuit can be made as long as the block. The current can be used, also, for lighting the signals, switches, stations and other buildings along the line. Furthermore, there is not so much chance of signal failure in unfavorable weather because of the greater amount of power available for such purposes. It does require, however, a constant generation of current and the additional set of poles for transmission. Should the transmission line fail at any place, that part of the system would go out of service that should lie beyond the point of failure unless power should be supplied from some other source. The first cost of installing alternating-current equipment is generally heavier than that for direct current.

On account of fewer complications in line construction, single-phase transmission is generally used in preference to three-phase where the current is not too heavy or the length of line too great. Voltages of 1,100, 2,200, 3,300, and 4,400 are being transmitted for signaling purposes. The higher the voltage the less copper necessary for the transmission service; but at the same time, the

high-voltage current requires more expensive auxiliary equipment, such as transformers and lightning arresters. Single-phase current also eliminates the difficulties that arise from an unequal distribution of the current in the three wires in the case of three-phase transmission.<sup>1</sup>

### SINGLE-RAIL RETURN<sup>2</sup>

**147. Direct-current Propulsion.**—There are two systems in practice where electricity is used for propulsion and where alternating current is used for signaling, the single-rail return and the double-rail return. The single-rail return can be used only where the return propulsion current is light enough to be carried by one rail and where it is not necessary to guard against broken rails, as in yards where train movements are slow. The double-rail

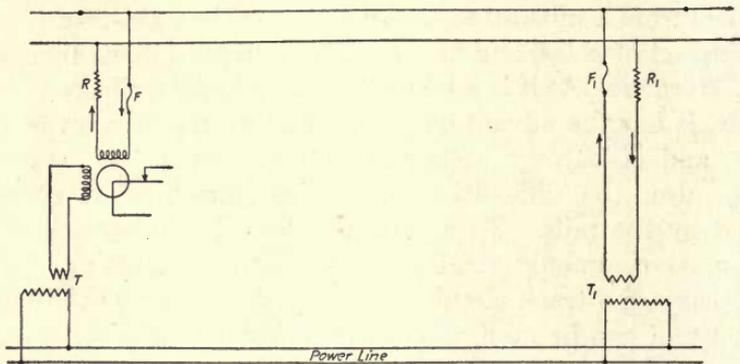


FIG. 236.—Single-rail return system.

return requires more track equipment, which makes that system less desirable in yards and busy terminals. In the single-rail return system one rail is divided into blocks, as shown in Fig. 236, to operate the signal, and the other is left intact to act as a return for the propulsion current. It also serves to complete the track circuit.

In practice when the block is not occupied or when the train is in the middle of the block almost all of the return propulsion current flows through the one rail and there is a drop in the potential between the two rails at each end of the block depending upon the amount of resistance inserted at each place, the resistance of

<sup>1</sup> Page 90, *Proceedings Railway Signal Association*, 1917.

<sup>2</sup> From a paper by W. K. HOWE, *Proceedings, Railway Signal Association*, Page 130, 1909.

the rail and the amount of propulsion current in the continuous rail. When the train is entering or leaving the block, there is a tendency for a greater portion of the propulsion current to go through the block rail. In the first case, when the block is not occupied, there would be a tendency for some of the current to flow from the return rail through the relay at one end of the block and through the block rail to the secondary coils of the track transformer at the other end and to the return rail again. In the second case there would be the tendency for a greater portion of the propulsion current to go through the track transformer when the train enters the block and to flow through the relay when it leaves the block. This would magnetize the iron of the

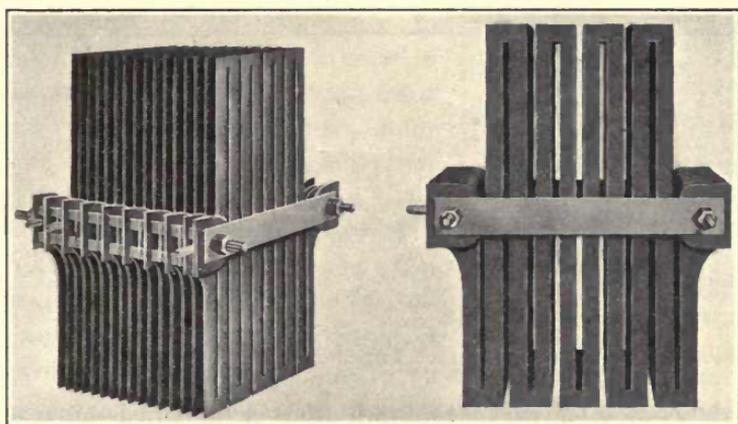


FIG. 237.—Cast iron resistance grid.

relay and transformers to such an extent as to interfere with the operation of the signal current. To eliminate this element of interference, two non-inductive resistances  $R$  and  $R_1$  are inserted in the track circuit, the one at the relay and the other at the track transformer. Where the blocks are only 200 or 300 ft. long and the current is comparatively light, tube resistances are sufficient, but where the blocks are 800 or 900 ft. long and the current correspondingly heavy, cast-iron grids, such as shown in Fig. 237, are employed. These resistances are high and the voltage of the track current will need to be proportionally high to drive the current through them. This will lead to a considerable waste of current by leakage between the two rails with a corresponding drop in voltage varying with the initial voltage, length of block, and the ballast and track conditions. This

type of construction can be used economically only in cases where the difference in the pressure of the propulsion current in the continuous rail at the two ends of the block does not exceed 15 volts. Such a drop would be equivalent to that from a current of 1,500 amp. in 1,000 ft. of ordinary 80-lb. rail. If the difference exceeds this amount  $R$  and  $R_1$  would have to be increased with a corresponding increase in initial voltage and greater loss of alternating current.

If this resistance is not sufficient, a low ohmic resistance impedance coil,  $x$ , is placed in multiple with the relay and a cast-iron grid for a non-inductive resistance in series with both the relay and the track transformer as illustrated in Fig. 238. The

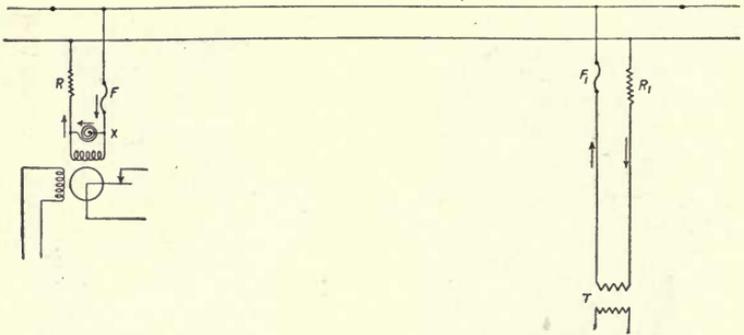


FIG. 238.—Single-rail return. Impedance coil shunting relay.

impedance coil shown in Fig. 239 offers a high resistance to the alternating current, but a low resistance to the propulsion direct current. The shunting of the relay and the peculiar construction of the track transformer allow a much heavier propulsion current to flow without injuring the relay and the track transformer. This permits of greater drop of voltage of the propulsion current in the continuous rail, allowing longer blocks and heavier currents than is possible to use with the other type.

As a further measure of resistance to the flow of the direct current through the track circuit line, an air gap is provided in both the impedance coil and the track transformer. The resistance in the track transformer circuit tends to reduce the flow of alternating current when the block is occupied by a train. Fuses are provided to protect the equipment should a short circuit occur between the block and continuous rails as when tools are laid across the track. In double track, the two continuous rails can be cross bonded as frequently as seems desirable.

The plan indicated in Fig. 238 has the advantage that since only a small amount of current flows through the relay and transformer, the wires permit the relay and transformer to be located in the tower at interlocking plants without very much additional expense. This avoids the necessity of having a secondary relay in those cases where the track circuit must be repeated into the tower and allows one large transformer to serve all track relays and track circuits. Since the resistance of  $R$  and  $R_1$  are relatively small, their cost is proportionally decreased, and their size permits of their being mounted in a comparatively small space.

On account of the difference in potential between the two ends of the block, the single-rail return finds its best service in short blocks, as for example, the New York Subway, where the average length is a little more than 800 ft. In the operation of this Subway, the transmission lines carry a 60-cycle current of 500 volts potential. The current is stepped to 50 volts for signal lights and to 10 volts for the track circuit. The non-inductive resistance at each end of the block accounts for about 2 or  $2\frac{1}{2}$  volts so that the current at the single-phase relay is practically 5 volts. The grid resistance between the transformer and the block rail and between the relay and the block rail is 1 ohm.

The single-rail system is suitable, also, for short blocks through interlocking plants where the track layouts are somewhat complicated. As only one rail is divided, the track circuit installation becomes much simpler requiring less expenditure in the first cost of construction and less expense for maintenance.

**148. Impedance Coil.**—Direct current will have no effect on the alternating-current relay except to further magnetize the core. Up to a certain point this is not detrimental, and beyond that it is taken care of by inserting the impedance coil, Fig. 239, in multiple with the relay. The iron core of the impedance coil is made with an air gap so that the extra magnetization does not take effect until the direct current reaches a value of 20 amps.

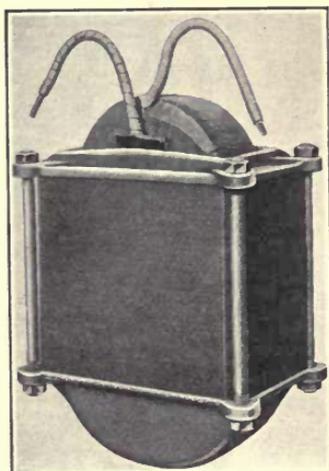


FIG. 239.—Impedance coil.

**149. Track Transformer.**—The track transformer, shown in Fig. 240, is of the open magnetic circuit type designed for use on roads having direct-current propulsion with single-rail return. Most of these transformers have secondary coils for supplying both track and light circuits.

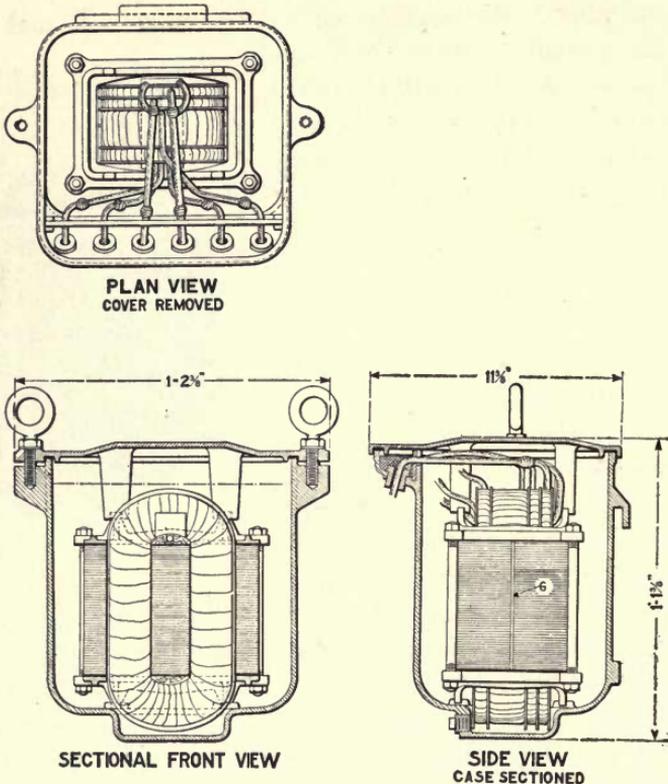


FIG. 240.—Transformer. Open magnetic circuit type.

#### DOUBLE-RAIL RETURN

**150. Direct-current Propulsion.**<sup>1</sup>—Whenever the propulsion current is heavy enough to require both rails to carry the return current, the double-rail return system is employed as illustrated in Figs. 241 to 243, inclusive. Either direct or alternating current may be utilized for propulsion. In order that there may be no conflict between the direct current used for propulsion and the alternating current used for signaling, impedance bonds either with or without iron cores are installed to connect the two rails

<sup>1</sup> *Proceedings*, Railway Signal Association, Page 130, 1909.

at each end of the block. Those with iron cores are shown in Figs. 241 and 242, while those without the core are represented by Fig. 243. These bonds have practically no effect on the direct current, but offer an impedance to the flow of the alternating current. Thus the track is continuous for the propulsion

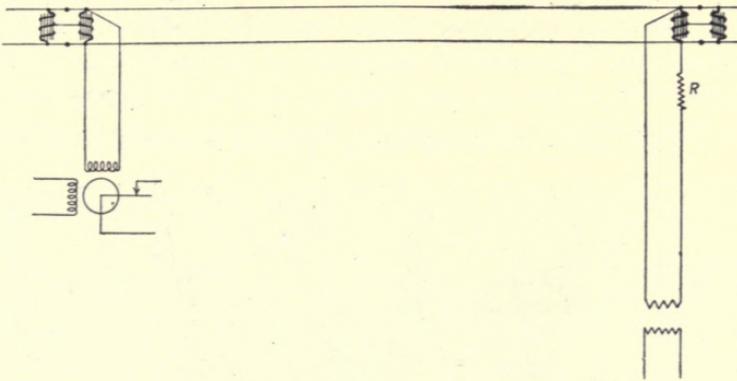


FIG. 241.—Double-rail return system.

current, but divided into blocks for the signaling current. The signaling current may be fed into the end of the block or into the center of the block, in which case they are known as “end-fed” or “center-fed.” Figures 241 and 243 are end fed, while Fig. 242 is center-fed.

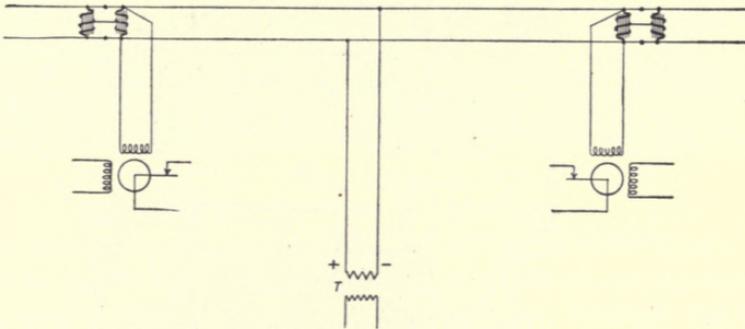


FIG. 242.—Double-rail return. Center-fed.

The iron impedance bond, Fig. 244, is made of six or eight turns of large carrying capacity strap copper, wound around a laminated core of iron, but insulated from the core. The coils of two adjacent blocks are connected by a copper cable tapped into the center of each coil as shown in Fig. 241. The coils and core

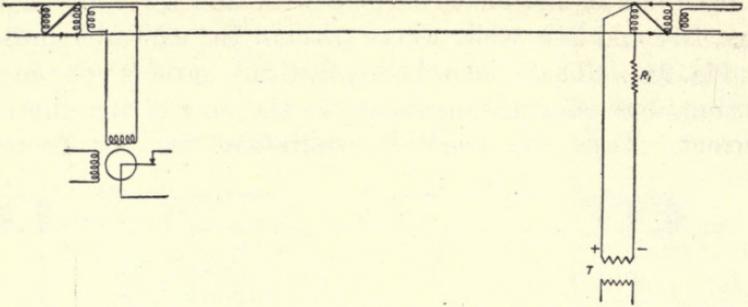


FIG. 243.—Double-rail return. Ironless impedance bonds.

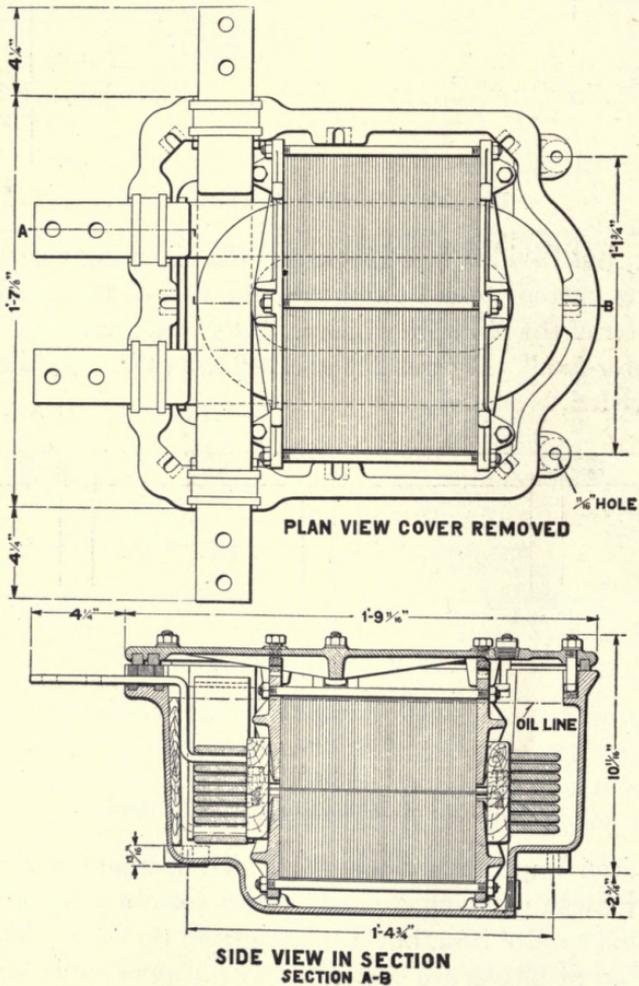


FIG. 244.—Impedance bond.

are enclosed in an iron box placed usually between the rails of the track.

As the propulsion current flows into the center of the impedance bond, and through the two halves of the coil in the opposite direction, there should be, theoretically, the same amount of return current in each rail with no magnetic effect on the cores of the bonds. With the same return current in each rail, there should be no difference in potential between the two rails at either end of the block and no direct current should flow through the relay and track transformer; consequently, there would need

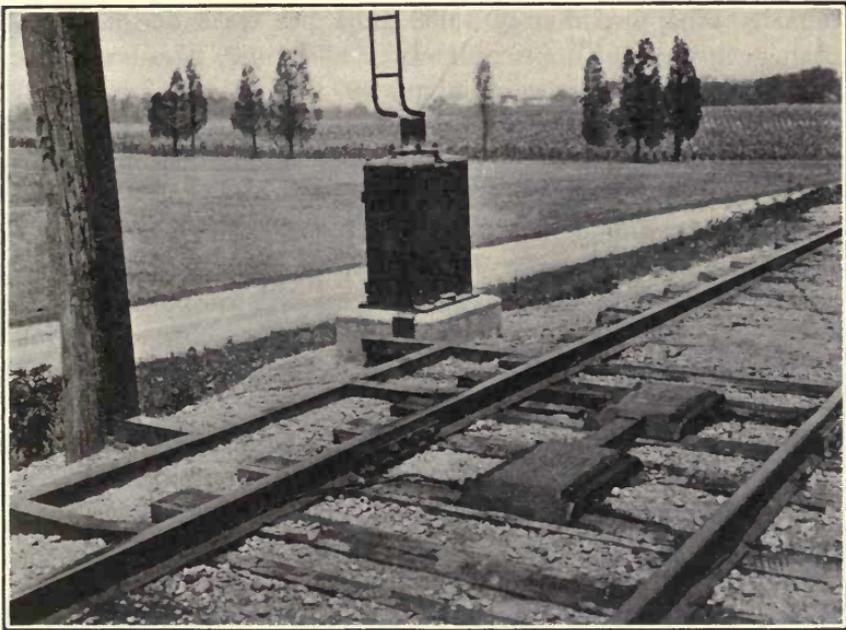


FIG. 245.—Impedance bonds in place.

to be no resistance grids nor shunt coil to protect them. In practice, however, on account of faulty bonds at rail joints, the same amount of return current does not flow through the two rails and the two halves of the coil; and this tends to magnetize or unbalance the core, reduce the resistance to alternating current, and divert more of the signal current from the relay. To eliminate this shunting of the relay, the impedance bonds are made with an air gap in the core so as to reduce the magnetizing effect and the consequent unbalancing. The track transformer is not, however, provided with an air gap as it was in the single-

rail return type. It is best in designing these bonds to provide for an unbalancing of 20 per cent.; that is, to figure that the difference in the amount of the current between the two rails may be as much as 20 per cent. of the total carried by both.

The coils used in the Hudson Tubes are 750,000 circular mil copper with a resistance of 0.00073 ohm per pair for the direct current. They have a continuous-current capacity of approximately 1,300 amp. per track and an unbalancing capacity of approximately 500 amp. Those used on the New York Central are 1,250,000 circular mil copper with a resistance of 0.00014 ohm per pair for the direct current. They have a continuous-current capacity of approximately 4,000 amp. per track and an unbalancing capacity of approximately 1,000 amp. The bonds used in the Hudson Tubes weigh about 950 lb. and on the New York Central about 1,500 lb. per pair when filled with oil.

When the alternating current flows through an impedance bond, it encounters a much higher resistance than direct current does. For example, in the case of the New York Central, while the ohmic resistance of the copper to the propulsion current is only 0.00028 ohm between the two rails at both ends, the resistance to the 25-cycle signal current is 0.06 ohm, or approximately 200 times greater, and is explained in the following manner:

A current through a coil, especially that of an electro-magnet, produces a magnetic field that sets up a counter electro-motive force in the coil itself. This opposes the voltage and interferes with the building up of the current. In the case of alternating current, there is no chance to build up a strong magnetic field because of such frequent change in direction of the current. The greater the number of turns in the coil and the greater the amount of iron in the core, the greater is this resistance of impedance. The impedance increases also with cycle frequency. A bond that would have an impedance of 0.06 ohm at 25 cycles would have an impedance of 0.14 ohm at 60 cycles.

End-fed track circuits may be installed in blocks up to 2,000 ft. long where 100-lb. rails are used in the track with 0.06 ohm impedance bonds connecting them. Beyond this length center-fed tracks circuits may be employed with the same rail and bonds in blocks up to 6,000 ft., if cross-bonding conditions will permit. The center-fed type requires no resistance at the track transformer, while the end-fed frequently does. It does require, however, an extra relay with its transformer at each end of the

block and a great deal of extra wiring to connect the signals with the two sets of relays. This type of bonding and signaling finds its best service where traffic is heavy requiring more return current than one rail can carry and where the blocks are average length or longer. Cross bonding between tracks can be done only at the ends of the blocks. On account of the size of the housing for the bonds and the size of the cables, the equipment is not very suitable for terminals and other complicated track construction.

The ironless impedance bonds, shown in Fig. 243, consist simply of a much greater number of turns of heavy copper wire without the enclosed iron core. The cost of the copper becomes such a factor in this case that it is practical to use this system only where the current is light enough to permit a smaller wire. Resistance is inserted in the track circuit at the transformer, and the bonds are connected between the rails as in the previous cases. Where the wire connecting the two bonds at the ends of adjacent blocks tap each coil in the middle, full protection is afforded against broken rails. In Fig. 243 the bonds are connected across as usual, but the relay itself is on a secondary winding. This prevents the heavy direct current from flowing through the relay. On account of there being no iron core, there is no unbalancing effect in this system to interfere with the impedance. End-fed circuits may be  $1\frac{1}{2}$  miles long and centered 3 miles long.

**151. Alternating-current Propulsion.**—The same type of construction is used as for direct-current propulsion, but on account of the high voltage of the propulsion current the amperage is low and consequently can be carried by lighter and cheaper impedance bonds. The track relays are somewhat different and the impedance bonds are made without air gaps. In order that the relay may not respond to both currents, the cycle frequency of the signal current must be different from that of the propulsion current. If the latter should be 25 cycles, the former should be 60, for these are the values commonly found in practice.

#### ALTERNATING-CURRENT SIGNALING ON STEAM ROADS

**152. General.**—On account of the difficulties experienced with foreign currents interfering with track circuits operated by batteries, it has seemed best in many cases to employ alternating current for signaling purposes on steam roads. This interference

comes in many cases from electric railway lines that run parallel to adjacent steam tracks. The signal current may be used also to operate signal motors and to give night indications in signals and switches. The current for the track circuit for operating the signal motor and for lighting switch and signal lamps is all taken from the signal mains and stepped down by transformers as before. Both rails are divided into blocks, but since there is no return propulsion current, no impedance bonds are necessary. A continuous track circuit is used the entire length of its blocks, thus eliminating the cut section so often necessary with direct-current signaling. Blocks as much as 2 miles in length may be operated in this manner.

### TRANSFORMERS

**153. General.**—The closed magnetic circuit type of transformer, shown in Fig. 246, is designed for use on roads having direct- or alternating-current propulsion with double-rail return. It is also used on steam roads having alternating-current signaling.

The following suggestions from the 1917 *Proceedings* of the Railway Signal Association are helpful in making connections for a series of transformers.

“Care should be taken to connect all transformer primary leads in the same manner, *i.e.*, take one transmission line wire and call it *A*. Connect the right-hand lead of all transformers as viewed when looking at front of same to this wire. This gives the same instantaneous polarity for the corresponding secondary lead of all transformers. This is very desirable in order to obtain proper polarity on track circuits and also on line circuits when using three-position line relays.

“In order to insure a uniform polarity scheme, the installation should be made as follows:

“*First.*—If possible, locate all transformers on the same side of the transmission line pole and connect the primary leads to corresponding wires. Care should be taken to avoid error due to transposition of the transmission line wires.

“*Second.*—If necessary to put a transformer on the opposite side of the pole, interchange the connections of the primary leads to the line wires; this should also be done if the transformer is on the standard side of the pole, but a transposition of line wires has been made.

“Primary leads may be interchanged at the terminal board inside the transformer, if they are long enough. This is not considered entirely desirable, however, as there is not much space to cross these

high-tension leads inside the transformer, hence this is usually done by cleating the leads to the underside of the cross arm with porcelain cleats and using wire insulated for high voltage for the taps from the transformer to the line.

“Where there is only one secondary winding, it is not absolutely necessary to interchange the primary leads as this may be done with the secondary leads. It is preferable, however, to interchange the primary

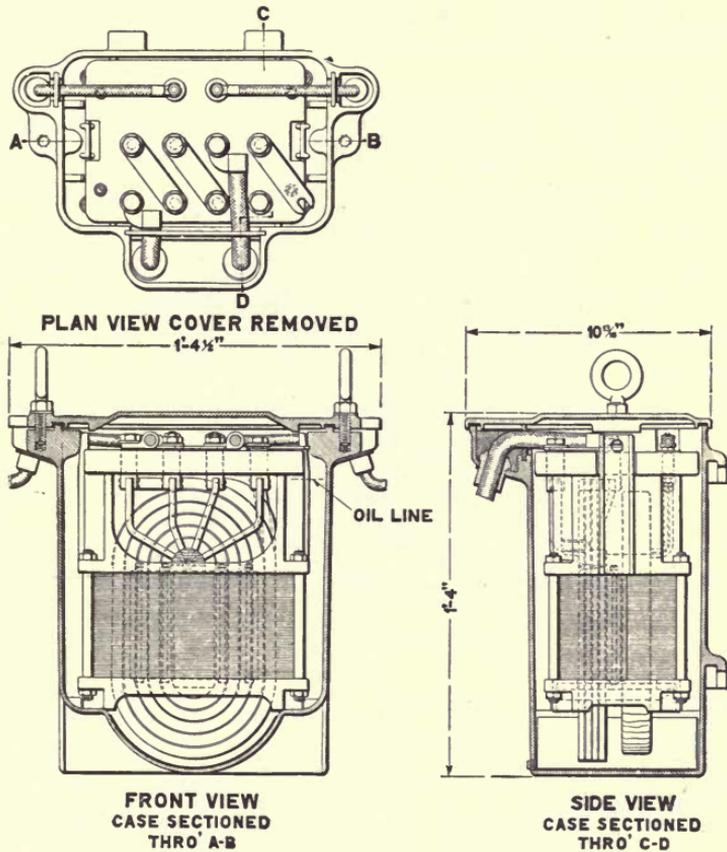


FIG. 246.—Transformer. Closed magnetic circuit type.

leads and have all corresponding secondary leads of the same polarity. This insures a uniform scheme in connecting and tagging all wires.

“In carrying out the polarity scheme, care must also be taken when energy is obtained from several sub-stations to insure that corresponding line wires from each sub-station have the same polarity. This is obtained by connecting each primary lead of the signal power transformers to the corresponding bus in each substation and taking corresponding line wires from corresponding secondary terminals of the power transformers.”

## ALTERNATING-CURRENT RELAYS

**154. General.**—Alternating-current relays may be the single-phase induction type energized by the track circuit only; or they may be two-winding, either the induction motor type or the poly-phase type, one winding of which is energized by the transmission line and the other by the track circuit. The single winding is simpler in construction, but requires more energy to actuate it than the two-winding. It would require a high voltage to send a current through a block 2 miles long and operate a single-phase relay successfully, so high that most of it would be lost by leakage. In the case of the two-winding relay, however, the transmission winding, which is located practically at the relay, is usually 55 to 110 volts and furnishes most of the energy with a very slight loss. The track winding of this relay requires very little energy. Therefore, the single-phase is better suited for short blocks and the two-phase for long ones. Since most of the energy is furnished by the local winding, it is possible to use long track circuits as compared with direct current. If all the energy had to be furnished through the track winding, the block could be practically no longer than with direct current.

## UNION SWITCH AND SIGNAL COMPANY DESIGNS

**155. Vane Type.**<sup>1</sup>—The two pole pieces in the vane type of alternating-current relay are made up of laminated iron cores instead of solid iron cores as is the case with the neutral relay. Be-

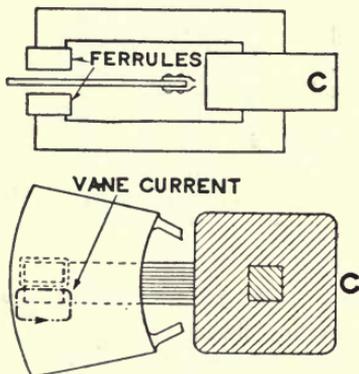


FIG. 247.—Operating element of vane relay.

tween the two cores wound with wires swings an aluminum vane mounted on a horizontal shaft. The vane is constructed to swing through an angle of 90 degrees. The alternating current flowing through the windings induces an alternating flux in the iron core and in the gap between the pole faces of the core. A copper ferrule, Fig. 247, encircling the upper half of each pole face, acts

just as a short-circuited secondary on a transformer to produce a counter magneto-motive force opposing that of the primary

<sup>1</sup> *Proceedings, Railway Signal Association, 1910.*

winding. This counter magneto-motive force causes a lag in the passage of the magnetic flux through the portion of the pole face encircled by the ferrule, with the result that the maximum and zero values of the magnetic flux in the part of the pole face encircled by the ferrule occur a short interval of time after the corresponding values are reached in the other half. There is then a traveling of the magnetic field over the pole face towards the portion that is enclosed in the ferrule. These lines of force traveling in this direction carry the vane along with them causing it to rotate about its axis.

Model 15 vane type, shown in Fig. 248 can be operated either as a two-position or a three-position relay. The two-position

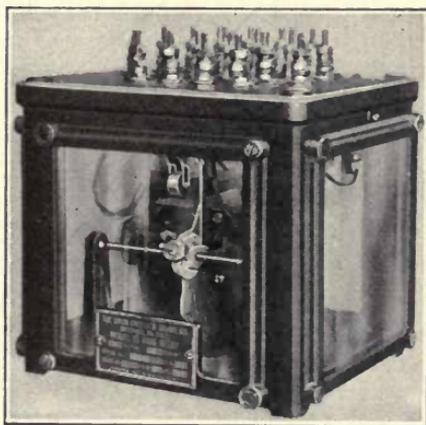


FIG. 248.—Model 15 vane type relay.

relay may have either one or two windings. The various arrangements are known as single-element two-position, two-element two-position and two-element three-position. The single element is used either on single-rail return or on center-fed double-rail return systems.

**156. Ironless Galvanometer Type.**—This type can be used either in track or line circuits, but it offers its chief advantage when used as a track relay. The field or stationary winding, which is the two outside coils, is connected to the transmission line; while the armature, which is the movable element, is connected to the track circuit. Most of the energy can be supplied by the transmission line leaving a very small portion to be furnished by the rails. This allows track circuits to be a mile or more in length without excessive loss by leakage. Current of

similar characteristics must flow through both windings at the same time to make the relay operate. Direct current from the rails has no effect either to operate or to hold the armature since it can act only on the one winding, which contains no iron.

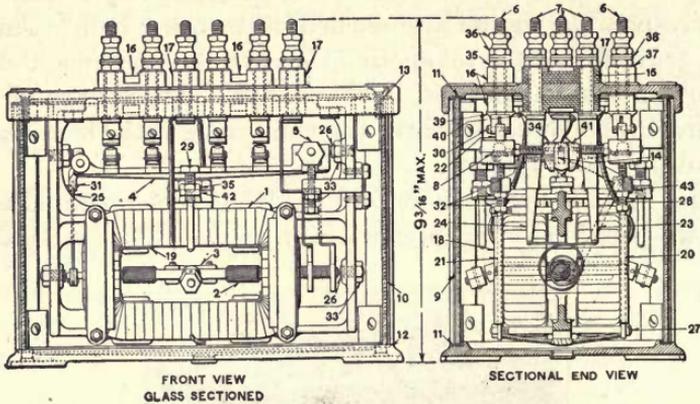


FIG. 249.—Three-position ironless galvanometer relay.

**157. Iron Core Galvanometer Type.**—The relay shown in Fig. 250 is a two-phase wire wound type whose operation depends upon the phase relations of the current in the track and transformer windings. It is built in the form of a motor in which the

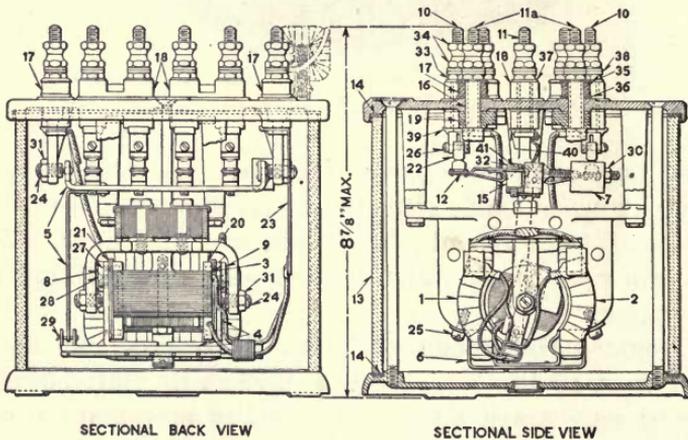


FIG. 250.—Iron core galvanometer relay.

armature makes only a part of a revolution, and the field and armature are connected in multiple or are excited from separate sources. Its characteristics are very similar to the Ironless type, and it is generally interchangeable with it for steam-road service.

It is not recommended for electric-road practice. It is slightly more economical of current than the Ironless type.

**158. Centrifugal Frequency Relay.**<sup>1</sup>—The frequency relay is designed for use in the track circuits of a railroad having alternating current for both propulsion and signaling. The number of revolutions per second,  $n$ , at which an induction motor operates is calculated from the formula,  $n = \frac{2f}{P}$ , where  $f$  is the cycle frequency of the stator winding, and  $P$  is the number of stator poles. If a current should have 60 cycles per second and a

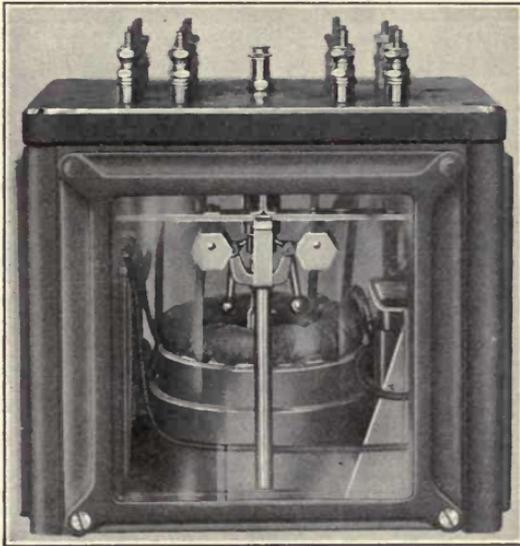


FIG. 251.—Centrifugal frequency relay.

stator 12 poles, the motor would make 10 revolutions per second; while if the current should have 25 cycles per second and the same number of poles, the rotor would make a little over 4 revolutions per second.

The stator windings of the Union frequency relay is made up of two elements so that the instrument may operate either as a single-element or two-element relay. The proper phase relation of the current flowing through the two windings is adjusted by inserting suitable resistances in the circuits. The centrifugal apparatus is constructed somewhat after the manner of the governor on a steam engine. With 60-cycle current the rotor turns with sufficient speed to cause the balls to swing out far

<sup>1</sup> *Signal Engineer*, February, 1914.

enough to lift the operating collar the proper amount for closing the contacts. With 25-cycle current the rotor does not acquire sufficient speed to lift the centrifugal apparatus to make the necessary contacts for operating the signals.

**159. Radial Contact Polyphase Induction Type.**—This instrument, shown in Fig. 252, is built on the induction motor plan and can be used either as a track or line relay. As the shaft rotates it causes the fingers to engage with contacts located around the periphery of the case. The chief advantage of this type of relay is its capacity for a large number of contacts.

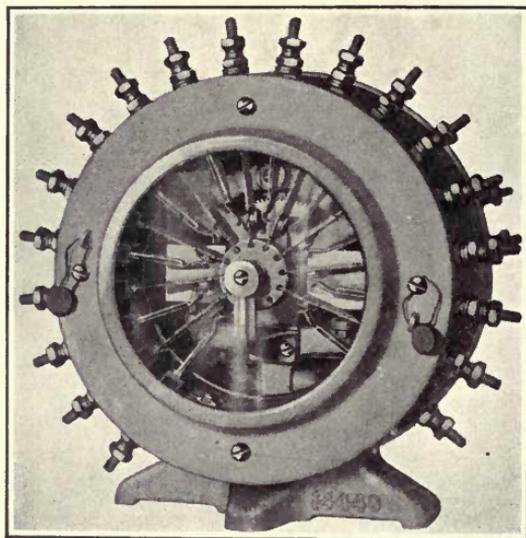


FIG. 252.—Radial polyphase relay.

#### GENERAL RAILWAY SIGNAL COMPANY DESIGNS

**160. Universal Alternating Current Relay.**—The universal alternating current relay is an induction type, with the stator winding made up of eight form-wound coils and with the rotor shaft mounted vertically. The contact movement is operated by contact rolls, as shown in the illustration, Fig. 253. The relay is made either direct connected or pinion and sector connected. The direct connected is recommended for average track circuit conditions, while the pinion and sector connected is recommended for long track circuits having unfavorable ballast conditions and for special work. The relay may be fitted for either single-rail or double-rail track circuits, and may also be equipped for line circuits. It may be converted to a three-

position relay by adding counterweights and readjusting the contacts.

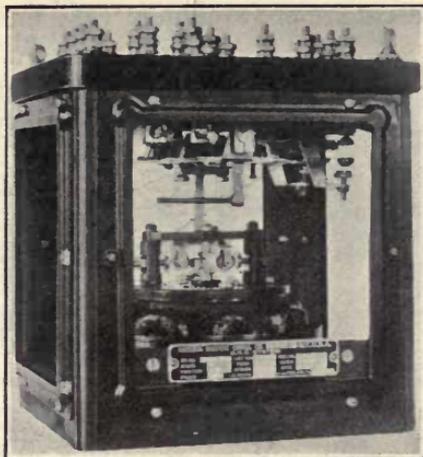


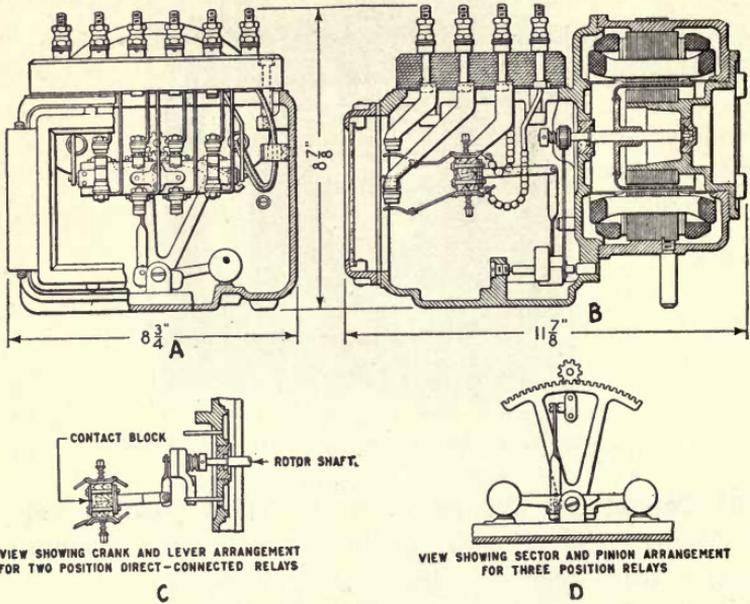
FIG. 253.—Universal A. C. relay.

**161. Models 2A and 2B Two- and Three-position Relays.**—The Model 2A relay shown in Fig. 254 is designed primarily for use as a track relay on steam roads, or electric traction lines employing direct current for propulsion. It may, however, be used as a line relay. The construction of this relay is very much like the two-phase induction motor type except that it has a rotor made of aluminum, a non-magnetic metal, instead of iron. One phase of the winding is energized by a transformer located near the relay and the other by the track circuit.

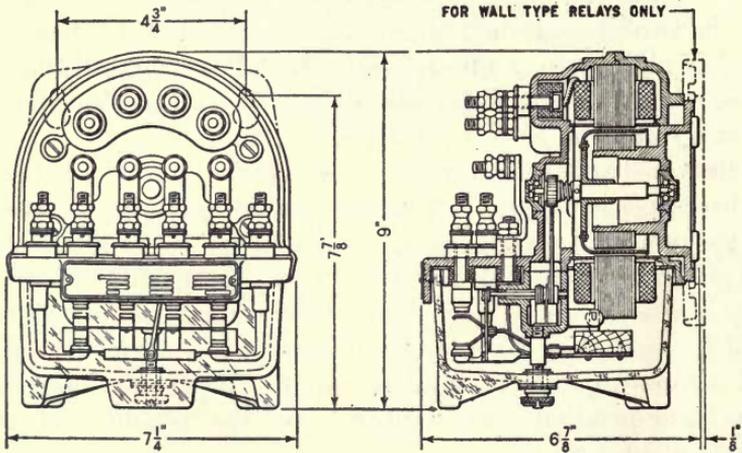
These instruments are made to operate either as two-position or three-position relays. The two-position may have either the direct-connected arrangement, as illustrated in *C*, or the sector and pinion arrangement, as shown in *D*. As the direct-connected relay is arranged with a crank and lever directly connected to the rotor for operating the contact fingers, it has a quicker pick-up and drop-away, but requires more energy for operation. The three-position relay always has the pinion and sector arrangement.

The Model 2B is designed primarily for use as a line relay, although it is employed as a track relay on steam roads having short track circuits. The two-position relay is used, also, as a track relay where there are short track circuits on electric lines employing direct current for propulsion. The sector operates a lever that lifts the fingers to make contact.

The Model 2B Time-element relay, has a gear train in place of the pinion and sector movement for operating the contacts. Time-element relays are of two kinds: (1) Time-element closing,



Model 2A relay.

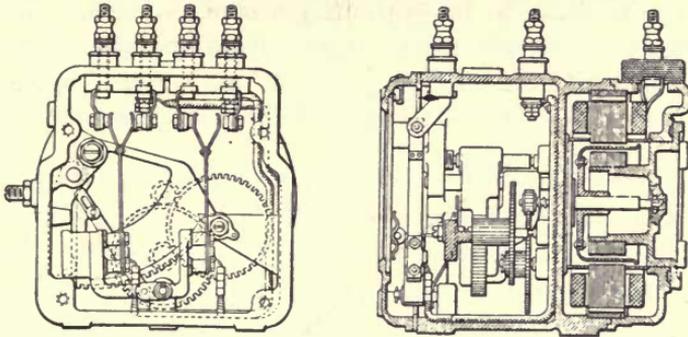


Model 2B relay.

FIG. 254, part 1. Models 2A and 2B relays.

in which the front contacts are not made until a predetermined time after the relay is energized and are immediately broken when the relay is deenergized. They operated as single-circuit relays only. (2) Time-element opening, in which the front contacts are made immediately when the relay is energized and

are not broken until a predetermined time after the relay is deenergized. They operate as two-circuit relays only.



Model 2B, time element relay.  
 FIG. 254, part 2. Models 2A and 2B relays.

**162. Model 2A Two-position Centrifugal Frequency Relay.—**

The frequency relay, illustrated by Fig. 255, is designed principally for service as a track relay for double-rail return circuits where alternating current is used for propulsion. It is employed on steam roads only at crossings with electric lines having alter-

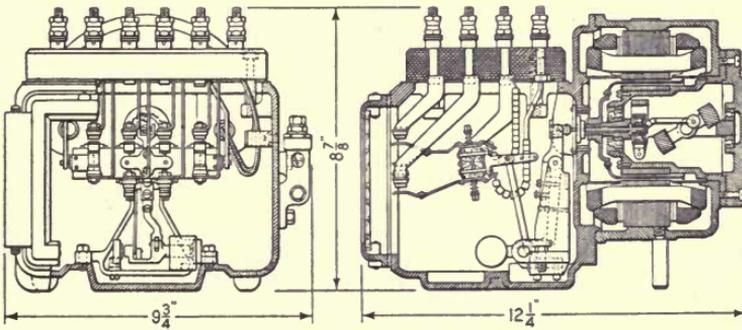


FIG. 255.—A. C. relay. Model 2A, two-position centrifugal frequency type. Rotor operated.

nating current for propulsion. It may be used, also, on short single-rail return circuits or as a line relay.

When the track section is not occupied by a train, the rotor operates at a speed proportional to the frequency of the signaling current, which is usually 60 cycles a second. When the rotor turns at this speed it rotates the centrifuge apparatus at such a rate as to cause it to assume a position more nearly at right angles to the axis of rotation. This causes a thrust on the lever arm, which lifts the fingers to make the proper contacts for closing the signal circuits. If a train occupies the section and short-circuits the signaling current, and the rotor runs at a

slower speed corresponding to that of the propulsion or stray current frequency, the centrifuge apparatus will not assume the proper position to cause the finger contact. This construction prevents the propulsion current from operating the relay. As the relay operates only in one direction, it gives broken joint protection when adjacent track feeds have staggered polarities.

#### ALTERNATING-CURRENT TRACK AND SIGNAL CIRCUITS

**163. Two-position Signals.**—Figure 256 represents the track and signal circuits installed on a portion of the Subway in New York. This is a single-rail return system with direct-current propulsion, as was previously explained. The vane type of relay was used in this installation.

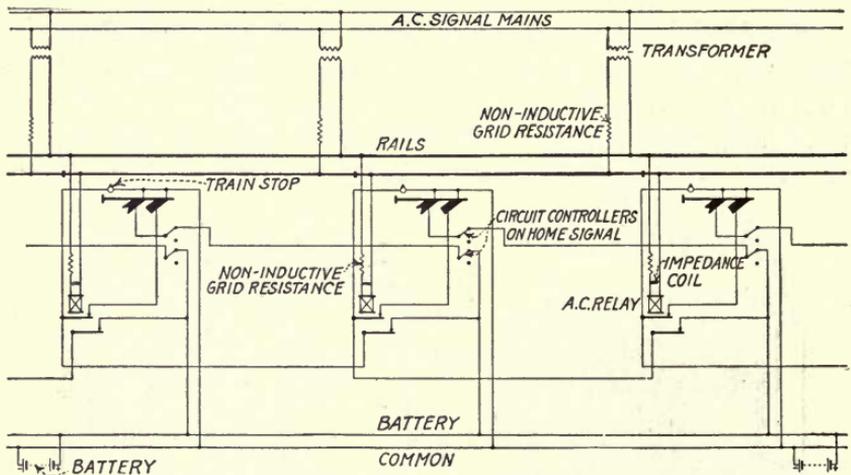


FIG. 256.—Track and signal circuits on a portion of the New York subway. (Union Switch and Signal Co.)

Figure 257 illustrates the track and signal circuits used on a portion of the Long Island Railroad.<sup>1</sup> This is a center-fed construction with the vane type of relay used at each end of the block.

Figure 258 represents the signaling plan used on another portion of the Long Island Railroad. The track transformer is attached to the rails near the middle of the track section, and a galvanometer type of relay is used at each end, the one at the exit end of the track circuit being a two-position and the one at the entrance end a three-position relay. The armatures of the relays are energized directly from the track circuit. The field of the relay at the exit end of the track circuit is energized directly from the 55-volt transformer; the field of the relay at

<sup>1</sup> Pages 412 and 413, *Proceedings Railway Signal Association*, 1910.

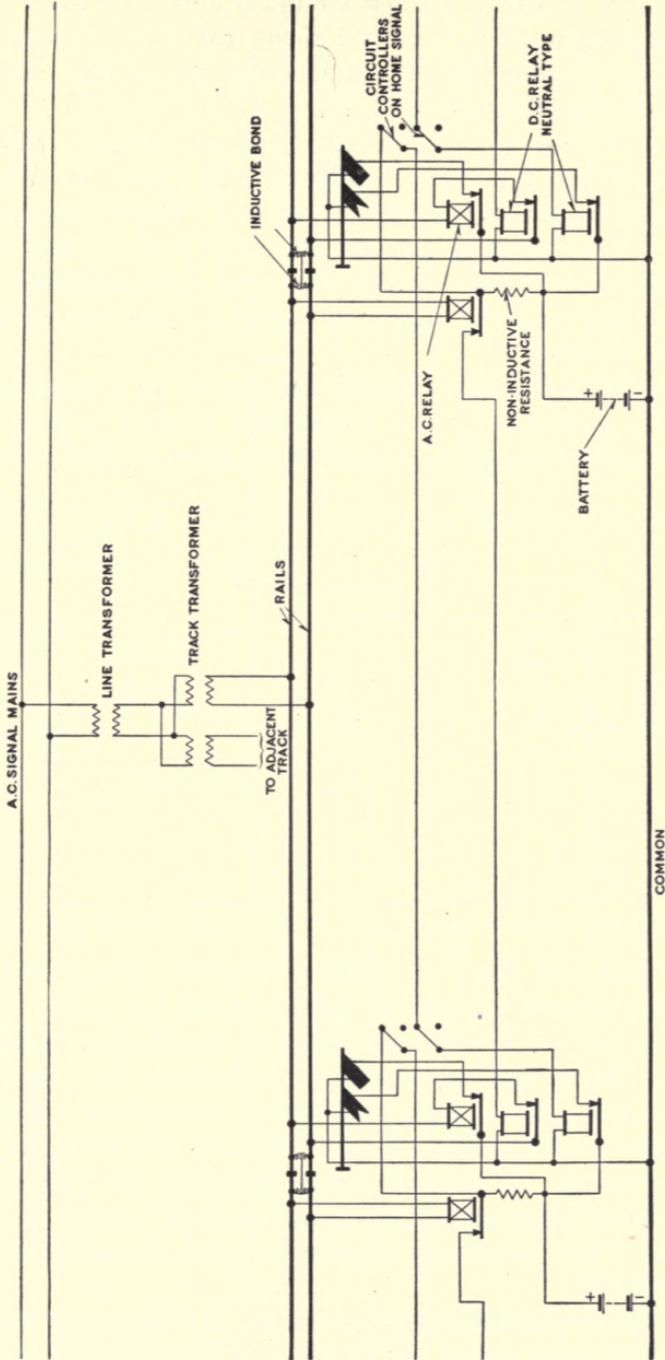


FIG. 257.—Track and signal circuits on a portion of the L. I. R. R. Vane type of relay. (Union Switch and Signal Co.)

the entrance end of the track circuit is energized over the line wire extending up to the exit end of the track circuit and over the point of the relay at this end, thence through the pole-changer to the 55-volt transformer.

The West Jersey and Seashore Railroad signal installation, represented by Fig. 259, has center-fed track circuits with blocks averaging about 4,000 ft. in length.<sup>1</sup> There is a wire wound armature type of relay at one end of the block and a step-up transformer at the other. The step-up transformer is connected to the relay by line wire furnishing the current for the armature winding.

Figure 260 represents a signal installation on a portion of the N.Y.N.H. & H.R.R.<sup>1</sup> The signal and lighting current is 110 volts, 60-cycle frequency, stepped down from a 2,200-volt trans-

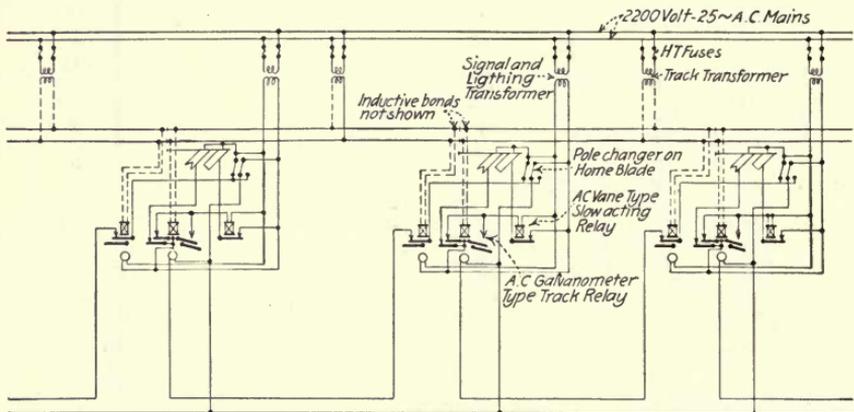


FIG. 258.—Semi-wireless control, L. I. R. R. (Union Switch and Signal Co.)

mission line fed from a 11,000-volt power transmission line. The track circuit equipment was designed for either 550-volt direct-current or 11,000-volt, 25-cycle, single-phase alternating current. As it was necessary to cross-bond the track every 3,000 ft., cut sections were employed in each block. Current is supplied to the track circuit by a transformer located at the middle of the section. Frequency relays designed to operate at 60 cycles, installed at each end of each section, control the signal circuits. There is also an impedance bond at each end of each track section.

**164. Three-position Signals.**—Figure 261 illustrates the Union typical track and signal circuit plan for three-position signaling arranged for direct-current propulsion with double-rail return.

<sup>1</sup> *Proceedings, Railway Signal Association, 1910.*

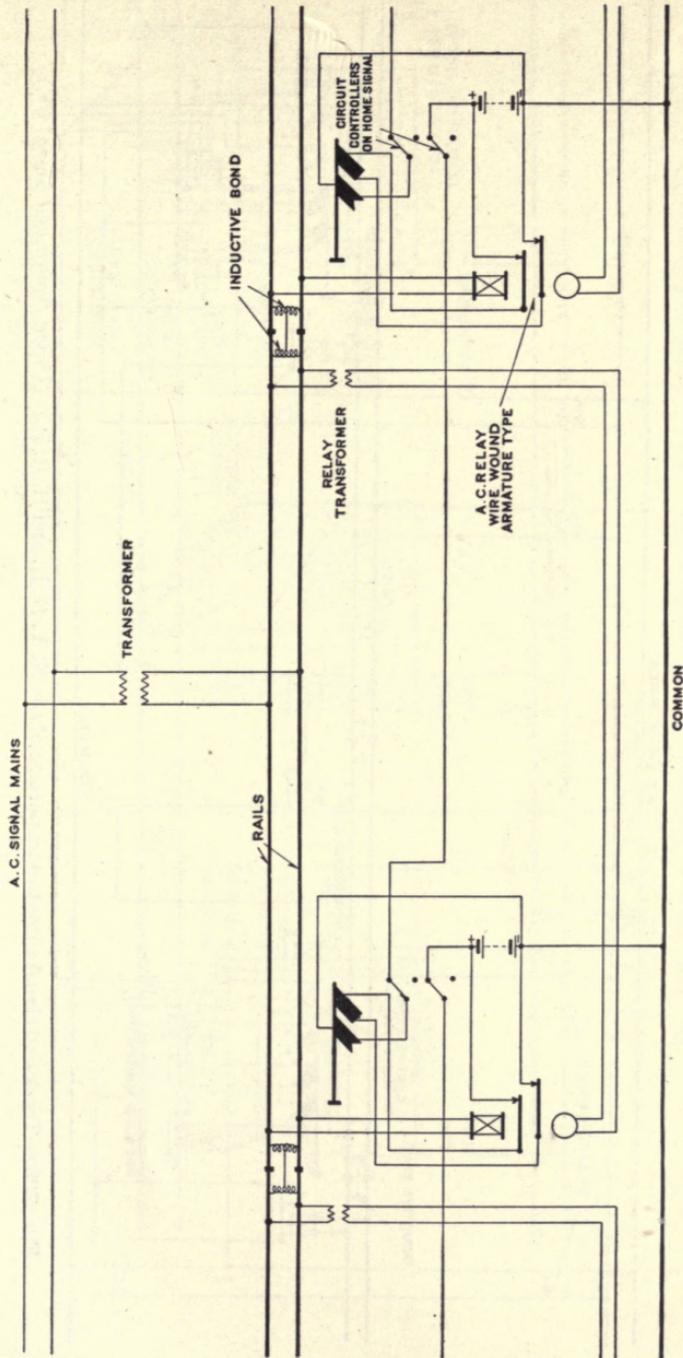


FIG. 259.—Track and signal circuits on the West Jersey and Sea Shore R. R. (Union Switch and Signal Co.)

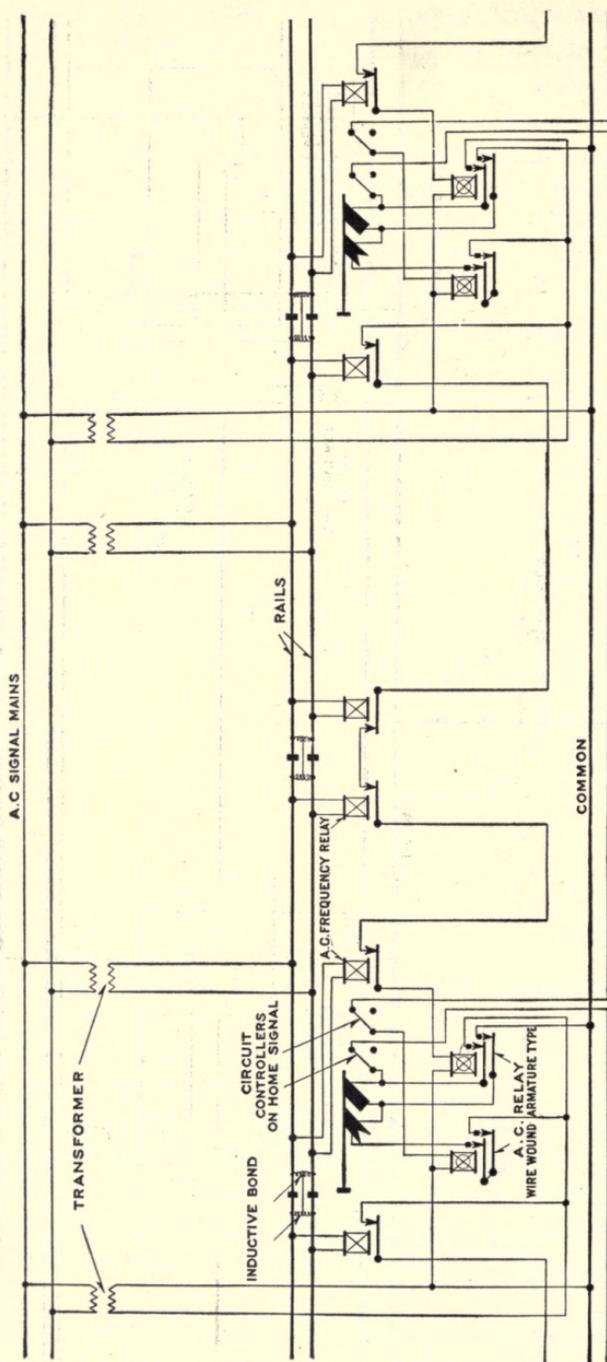


FIG. 260.—Track and signal circuits on a portion of the N. Y. N. H. and H. R. R. (Union Switch and Signal Co.)

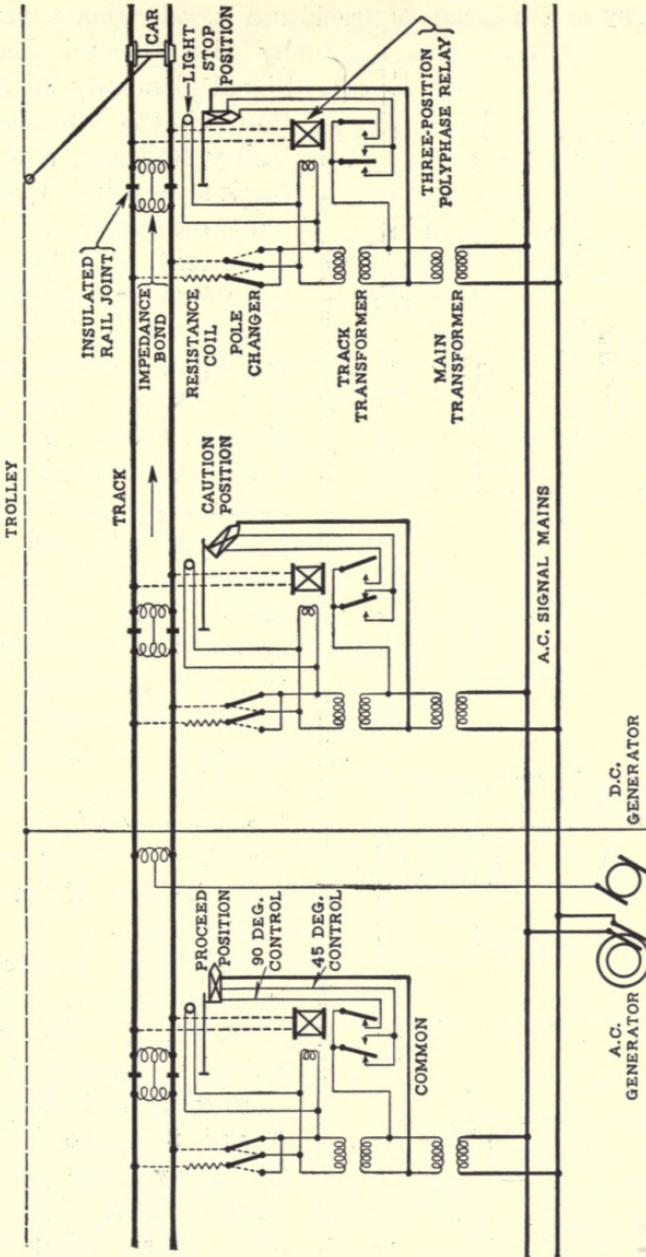


Fig. 261.—Three-position track and signal circuits. (Union Switch and Signal Co.)

Figure 262 is a diagram of track and signal circuits installed

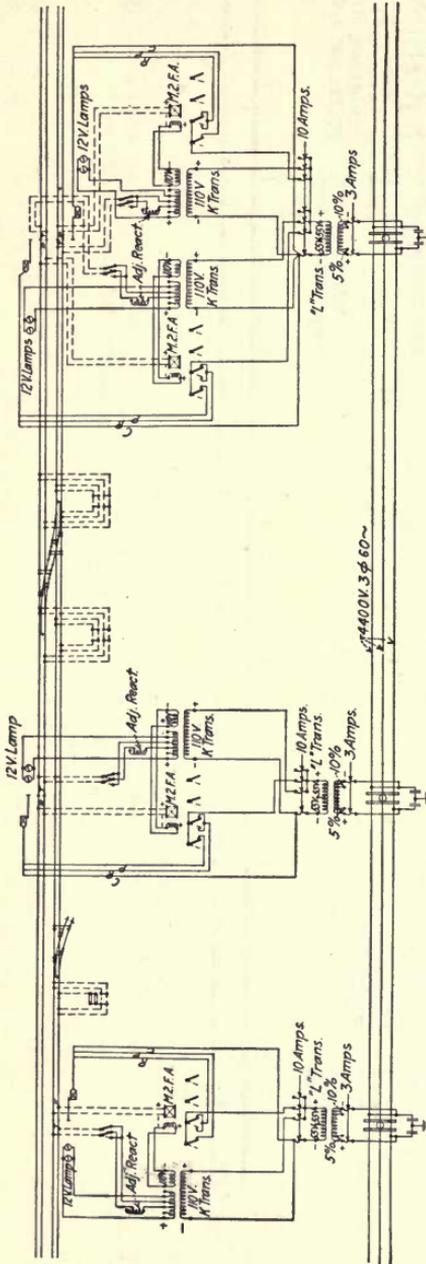


Fig. 262.—Diagram of track and signal circuits for three-position signals on the Cumberland Valley Railroad.

by the General Railway Signal Company on a portion of the Cumberland Valley Railroad, a double-track steam line. The signal transmission line carries a current of 4,400 volts. Transformers step the current down to 110 volts for the signal circuits and to 2, 4, 6, 8, and 10 for track circuits. This range in voltage is obtained by placing an adjustable resistance in series with the transformer leads. All the automatic track circuits are arranged for wireless control by operating three-position track relays. The 90-degree, or distant indication, is given by reversing the polarity of the track circuit by means of the pole changer on the signal mechanism.

The track circuits vary in length from 2,000 to 8,000 ft. 4 volts are required to operate the track circuits up to 5,000 ft. and 6 and 8 up to 8,000 ft. The relay is the polyphase three-position type, the local phase being wound for 110 volts. The relay operates in one direction to bring the signal to the 45-degree position and in the reverse direction to the 90-degree position. It stands in the neutral position when shunted.

Figure 263 is a diagram of typical circuits used by the same company in installing the signal system on a portion of the double-track line of the Southern Railway. The current furnished by the signal transmission line has a potential of 4,400 volts. Transformers step the current down for the 110-volt induction motors used to operate the signal mechanisms and for the 110-volt primary winding of the separate track transformers. The secondary taps of the track transformers, arranged to secure any voltage from 1 to 10 in steps of 1 volt, furnish current to

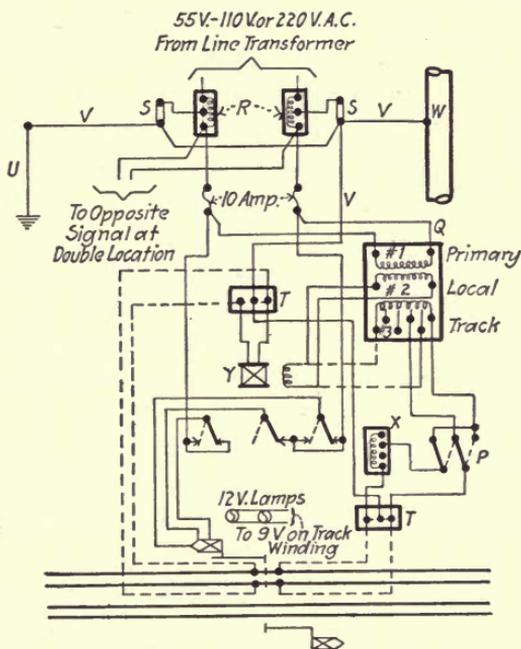


FIG. 263.—Typical circuits used on the Southern Railway.

energize the three-position track relays. The track circuits are end-fed and are continuous from one signal to the other, varying in length from 300 to 14,000 ft. The 45- to 90-degree movement of the signal is secured by a reversal of the track transformer leads. In the figure, when a 12-volt local is used, the winding on No. 2 track transformer is omitted and the connection is made as indicated by the dotted lines. *P* is the pole-changer on the signal, *Q* is the track transformer, usually the *K-1* type, *R* is a choke-coil air-gap arrester, *S* is a resistor in the ground lead for circuits, *T* is an air-gap arrester without choke-coil, *U* is a low-voltage ground element, *V* is a low-tension ground wire, *W* is the

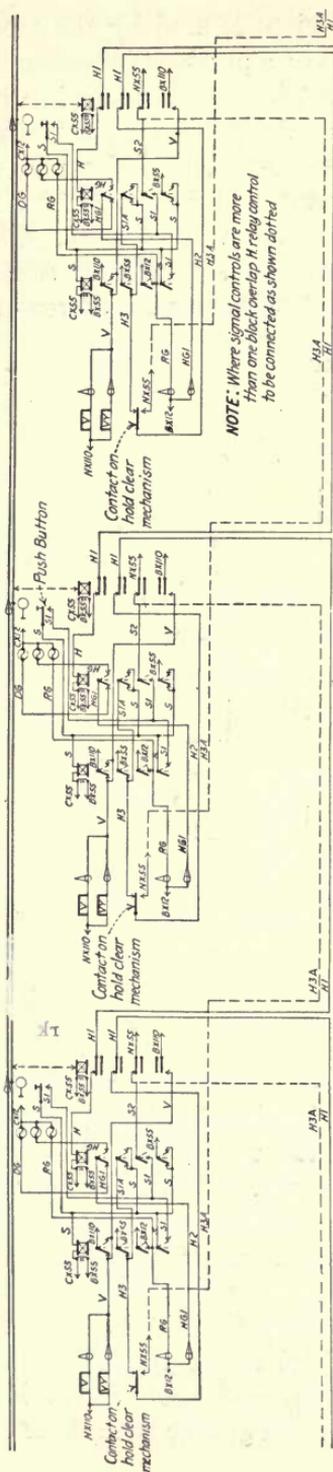


Fig. 264.—Typical circuit plan for signals on lines of the New York Municipal Railway Corporation. (General Railway Signal Co.)

signal pole or case,  $X$  is an adjustable track resistor, and  $Y$  is a three-position polyphase track relay.

Figure 264 shows a typical circuit plan for signals installed on the lines of the New York Municipal Railway Corporation. It provides for one full block overlap with automatic train stops used in connection with the signals. (A) in Fig. 265, shows the control limits for the circuits, while (B) shows the indications of signals and the positions of automatic stops with a train in a block. The reason for retaining the stop on the first track section in advance of the signal is that occasions frequently arise where it becomes necessary to operate trains against the normal direction of traffic, and this scheme provides a very simple means of automatically clearing the stop for such moves.

Normal danger signals having time-element control are used on down grade track or on approaches to sharp curves where it becomes necessary to limit the speed of trains regardless of whether or not the track is occupied. The control is secured by the use of time-element relays in conjunction with approach sections that are generally two blocks long. The control limits for this scheme are the same as in (A) with the normal danger time-element feature added.

In (C) a train approaches signal 5 with the track ahead un-

occupied. If the train occupies the track between signals 9 and 7 for the required time, for example 14 seconds, signal 5 will display a yellow or caution indication that will cause signal 7 to change from a yellow to a green indication, as shown in (D). As the train proceeds and occupies the track between signals 7 and 5 for the required length of time, signal 3 changes from a red to a yellow indication and this, in turn, causes signal 5 to change from a yellow to a green indication. If the train should pass over

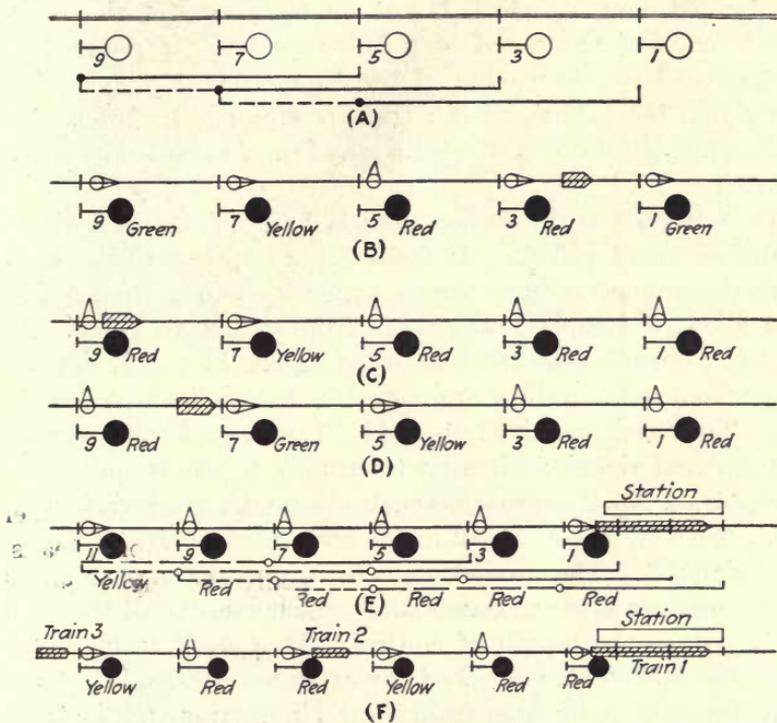


FIG. 265.—Control limits and indications on lines of the New York Municipal Railway Corporation.

the track between signals 9 and 7 in too short a time to permit signal 5 to change from red to yellow, signal 7 would be passed indicating yellow or caution, and the train would be forced to occupy the track between 7 and 5 just about twice as long as would have been the case if it should have waited and allowed signal 7 to indicate green before passing it. If the train should continue at a speed faster than should be permitted and should pass over the track between 7 and 5 before the time-element relay should have operated, the train would be automatically tripped at signal 5. The time-element control, as used on the Manhattan

and Williamsburg bridges, limits the train speed on the down grade portion to about 15 miles an hour.

In approaching stations the time-element is involved with extended length of control. In this case the blocks are short and the control is extended to cover three or more track circuits, depending upon conditions. The signals are normally clear and operate as shown in (*E*) and (*F*). The long-dashed lines indicate the regular two-block overlap control and the solid lines indicate the extended control, which is cut off by means of the time-element relays if the speed of a following train is reduced as predetermined by the timing of the time-element relays. (*E*) shows signal indications with a train occupying the track at a station, while (*F*) shows how a train may follow provided its speed is reduced.

With train No. 1 at the station, signals 1, 3, 5, 7, and 9 indicate red, and signal 11 yellow. As train No. 2 approaches signal 11 at a predetermined reduced speed, signal 9 changes from red to yellow allowing signal 11 to change from yellow to green. As train No. 2 occupies the track between signals 11 and 9, signal 7 changes from red to yellow and signal 9 changes from yellow to green. Thus each signal, 11, 9, and 7, changes to display a green indication and signal 5 changes to display a yellow indication provided train No. 2 approaches each at a predetermined reduced speed. With train No. 1 still in the station, train No. 2 has to stop at signal 3. The time-element feature works in practically the same manner as in the normal danger scheme, except that it is used to reduce the length of control. That is, if train No. 2 exceeds the predetermined speed the extended control is not cut off, the signals do not change from the red indication and the train is automatically stopped.

## CHAPTER XIV

### AUTOMATIC BLOCK SIGNALING ON SINGLE TRACK

**165. General.**—Automatic block signals provide for efficiency and safety in operation on a single-track road as well as on a double-track line. When a single-track line reaches the point of congestion, the installation of automatic block signals will relieve the congestion and prolong the day when double-tracking becomes necessary. The installation of the signals requires very little time, expense and labor in comparison with the construction of a double track. Some roads report that the capacity of a single track has been increased by 20 per cent. with the installation of automatic block signals.

**166. Union General and Special Plans—TDB System.**—In double-track block signaling, the signals must protect trains

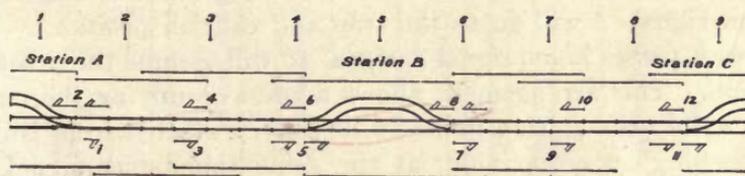


FIG. 266.—Union plan of single track signaling.

that follow each other; whereas in single-track operation the signals must protect not only trains that run in the same direction, but also those that run in the opposing direction. In order to do this several plans have been devised, one of which is the two-position scheme by the Union Switch and Signal Company. Figure 266, shows the relative location of home and distant signals in the case where the stations lie about 4 miles apart. Should the distance be greater, one or more sets of intermediate home signals should be added in order that the blocks should not be so long as to cause delay to traffic.

The lines above and below the signals in Fig. 266 represent the length of track that controls the signals and holds them in the stop position; for example, the line from signal 1 extends to the right as far as the end of the first track section beyond signal 4,

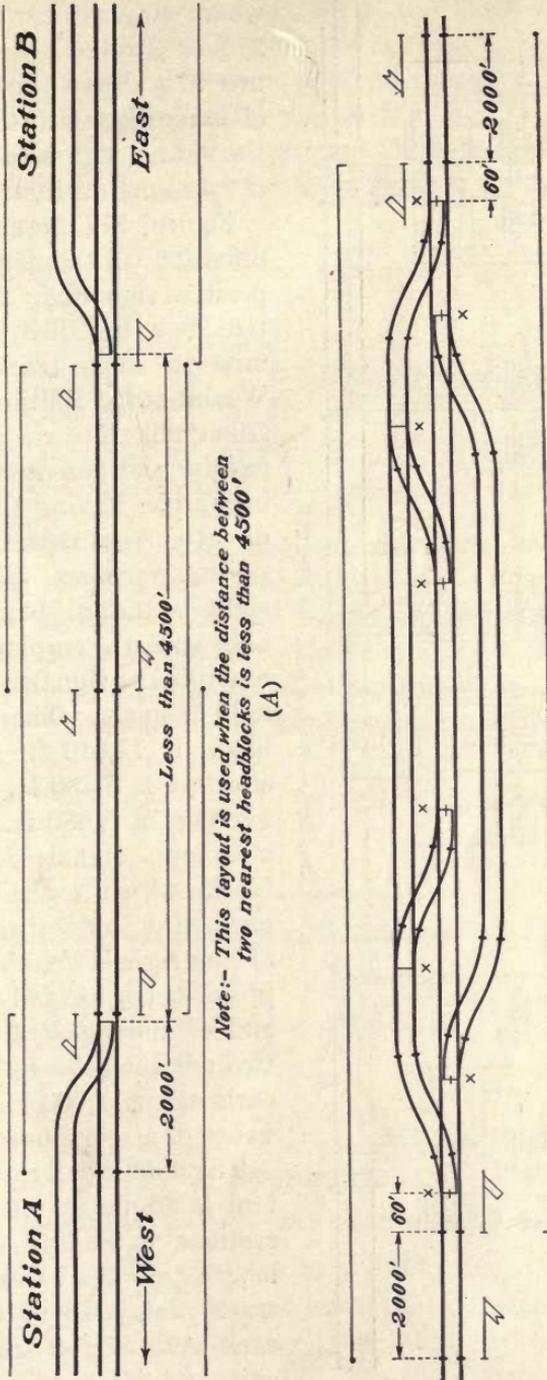
and if a train should occupy any portion of the track between these two points signal 1 would be in the stop position. Likewise, the control for signal 4 extends to signal 1 so that if a train should be at any point between signals 1 and 4, signal 4 would be in the stop position. A train leaving station *A* and moving to the right will place 4 to the stop position as soon as it passes signal 1, and a train moving to the left will place signal 1 in the stop position as soon as it enters the section to the right of signal 4. This overlap of one track section affords head-on protection and eliminates the possibility of trains passing signals 4 and 1 both in the clear positions at the same time.

The reason for placing signals 3 and 4 one track section apart is for head-on protection also. Should opposing trains pass signals 1 and 6 at the same time, they would stop at signals 3 and 4 with a full track section between them.

There is a home signal at the beginning and end of each siding. The distant signals are governed by the siding entrance signals. The control for home signal 5 extends to distant signal 8 and the control for home signal 8 extends to distant signal 5. As soon as a train moving to the left passes distant signal 8, the home and distant signals 5 will go to the stop and caution positions. As soon as it passes home signal 8, signal 10 will assume the proceed position. This arrangement allows a train occupying the main track within the station limits to be fully protected from trains approaching on either side; at the same time, since signals 3 and 10 both give proceed indications under these conditions, a train can reach the siding without passing any home signal set at the stop position except the siding entrance signal near the switch.

Sometimes where the distance between stations is short, home signals are placed only at stations, as shown in (*A*), Fig. 267. Sometimes where the distance is the ordinary length they are placed at the stations only for protecting trains within station limits. The control between stations is as shown in (*A*), Fig. 267, and that through stations as shown in (*B*). A preliminary overlap section, as shown at Station *A*, Fig. 267, is generally made in favor of superior trains so that two trains will not pass at the same time home signals set at the proceed position.

Figure 268 is a wiring plan for the signals in Fig. 266. Figure 269 is a wiring plan where intermediate signals come opposite distant signals, which frequently occurs in continuous blocking



Note:-X-Switchboxes  
(B)

Fig. 267.—Single-track signals.

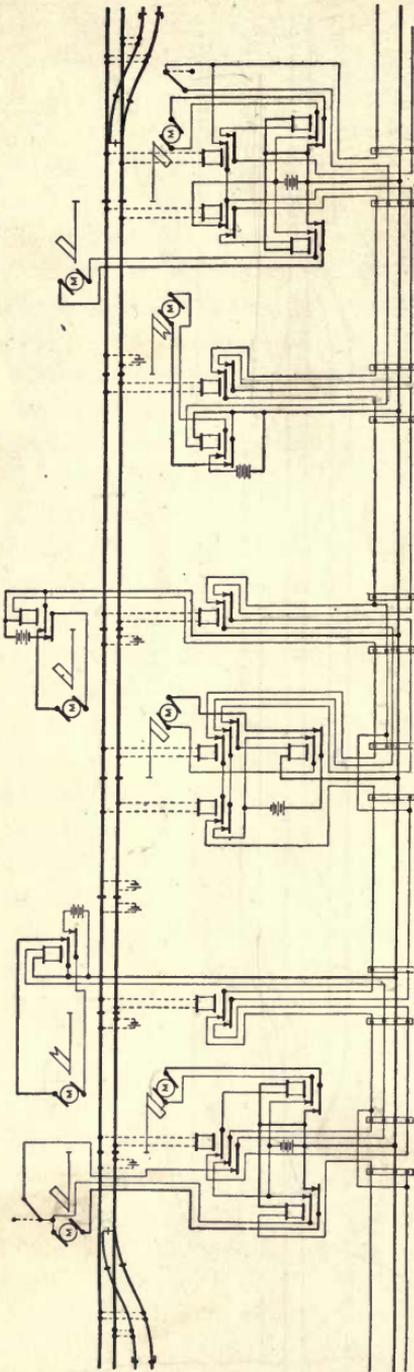


Fig. 268.—Wiring plan for Fig. 266.

where stations are not over  $2\frac{1}{2}$  or 3 miles apart. Figure 270 shows the location of home signals at the end of the siding with some details of trunking arrangements.

Figure 271 represents a different Union plan of two-position signaling. This system was installed on 13.2 miles of single track on the Washington, Baltimore and Annapolis Electric R. R., a freight and passenger inter-urban line having 1,200-volt direct-current power for propulsion purposes. There are eight standard blocks and one special, employing 17 semaphore signals and 16 light signals. The longest block is 11,610 ft. and the shortest is 5,430 ft. with an average of 8,680 ft. There are four signals for each block, which extends from one siding to another. Two of the signals are the semaphore type, located at each end of the block; the other two are the color-light type, each about 1,000 ft. in advance of a semaphore signal.

The double-rail return system is employed with track sections extending the full length of the block. One track relay is located at each end of the track circuit and is energized by a

transformer feeding at the middle of the block. The relay at the west end of the block is controlled by the track to a point about 1,000 ft. east of the center of the block, while the relay at the east end is controlled by the track to a point the same distance to the west of the center. Each semaphore signal is controlled by both track relays, while each light signal is con-

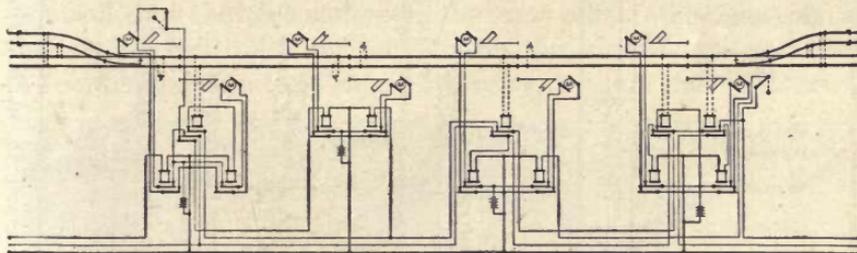


FIG. 269.—Wiring plan where intermediate signals come opposite distant signals.

trolled by the relay at the opposite end of the block. An east-bound car entering the block with signal 115 at clear, places this signal as well as 102 and 104 in the stop position. As the car passes 113 at clear and reaches the western control limit of this signal, it sets 113 in the stop position. As soon as the car passes 102, all signals in the block assume the proceed position.

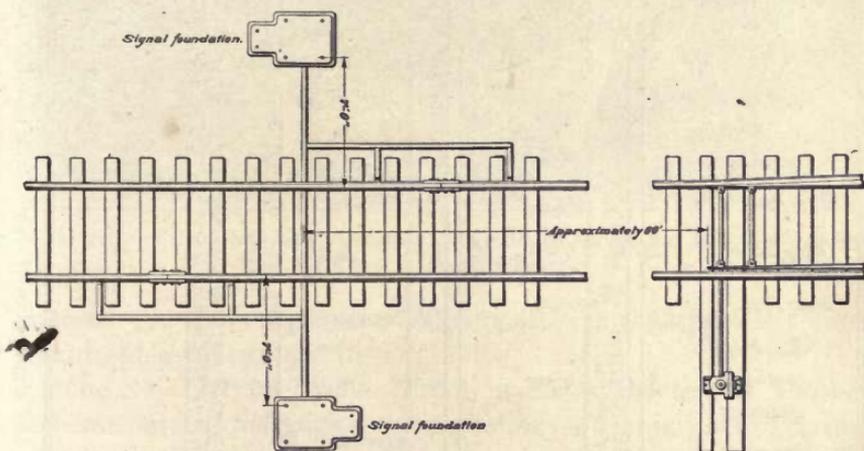


FIG. 270.—Arrangement for the location of a home signal at the end of a siding.

The light signals would act as a check should two approaching trains pass opposing semaphores at the same time; for example, if an east-bound car should pass signal 115 at the same time that a west-bound car should pass 102, the east-bound car would be stopped by signal 104 and the west-bound by signal 113.



From the 2,200-volt signal transmission line current is stepped down to 110-volt for signal circuits and to 10-volt for track circuits. Each light signal is controlled by a 110-volt line relay, which is in turn controlled by the galvanometer type of track relay. The lamps behind the green lens are controlled by the front contact of the line relay, while those behind the red lens are controlled by the back contact of the same relay. The semaphore signals are controlled by contacts on the track relays and also by contacts on the light signal line relay, without the use of extra

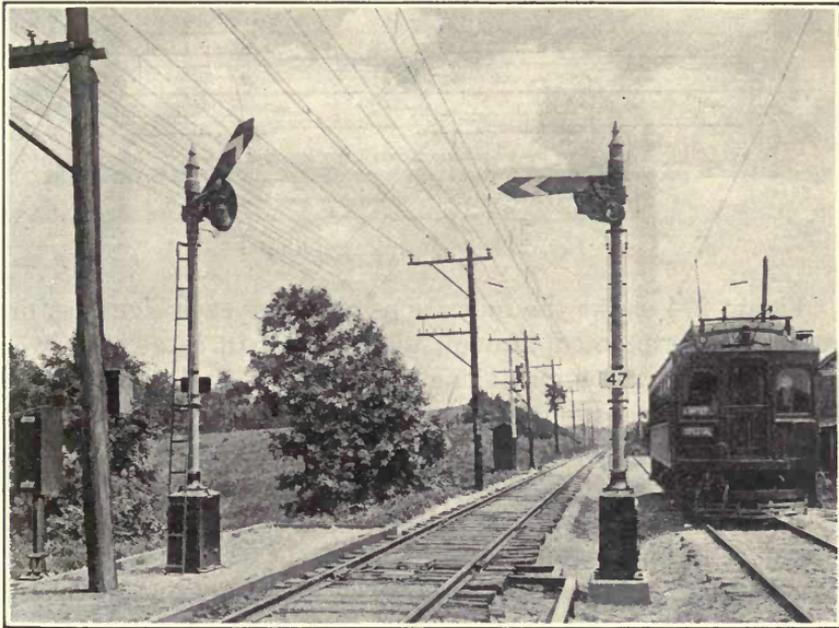


FIG. 272.—Upper left-hand quadrant semaphore signals on the Washington, Baltimore and Annapolis Electric R. R.

line relays. The semaphore arm operates in the upper left-hand quadrant as illustrated by Fig. 272.

The "T D B" (Traffic Direction Block) system is another scheme devised for single-track signaling used largely in interurban service.<sup>1</sup> The length of block for opposing movements is the distance from one siding to the next, while the length for following movements is just half the distance between sidings; that is, there are two "following" blocks in each "opposing" block. There are four signals in each "opposing" block, two near the ends of the sidings and two near the middle of the block. The

<sup>1</sup> Pages 351-363, A. C. Signaling, U. S. & S. Co.

control limits for the different signals are shown by Fig. 273. Each signal at a siding governs both "opposing" signals in the block, while the intermediate governs only the one. All signals govern to the first signal in the rear for following movements.

The circuits of the entire system are operated by alternating current. The signal transmission line carries a potential of 2,200 volts and from this the current is stepped down by transformers to 110 volts for signal circuits and to 10 volts for track circuits. The double-rail return system is employed for the propulsion current.

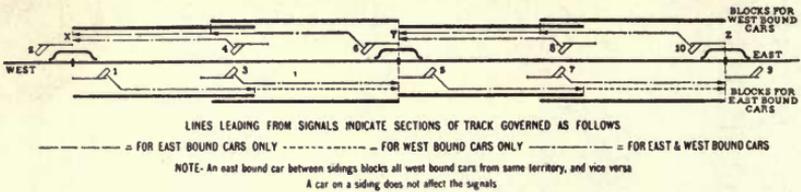


FIG. 273.—Signal control limits.

Figure 274 shows the indications given by each signal as one or more cars proceed through the blocks. In case *A*, there is a west-bound car approaching the siding *x*, and the opposing signal 2 is in the stop position. In *B*, the car is passing signal 1, setting it in the stop position, and also setting signals 4 and 6 in the stop position. Signal 2 goes to clear as soon as the train passes out of its block. In *D*, the first car, *R*, has proceeded to signal 3, and a following car has approached signal 1. Signal 1 protects car *R* from a following car, while signals 4 and 6 protect it against an approaching car. As car *R* has passed signal 4 in *E*, signal 1 has cleared for car *S*. In *F*, car *S* has entered the first "following" block, while car *R* is in the second "following" block. Signals 1 and 3 protect against following movements and signals 4 and 6 against opposing movements. In *G*, car *R* has entered the next "opposing" block while car *S* is following and both are protected by signals in the front and rear. The operation for east-bound cars is similar.

*H*, *I*, *J*, *K* and *L*, show the positions of cars and the indications of signals as the cars meet at siding *Y*. Cars between *X* and *Y* do not in any way affect the signals between *Y* and *Z* as *M*, *N*, *O*, *P*, and *Q* indicate.

Each opposing block has one track circuit with a relay at each end operated by current from a transformer located at the

middle of the block. In the block X-Y, Fig. 275, there will be one track relay at signal 1 and another at signal 6. Normally, signals 1 and 6 are controlled by both track relays, or the entire section of track between signals 1 and 6. Signal 3 is controlled by the track relay at signal 6, and signal 4 is controlled by the track relay at signal 1.

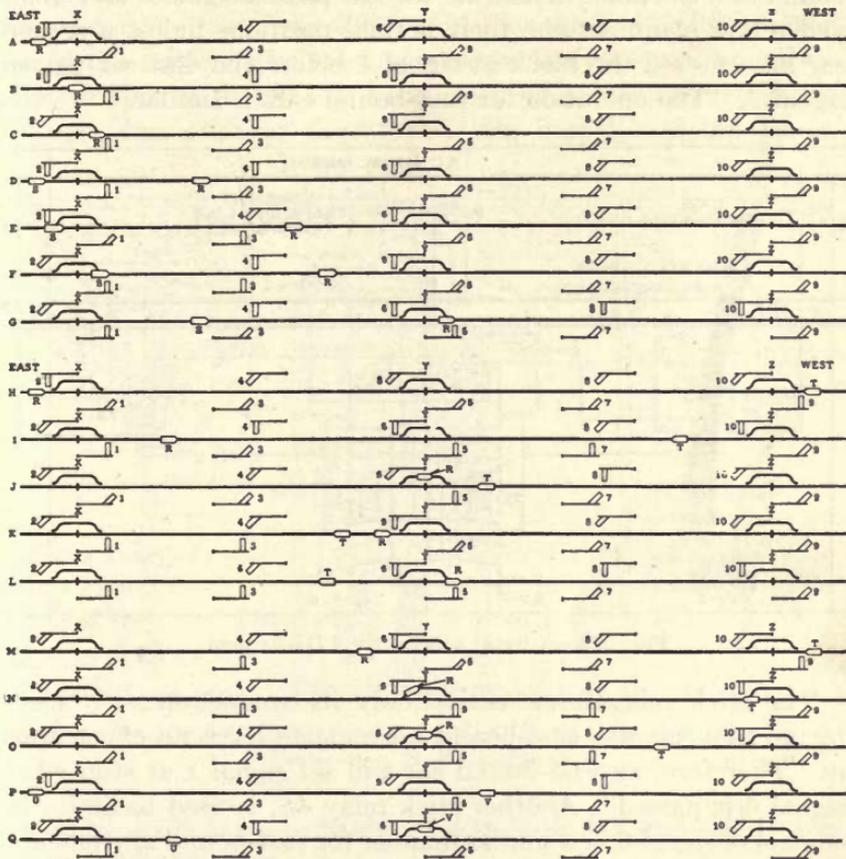


FIG. 274.—The TDB system; effect of train movements on signal indications.

A west-bound car entering the block X-Y at X, will deenergize the track relay at signal 1, thereby setting signals 1, 4 and 6 to the stop position. As signal 3 is controlled by the track relay at signal 6, it will not be set at stop until the car reaches the point where it affects this track relay.

The car in deenergizing relays T1 and 4L, energizes stick relay 3S which is used to clear signal 1 after a car has passed signal 4. This stick relay cuts out the control of signal 1 from

the track relay *T6* and the line relay *3L*. As the car proceeds, passing signal 3, the track relay *T6* is deenergized, setting signal 3 at stop and still holding the other three signals at stop. When the car passes signal 4, track relay *T1* is again energized and signal 1 is cleared. Incidentally, signal 4 is cleared because the track relay at signal 1 is energized, but this has no effect on west-bound movements. When the car has passed signal 6 all signals and relays again assume their normal positions unless a second car has entered the block at signal 1 before the first car passed signal 6. The operation for east-bound cars is similar.

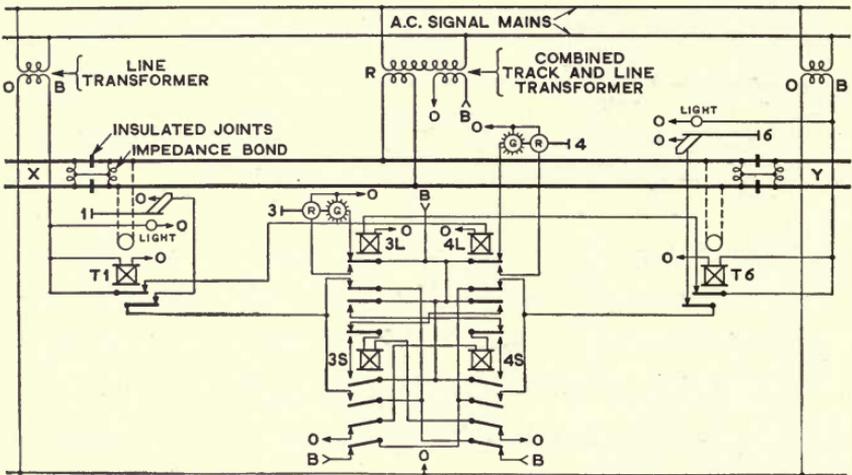


FIG. 275.—Circuit scheme for TDB system.

The stick relay *3S* is active only in connection with west-bound movements; east-bound movements have no effect upon it. Therefore, an east-bound car will set signal 1 at stop when signal 6 is passed. Another stick relay *4S*, is used to limit the control of signal 6 in a similar manner for east-bound movements.

The circuits are so arranged that but one of the two line relays can be energized at any one time. It will be evident that if west-bound car should pass signal 1 at the same time that an east-bound car should pass signal 6, signals 3 and 4 being directly controlled by the track relays, would afford positive protection.

Figure 276 represents a single-block "T B D" installation with four color-light signals on the Cleveland, Southwestern and Columbus Railway at Puritas Junction, Ohio.<sup>1</sup> This line is electrically operated, handling both interurban passenger and

<sup>1</sup> Volume XIV, 1917, *Proceedings*, Railway Signal Association.

freight service. It is a double-rail return system having 600-volt direct current to supply the trolley for propulsion, and 2,200-volt, 25-cycle, single-phase alternating current to operate the signal system. There are two types of transformers; one, an adjustable filler type, *T3*, that steps the current from 2,200 to 110 volts for the line circuit and from 2,200 to 10 for the center-fed track circuit; the other, a constant-potential type, *T2*, that steps the primary voltage from 2,200 to 110 for the line circuit at each end of the track. The track relays are the two-position galvanometer type with 110-volt local coils, while the line relays are 110-volt, two-position vane type. The signals are the Union

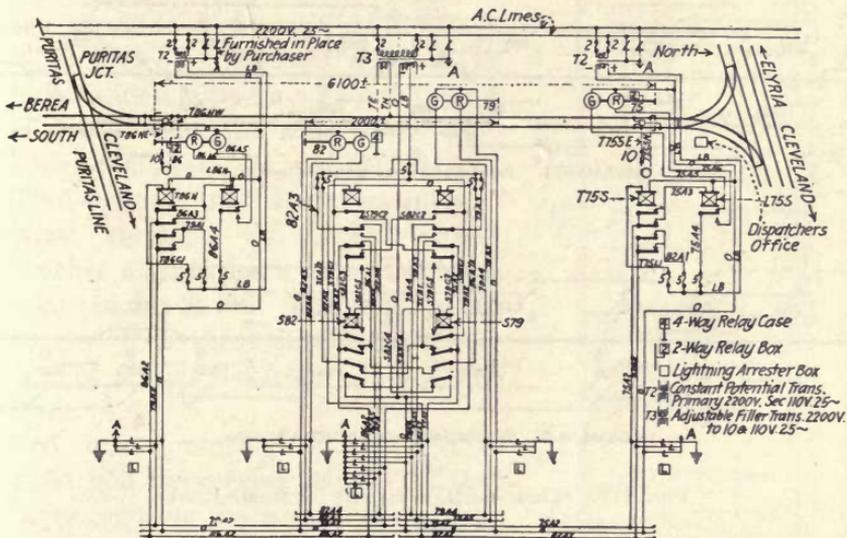


FIG. 276.—Wiring plan for light signals on the C. S. & C. Ry. at Puritas Jct., O. (Proceedings, R. S. A., 1917.)

Model 13, light type, designed to give both day and night indications by lights only.

**167. General Railway Signal, General and Special Plans, A. P. Block System.**—(A), Fig. 277, represents a general arrangement of three-position signals for single track. The full lines above and below the signals mark the length of control for the stop position as before, but the dotted lines shown in addition indicate the control for the caution position. If a train should be at any point between signals 1 and 5, 1 would be in the stop position. If it should be at any point between signals 3 and 7, 3 would be in the stop position and 1 in the 45-degree or caution position. In

(B) a train at any point between signals 3 and 7 would place 3 in the stop position and 1 in the caution position. In (A) signals 3 and 4 indicate in only two positions, stop and proceed. If a train should occupy the track between signals 3 and 7, signal 3 should show a stop position; but if not, signal 3 should give a proceed indication. Signal 5 should show caution if there is a train between signals 7 and 10.

Another plan for three-position signaling on single track has been devised, known as the Absolute Permissive System—absolute for opposing trains and permissive for following trains. When a train enters a block, it sets all the opposing signals in

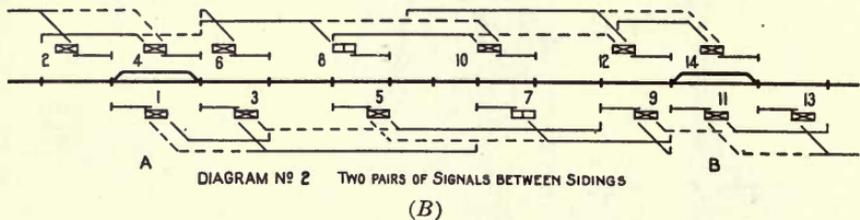
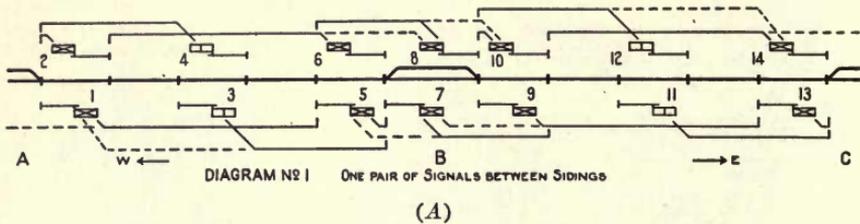


FIG. 277.—Three-position signals for single-track.

that block to stop, but controls only two signals in the rear just as in double-track operation. Figure 279 shows the spacing of the signals and the lengths of their controls. There is one permissive and one absolute signal at each end of each siding and there are four intermediate permissive signals between sidings.

An east-bound train leaving siding A, Fig. 279, sets 2, 4, and 6 all to stop and 8 and 10 to caution; likewise a west-bound train leaving siding C sets 9, 11, and 13 to stop and 5 and 7 to caution. After the east-bound train passes 2, 2 will go to clear; after it passes 3, 1 will go to caution; and after it passes 5, 1 will go to clear and 3 to caution. Diagrams Nos. 4, 5, 6, 7, Fig. 280, show the positions the signals take as a west-bound train moves from B to A. Diagrams 8, 9 and 10 show the positions that signals take governed by two trains moving with



be in the stop position before the train enters section *A*, the stick relay *S* will not be energized. In (*B*), when a train moves from left to right, the control relay *H* for signal 2 becomes energized by means of wire *X* as soon as the train passes signal 4. The wiring is so arranged through a polarized relay that signal 2 then goes to the 45-degree position. When the train reaches *M*, 4 will go to the 45-degree position and 2 to the 90-degree position.

Figure 282 shows the wiring for two sidings with an absolute and a permissive signal at each end and two pairs of intermediate signals opposite each other.

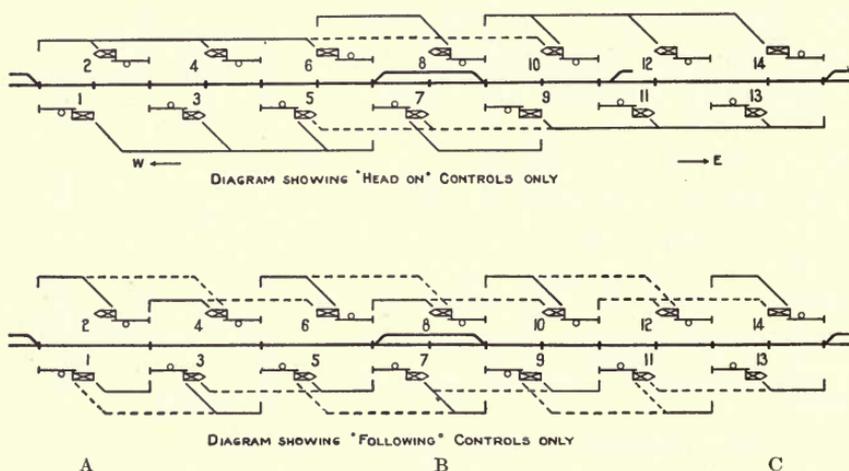


FIG. 279.—Signal control and location diagram for the A. P. block system.

Figure 283 is a typical plan of the A. P. Block System installed on 20 miles of single track on the Puget Sound Electric Railway operating between Seattle and Tacoma, Wash.<sup>1</sup> It is a double-rail return system with 600-volt direct-current power for propulsion. The passing sidings average about  $2\frac{1}{2}$  miles apart. There is a starting signal for traffic in each direction located at the passing track, and there are two intermediate signals between sidings. From the 60-cycle, 2,200-volt, transmission line, the current is stepped down to 110 volts for signal circuits. The signals operate in three positions in the upper left-hand quadrant.

**168. Other Installations.**—Figure 284 represents a typical wiring diagram of a 37-mile installation of alternating-current

<sup>1</sup> *Proceedings, Railway Signal Association, 1915.*

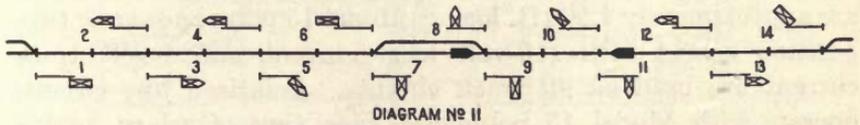
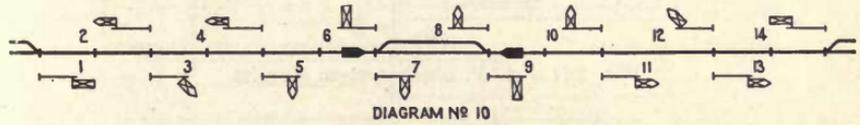
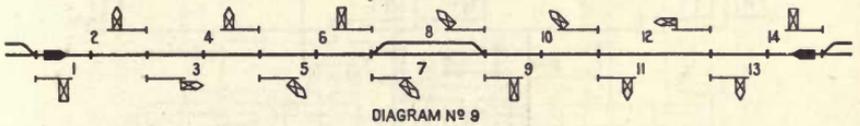
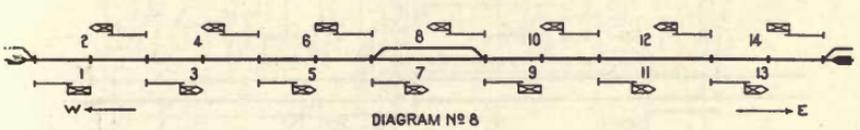
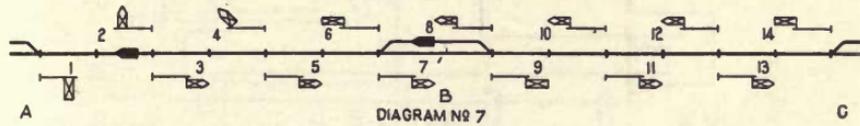
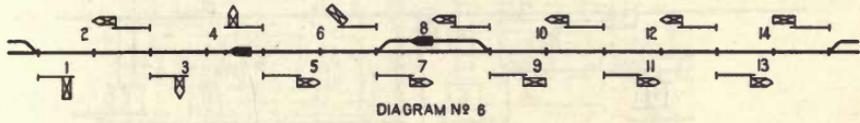
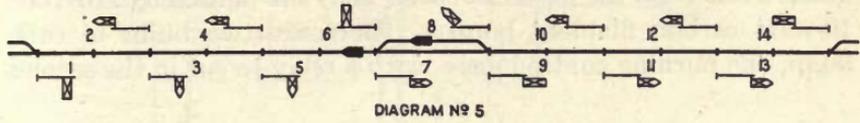
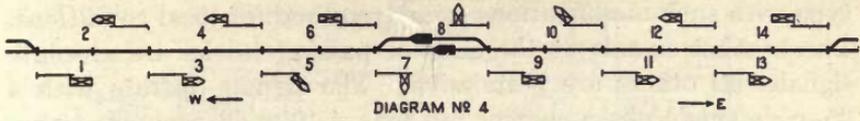
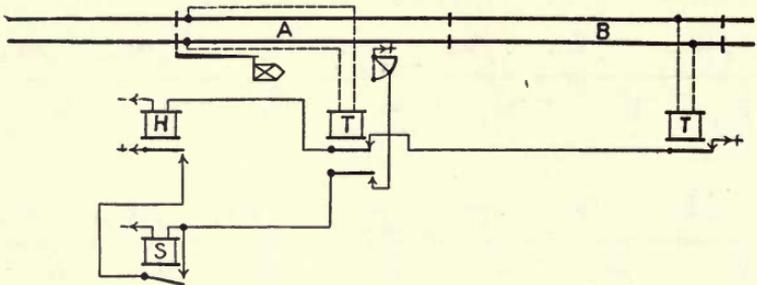
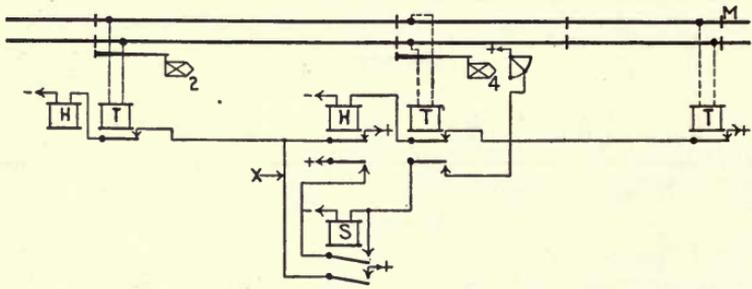


FIG. 280.—A. P. block system diagrams.

signaling on the N. & W. Ry.<sup>1</sup> The circuits are the "T. D. B." type with such modifications as are required for local conditions. The bracket signals at the ends of passing tracks are absolute signals; all others are permissive. The signals operate with a 25-cycle single-phase current fed by a 4,400-volt separate transmission line from the power house. They are lighted by 110-volt, 10-watt carbon filament lamps. There are two bulbs in each lamp, one burning continuously, with a relay to cut in the second



(A)



(B)

FIG. 281.—A. P. block system circuits.

in case of failure of the first. The blocks between passing sidings are approximately 4,500 ft. long. Model 15 polyphase vane two-position relays with 110-volt local current and 4-volt track current are used on all track circuits. Polarized line circuits operate with Model 15 polyphase vane type of relays having 110-volt line and 110-volt local current. All other line circuits operate with vane type of relay.

<sup>1</sup> *Proceedings, Railway Signal Association, 1917, page 448.*

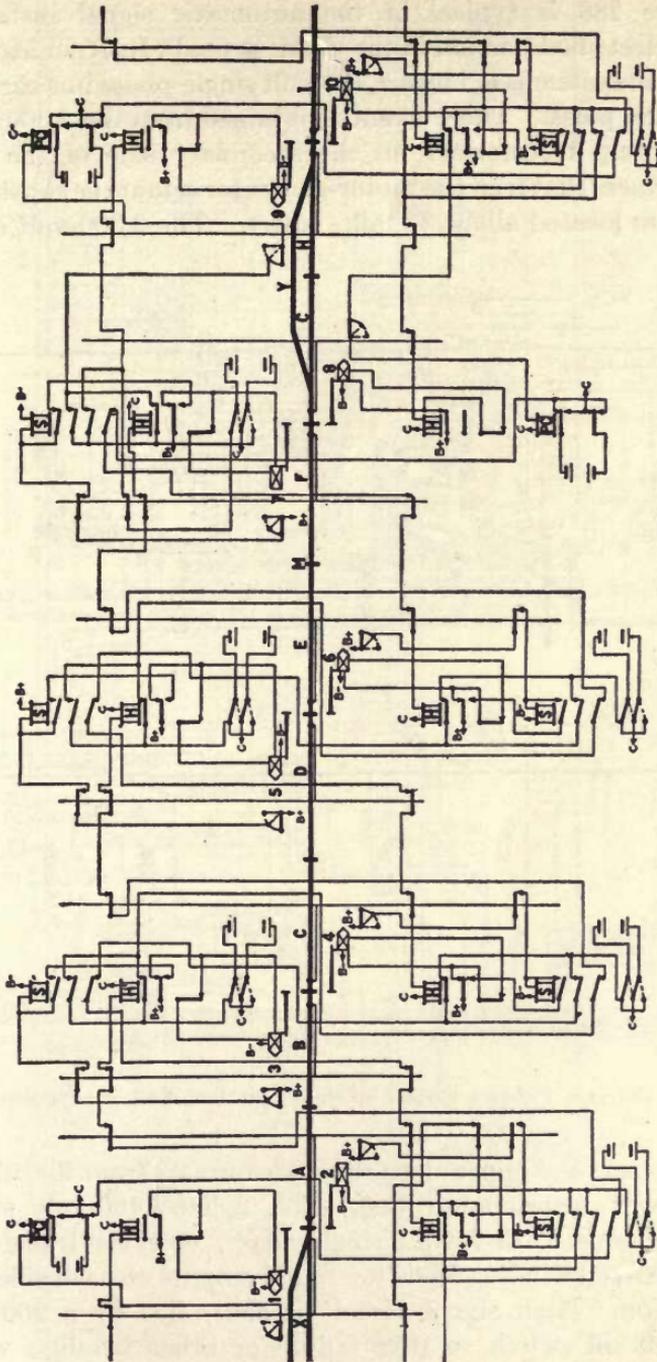


FIG. 282.—A. P. block system circuits.

Figure 286 is typical of the automatic signal installation on the electrified portion of the C. M. & St. P. R. R. in Montana. The signal system is fed by a 4,400-volt single-phase line carried on the trolley poles. This current is obtained from the 2,300/4,400-volt step-up transformer on the secondary side of the power transformers that feed the motor-generator sets at the substations, which are located about 35 miles apart. The 2,300-volt current

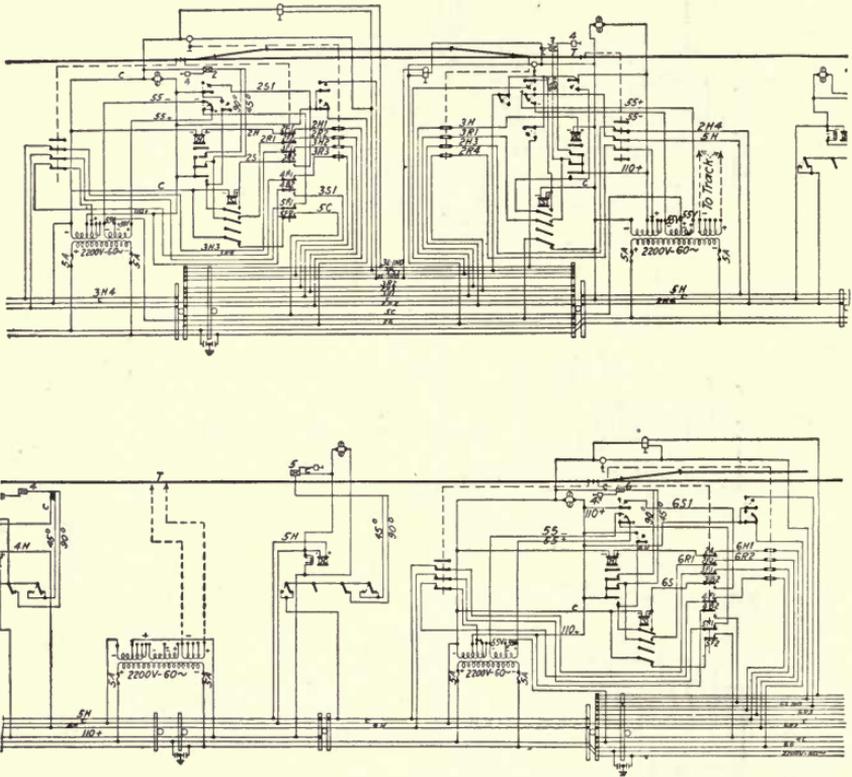


FIG. 283.—A. P. block system on the Puget Sound Electric Railway.

for these sets is stepped down by transformers from the 100,000-volt power transmission line. The 2,300/4,400-volt step-up transformer is a 25 k.v.a., single-phase, 60-cycle transformer. The 4,400-volt winding feeds the signal circuits on each side of the sub-station. Each signal circuit is controlled by a 200-amp., 4,500-volt oil switch so that failure or other troubles will be limited to comparatively short sections. Each sub-station in the automatic signal territory is equipped with transformers,

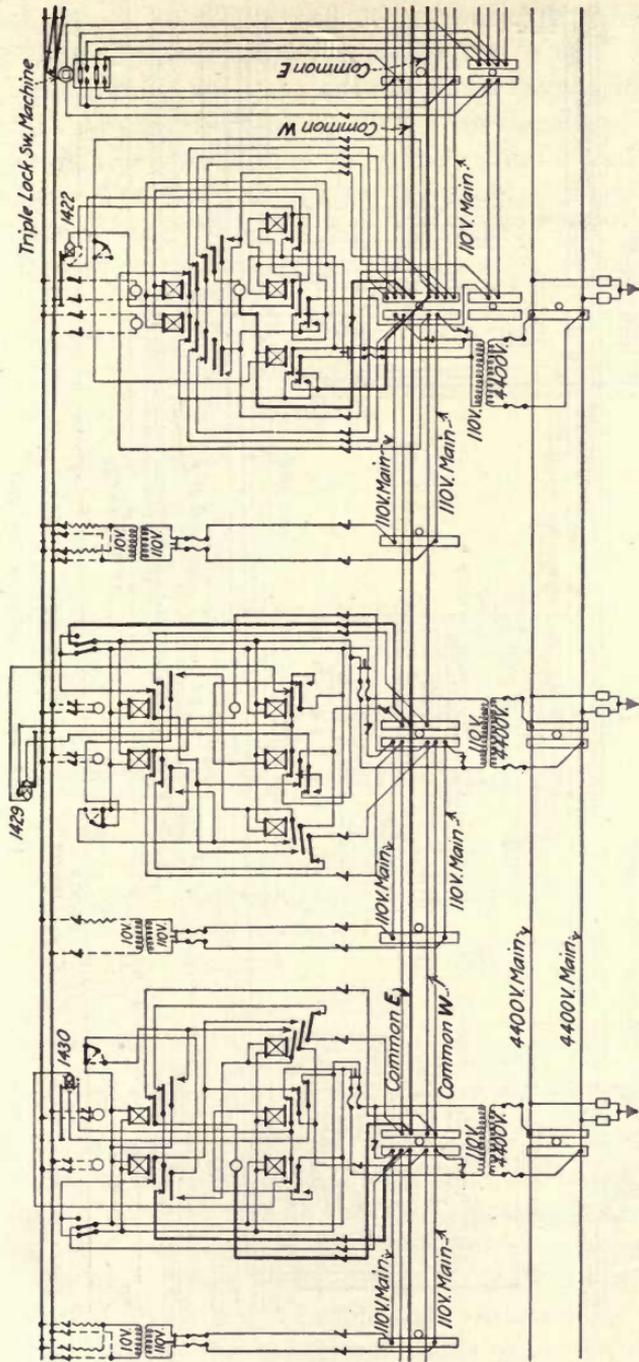


Fig. 284.—Signal circuits on the N. and W. Ry. (Proceedings, R. S. A., 1917.)

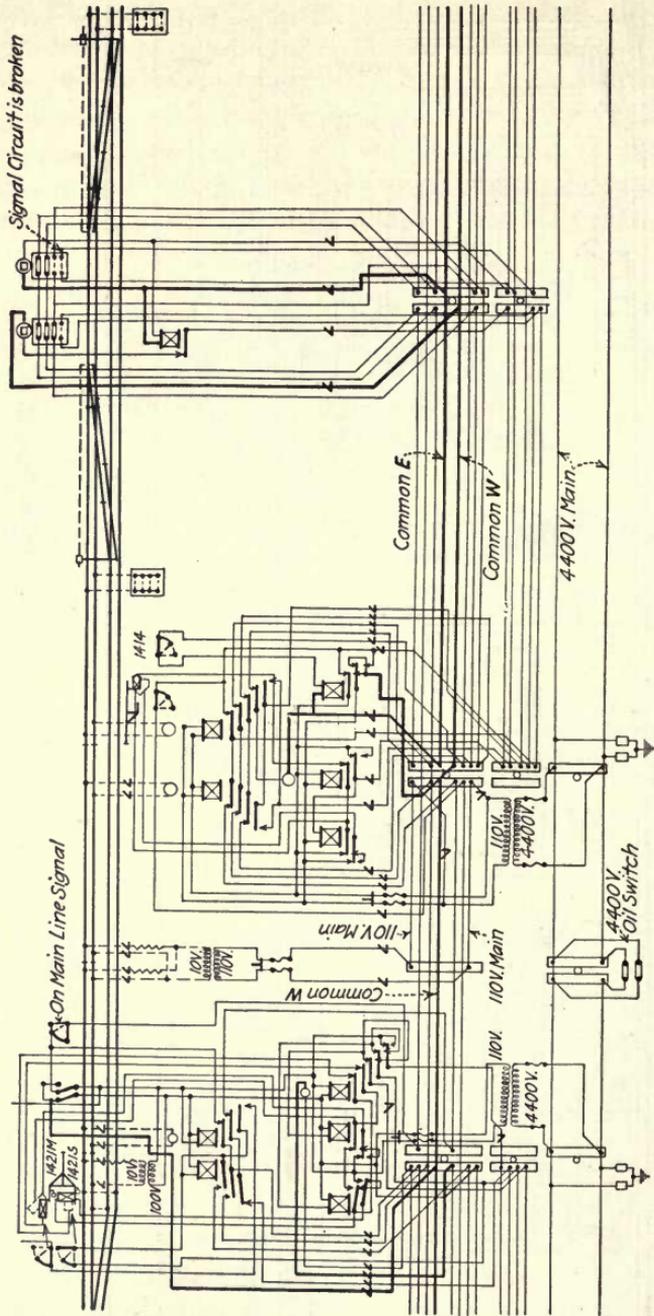


Fig. 285.—Continuation of Fig. 284.

switches, relays, recording and other apparatus shown in Fig. 287 for controlling the 4,400-volt signal line.

The transformers step the current down from 4,400 volts to 110 volts, 60-cycle, single-phase current for signal and other purposes; while track transformers step the current from 110 volts to 1-18 volts. The track circuits are the double-rail return system with end feed when the length does not exceed 7,500 ft., and with center feed when they do exceed this distance. The relays are:

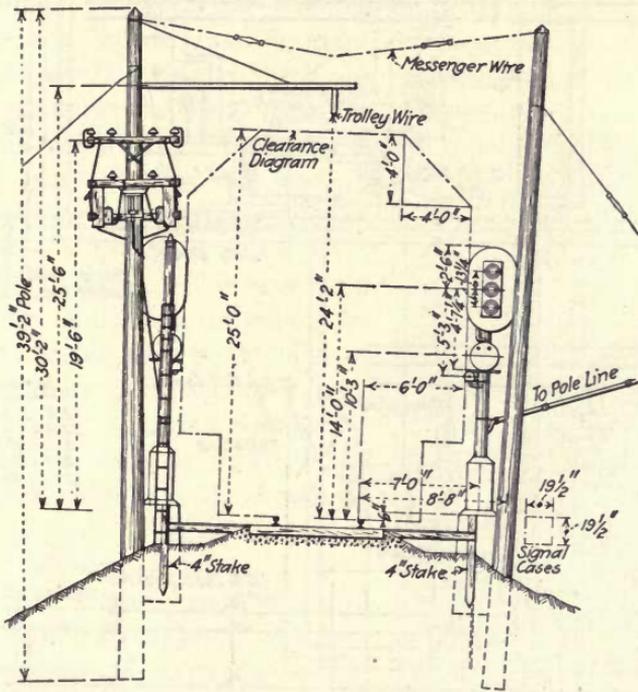


FIG. 286.—Arrangement of apparatus at double signal location, C. M. & St. P. Ry. (*Proceedings, R. S. A., 1917.*)

Model 15 vane type, 60-cycle, single-phase, two-element, two-position, for track circuits; and Model 15, two-element three-position, vane type, both simple and slow-releasing, and Model 15, single-element, two-position vane type, operating as a stick relay for line circuits. The normal voltage for the rail element of the track relay is about 1 volt, while that for the local element is 110 volts. Where the maximum grade does not exceed 1.6 per cent., impedance bonds of 500 amp. capacity with direct-current resistance of 0.0014 ohm are used; and where the grades

exceed this value, bonds of 1,500 amp. capacity with direct-current resistance of 0.0003 ohm are used. The signals are

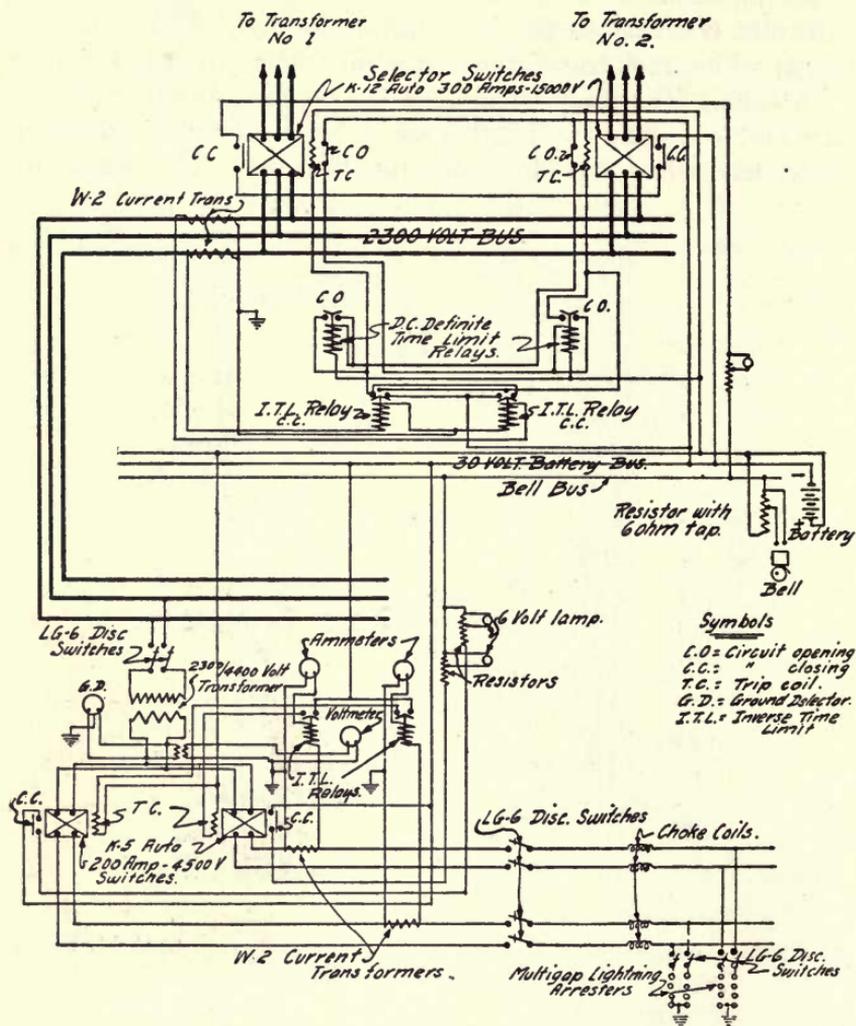


FIG. 287.—Typical substation wiring for feeding signal circuit on C. M. & St. P. Ry. (Proceedings, R. S. A., 1917.)

three-position color-light type for giving both day and night indications.<sup>1</sup>

<sup>1</sup> Proceedings, Railway Signal Association, 1917, and *Signal Engineer*, September, 1917.

## CHAPTER XV

### SIGNAL MECHANISMS

#### TWO-POSITION SIGNALS

**169. Hall Disc Signal.**—The Hall disc signal consists of a cloth disc 17 in. in diameter for giving day indications and a lamp with a glass or roundel  $6\frac{1}{2}$  in. in diameter for giving night indications. The disc and roundel are mounted on aluminum arms that are fastened to the Z-shaped armature of an electro-magnet as shown in Fig. 288. The larger disc is made by fastening a piece of cloth over a wire hoop, a red cloth being used for home signals and a yellow or green cloth for distant signals. The day stop or caution indication is given by exposing the full disc to the view of the engineman; the proceed indication is given by withdrawing the disc from view, showing in its stead the white background on the inside of the signal case. The night stop or caution indication is given by having the red or green roundel stand in front of the signal lamp; the proceed indication is given by having the roundel swing aside exposing the lamp and giving a white light.

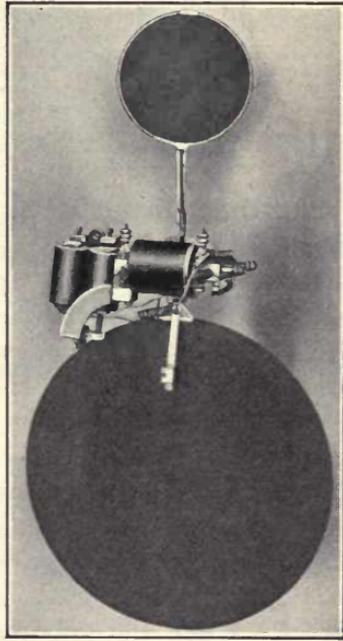


Fig. 288.—Hall disc signal mechanism.

The signal is moved to the clear indication when the Z-shaped armature that supports the colored discs is rotated between the poles of an electro-magnet as shown in Fig. 289. The "hold clear" mechanism is made up of a set of high resistance coils whose armature is a flat bar fastened to the Z armature of the clearing coils. Just as the clearing coils pull the disc to the complete clear position they operate the circuit breaker to place the clearing and the holding coils in series. The total resistance diminishes

the flow of the current to the minimum necessary to hold the signal clear, for it requires much less current to hold the signal clear than it does to operate it. In the normal clear system the signals stand cleared except when the block is occupied by a train. The operating mechanism is all enclosed in a combination metal and wooden case mounted on top of a pole of suitable height.

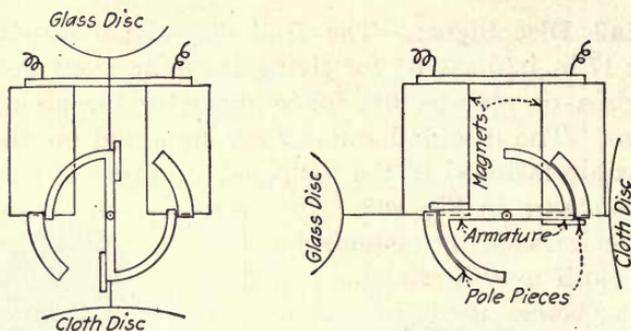


FIG. 289.—Electro-magnets and Z-armature.

**170. Union Style "B" Signal.**—Figure 290 shows the operating mechanism for a Union Style "B" two-position signal where the home and distant signals are on the same mast. The motor, *M*, connected in the signal circuit has on the end of its armature shaft a small pinion, which by means of a train of intermediate gears, drives an endless chain, 10. This has in one of its links a trunnion, 12, that under certain conditions lifts a slot arm, *A*, to which is fastened the up-and-down rod, 6, that operates the signal blade. The slot arm is pivoted near the right-hand end. When the electro-magnet, 7, on the slot arm is energized, the arm becomes rigid, and as the motor armature rotates, the trunnion lifts the fork-head, 5, of the slot arm and clears the signal. When the arm reaches the height where the signal is fully cleared, the lugs on the sides of the fork-head, 5, are caught by the hooks on pawl 24 and the signal is held in the clear position. The top of the slot arm makes contact with 30, breaking the circuit to the motor and making contact for closing the circuit to the distant signal.

The distant slot magnet is made with two windings about the same core, one a low-resistance winding in series with the motor to energize the magnet and yet allow a sufficient amount of current to flow to the motor, the other a high-resistance winding in multiple with the motor to keep the magnet energized when

the motor is cut out and yet reduce the amount of current, for less is required when used only for holding purposes. A wiring

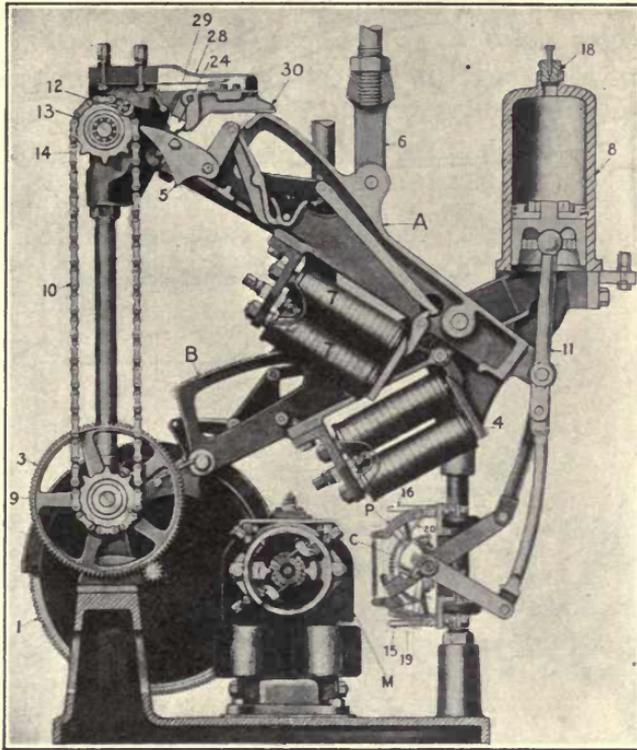
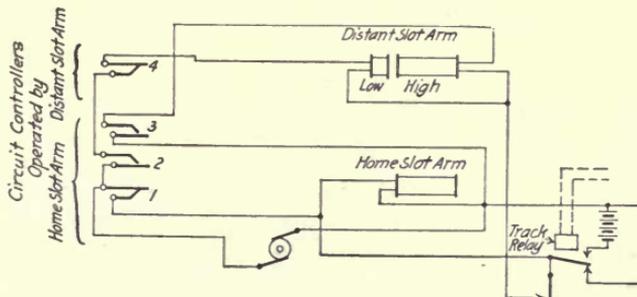


FIG. 290.—Style "B" two-position signal mechanism.

diagram for direct-current control is shown in Fig. 291. The signals stand at the proceed position except when the block is



NOTE: Contact 1 opens and 2 and 3 close just as the home signal reaches the full clear position

FIG. 291.—Wiring diagram for style "B" signal when operated by direct current and controlled by polarized relay.

occupied by a train. When the slot magnets become deenergized, the armature, *T*, falls away by gravity releasing *H*, *W* and *L*, Fig.

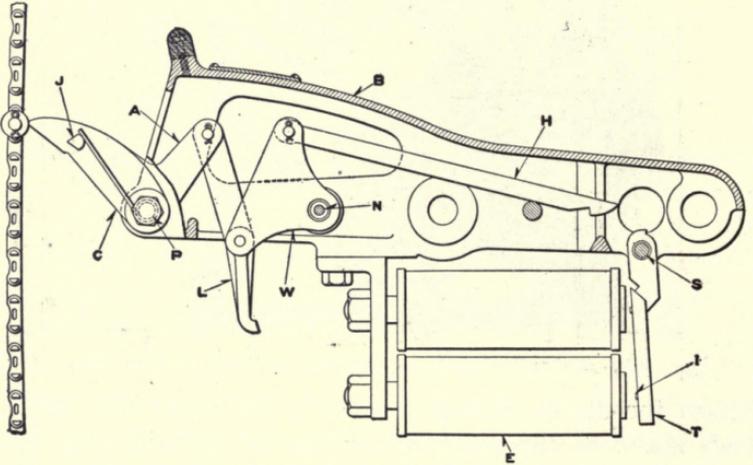
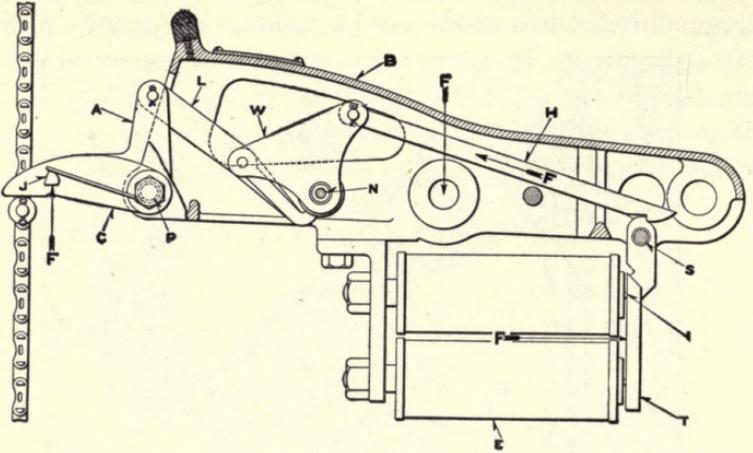


FIG. 292.—Style "B" slot arm.

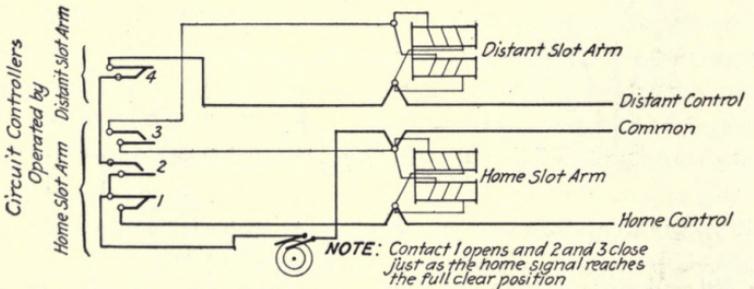


FIG. 293.—Wiring diagram for style "B" signal when operated by alternating current.

292, thereby destroying the rigidity of the arm and allowing the signal to go to the normal position by gravity. The dashpot on the rear of the machine serves to diminish the shock of the fall. There are two sets of chains operated by the same motor, one to clear each signal arm. Figure 293 is a wiring arrangement when the signal is operated by alternating current instead of direct current.

### THREE-POSITION SIGNALS

**171. Union Electro-pneumatic Signal.**—Figure 294 illustrates the principle of three-position semi-automatic signal movement

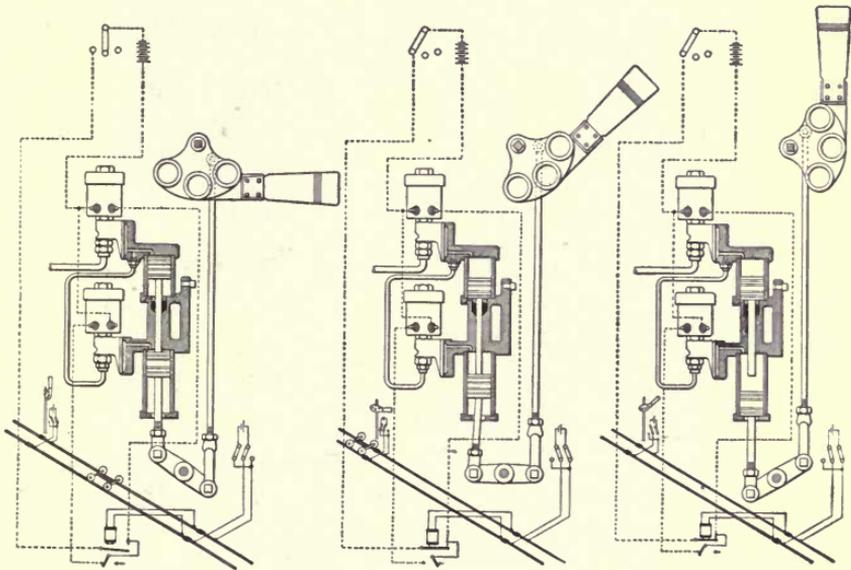


FIG. 294.—Diagram showing the operation of three-position semi-automatic signals.

controlled by both electro-pneumatic interlocking and polarized track circuits. While there is a valve and magnet for both 45- and 90-degree positions, the air supply from the main comes only to the 45-degree valve. The supply for the 90-degree position comes from the 45-degree cylinder, an arrangement which insures that if the air or current to either the 45- or 90-degree positions should be cut off, the signal would recede from the vertical to the caution or stop position respectively.

**172. Union Style "S" Signal.**—The Style "S" mechanism shown in Fig. 295 is an outgrowth of Style "B" to meet the requirements of three-position signaling. The equipment may

be designed to operate with either direct or alternating current. It has only one slot arm, but it has two fork-heads and operates with two chains. The lower chain raises the arm from the stop to the caution position, and the upper one from the caution to the proceed position.

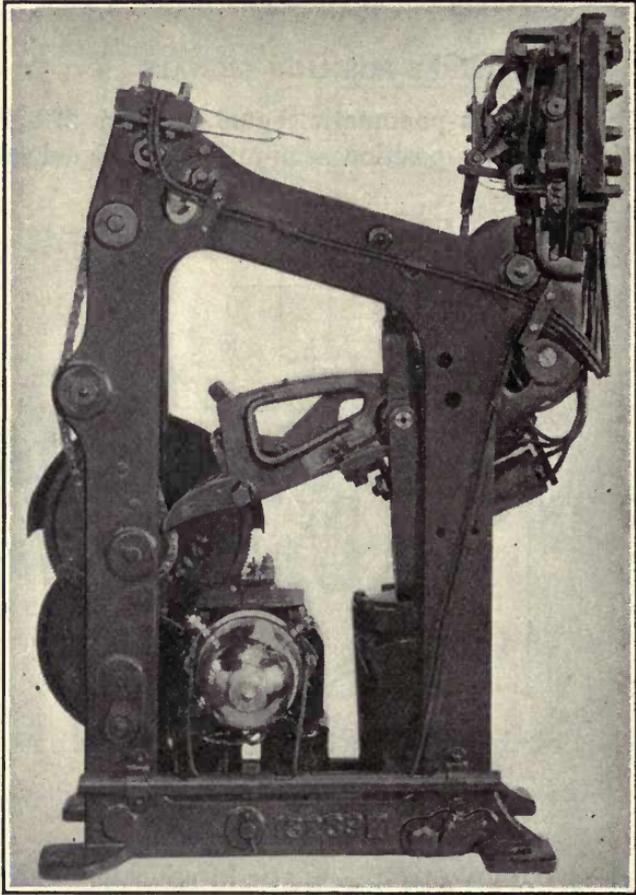


FIG. 295.—Style "S" D.C. motor mechanism.

**173. Union Style "T-2" Signal.**—The Union "T-2" top-post three-position upper quadrant signal is made to operate with either a direct-current or an alternating-current mechanism. The direct-current equipment, shown in Fig. 296, consists of an electric motor that drives a train of gears to operate the semaphore shaft, a direct-current controller, and an appliance for holding the signal in the proceed or caution position. The holding mechanism is placed at the outer end of the armature

shaft. It consists of a ratchet connection, shown in Fig. 297, that engages the shaft only when the motor is moving the

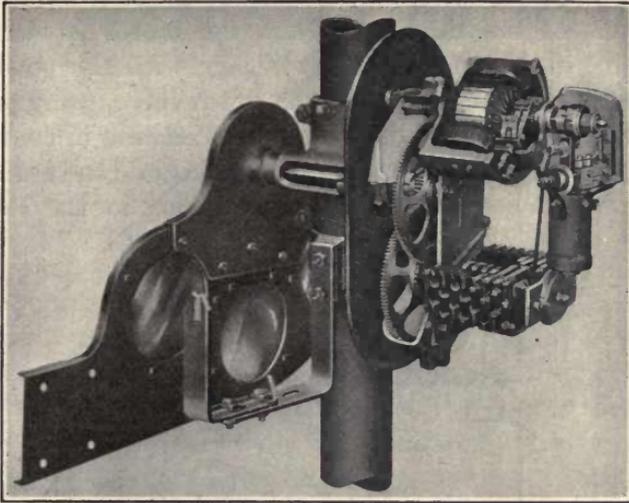


FIG. 296.—Style "T-2" D.C. signal mechanism. Parts cut away to show construction.

semaphore to the caution or the clear position. Connected to the ratchet are three stop blades held by the drum 5. Directly below

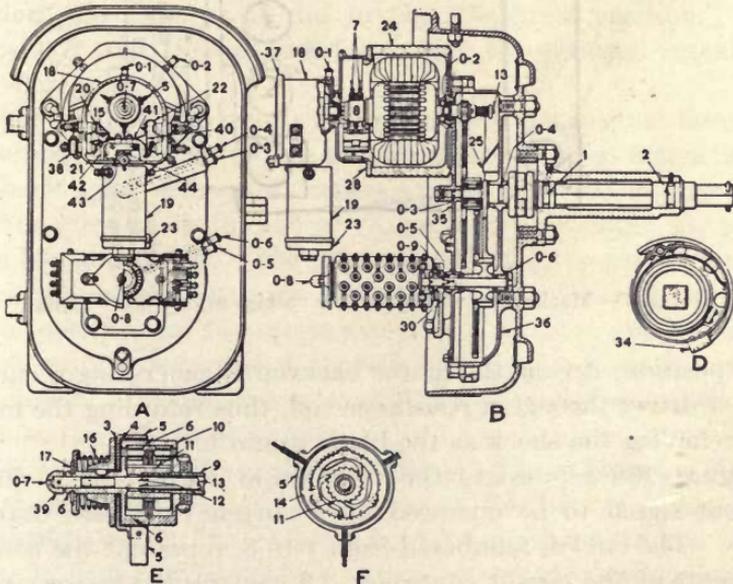


FIG. 297.—Diagram of style "T-2" D.C. signal mechanism and parts.

the stop drum is the slot magnet constructed very much like the pin valve used in electro-pneumatic mechanisms. When the magnet is energized, arm 42 is raised carrying with it the steel

roller, 15, and the contact finger 41, closing the motor circuit at 20. As the stop drum rotates, the blades come in contact with the roller stopping the drum, but allowing the armature to turn on account of the ratchet. When the motor is clearing the semaphore, the ratchet does not engage with the pawls in the stop-drum and consequently it does not revolve, being prevented from doing so by one of the stop blades coming in contact with roller 15. When the slot magnet is deenergized the arm 42 drops by gravity. When the signal blade drops to the caution or

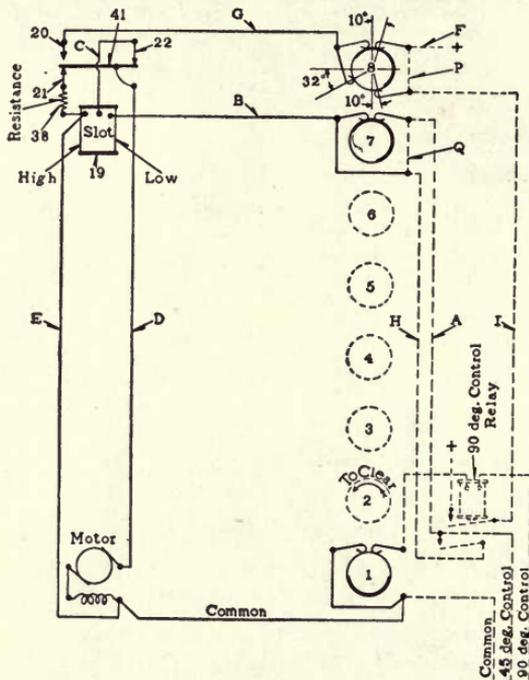


FIG. 298.—Mechanism wiring for low voltage style "T-2" signal.

stop position, it runs the motor backwards generating a current that it drives through a resistance coil, thus retarding the motor and relieving the shock as the blade comes to rest.

Figure 298 represents the mechanism wiring for a direct-current signal to be operated by a current with less than 30 volts. The circles, numbered from 1 to 8, represent the contact segments of the circuit controller. 8 controls the motor circuit, 7 brings the slot under the control of the 90-degree control relay when the semaphore arm is at the caution position, and 1 prevents

this relay from energizing until the signal reaches the caution position.

The signal arm is moved from the stop to the caution position by first energizing the slot magnet 19 through the 45-degree control wire *A*, segment 7, wire *B*, low-resistance winding of the slot coil, wire *C*, contact 22, wire *D*, motor, and common wire. The slot thus energized raises finger 41, which opens contact 22 and places the high- and low-resistance coils in series with wire *E*. This circuit complete to the common wire holds the slot energized, closing contact 20 and thereby completing the motor circuit through wire *D*, wire *G*, and segment 8, to wire *F*. When the semaphore arm reaches the caution position, segment 8 opens the circuit to the motor, but the slot remaining energized by another route will retain the signal in this position.

The semaphore arm is moved from the caution to the proceed position by energizing the 90-degree control relay through segment 1. The current then flows through wire *H* instead of through wire *A* and segment 7, for 7 opens in the first movement of the semaphore arm towards clearing. Another contact on the relay closes the motor circuit through wire *I* and the lower contact on segment 8. This segment opens when the semaphore arm reaches the proceed position, but the coil serves to hold the arm in this position the same as it did in the 45-degree position. The jumpers *P* and *Q*, are added only for two-position signaling, 0 to 90 degrees.

When the control circuits are broken the slot magnet becomes deenergized. The blade falls and the motor becomes a generator. The back point of finger 41 makes contact at 21 closing the local "buffing circuit" to the motor through wire *D*, finger 41, resistance 38, and wire *E*. The generator driving its current through the resistance 38 thus acts as a brake at both the 45- and 90-degree positions of the semaphore arm. If only the 90-degree control relay is deenergized, the slot will be released until contact 7 is closed. The 45-degree control circuit will then retain the signal in the caution position.

**174. General Railway Signal Model "2A" Signal.**—Figure 299 shows the General Railway Signal Model "2A," stop-post mechanism for a three-position upper quadrant signal. The signal is made with either a direct- or an alternating-current mechanism. The direct-current motors are made to operate on either a low voltage, 8, 10, and 20 volts, or a high voltage,

110 volts. Formerly, the alternating-current mechanism voltage varied from 55 to 220, but more recent practice employs induction motors with a voltage of 110.

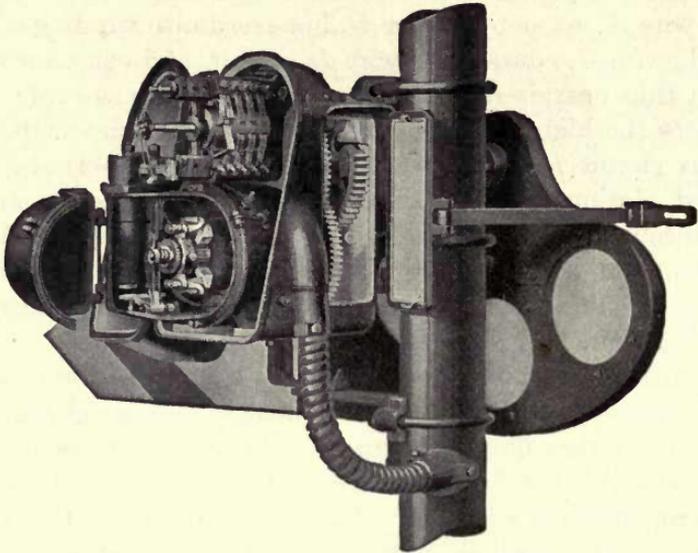


FIG. 299.—Model 2A, top-of-mast mechanism.

The most common low-voltage direct-current type of equipment is made to operate at 10 volts with a current of 2 amp. It is equipped with a four-pole series-wound motor.

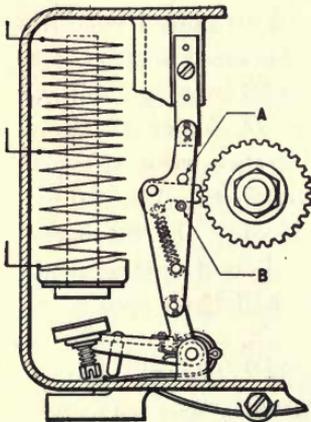


FIG. 300.—Retaining mechanism.

The hold-clear mechanism is shown in Fig. 300. This retaining mechanism is actuated by a compound-wound electro-magnet whose armature operates a pawl that meshes with a toothed disc on the motor shaft. One set of the windings, having a resistance of 26 ohms, is the pick-up coil; while the other set, having a resistance of 630 ohms, is the retaining coil. In the case of the 10-volt machine, 0.25 amp. is required to pick up the armature, but only 0.016 amp. is necessary to hold it and

hence retain the motor in the caution or clear position. The circuit controller makes a contact just before the signal blade reaches the 45-degree and 90-degree positions energizing the pick-up coil and picking

up the hold-clear armature. A second contact throws the pick-up and holding coils in series making a total resistance of 656 ohms. As the signal stands at the proceed position in the normal clear circuit except when a train is in the block, the current is flowing through the coils a very large portion of the time, and

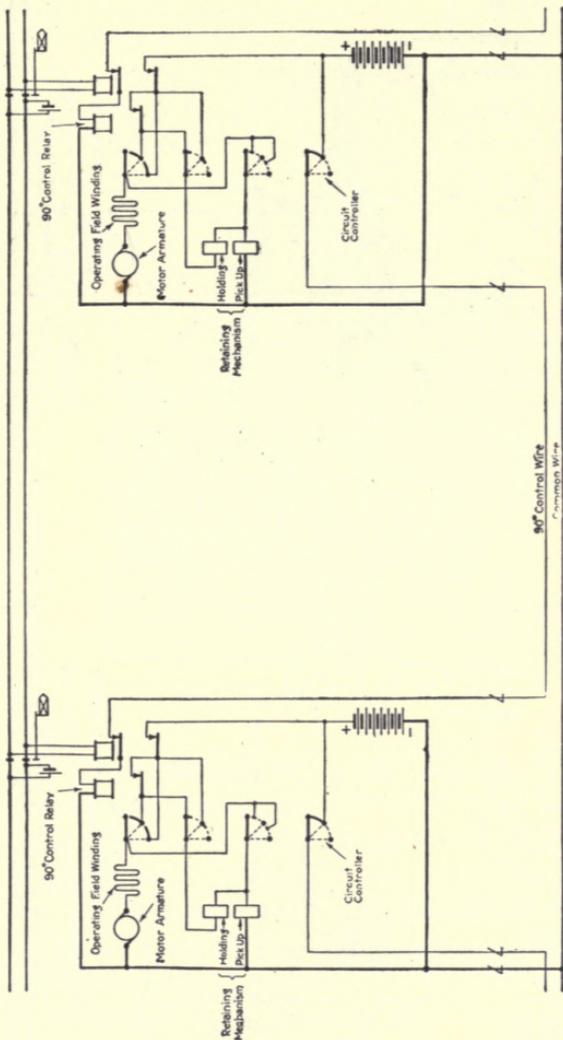


Fig. 301.—Simplified diagram, three-position, D.C. automatic signal, S-, 10- or 20-volt motor.

the high-resistance winding is used to reduce the amount of current to a minimum.

As soon as the track relay becomes deenergized by a train, the holding coils become deenergized also, and their armature falls away by gravity allowing the signal to drop to the caution or

stop position. The force of the falling signal arm is checked by driving a current through a resistance coil. As the blade drops it operates the gears and the motor in a reverse direction from

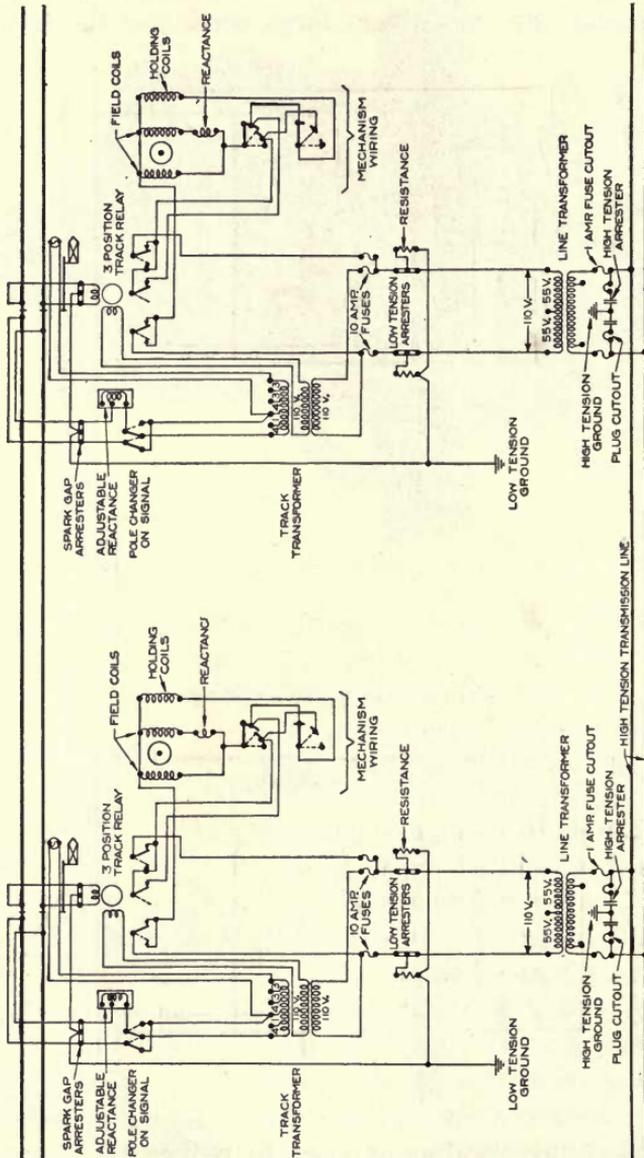


Fig. 302.—Wiring diagram, three-position, A.C. automatic signal.

that used to place the signal at caution or clear. This backward movement of the motor makes it a generator; and just before the blade reaches its caution or horizontal position, this generator

drives its current through the resistance coil, checking the fall of the blade, thereby preventing damage to the equipment. Figure 301 shows the wiring diagram for low-voltage direct-current control of an automatic signal while Fig. 302 shows it for alternating-current control.



FIG. 303.—Style "K" signal.

**175. Hall Three-position Style "K" Signal.**—The Hall Style "K" three-position signal is made with either a direct- or an alternating-current mechanism. Figure 303 represents the top-post type built with direct-current equipment. The motor operates on a vertical axis and drives the signal arm by means of a series of gears. Gear *B*, Fig. 304, is attached rigidly by screws to the hold-clear clutch magnet *G*. The armature *M*, of this magnet is supported on a separate shaft from the gear *B* and magnet *G* and rotates independently of them. The blade is held in the caution or clear position by energizing the magnet *G* causing a friction contact between the magnet surface and the outside bronze rim on the armature. The motor armature is held from rotating in the reverse direction by means of the brake *N*, Fig. 305. A train coming into the block will deenergize the

magnet and allow the blade to drop to the caution or stop position.

Two governors, *O-O* fastened to the armature *M*, revolve with it and as the speed increases due to the fall of the blade, the governors swing out by centrifugal force and engage against the under surface of *I*, a stationary portion of the hold-clear magnet. The tendency of the blade to increase its speed as it falls, serves to exert a pressure by the governors to hold it in check.

The magnet is shown partly in section in Fig. 304. *U* is the winding and *T* is the core. The core is fastened to an outside shell connected with the insulated piece *W*, the bottom of which at *I* serves as a friction contact for the governors, *O-O*. The

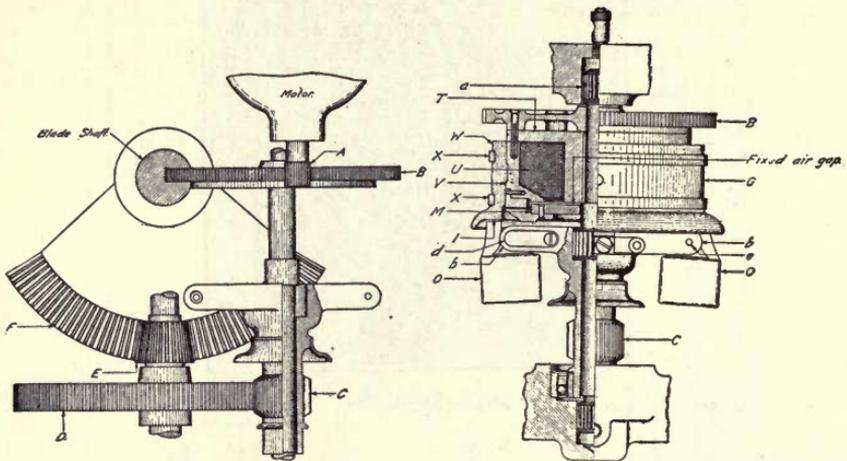


FIG. 304.—Operating mechanism for style "K" signal.

brass rings, *X*, serve to connect the terminals of the magnet winding with the outside battery through two brushes, one on each ring. In order to prevent such injury to the mechanism as comes from stopping suddenly, there is a ratchet appliance to permit the motor to continue to run after the blade comes either to the caution or stop position.

**176. Hall Style "L" Signal.**—The motors of the Hall Style "L" signal are made to operate on either 8 or 110 volts direct current or on standard voltages and frequencies of alternating current. Figure 306 represents the top-post mechanism constructed with direct-current equipment. The motor is a bi-polar series type operating on a horizontal axis. Its power is transferred to the

signal arm through a train of gears driven by a small pinion secured to the motor spindle by means of a double cone slip clutch.

The hold-clear mechanism is located in front of the motor and consists of a latch lever in which is a spring actuated latch dog shown in (A), Fig. 307.

One end of the lever is pivoted on the bearing frame, and the lever itself is free to swing downward. As the hold-clear magnet becomes energized after the signal arm comes to the desired position, its armature lifts the latch lever until the latch dog engages with one of the rollers mounted in a support flexibly connected to the outer end of the motor spindle. This prevents the mechanism from backing up.

The controller consists of two spindles so geared together that when they are operated by the pinion that is connected to the main gear spindle they will move simultaneously. These spindles carry hubs on which are mounted contact cams, one of which is shown in (B), Fig. 307. A snubber is provided to relieve the shock when the signal arm drops to the 45 and 0 positions.

**177. Federal Three-position Type "4" Signal.**—The Federal Type "4" signal is provided with an electric motor of suitable characteristics to adapt it for use on direct currents of varying potentials from 8 to 110 volts or on alternating currents of 110 and 220 volts with the usual variation in frequency which may be encountered.

Figure 308 represents a 10-volt direct-current top-post mechan-

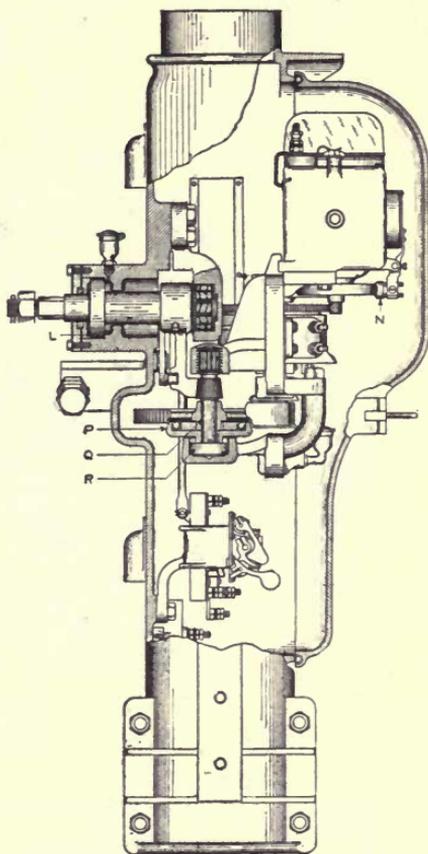


FIG. 305.—Operating mechanism for style "K" signal.

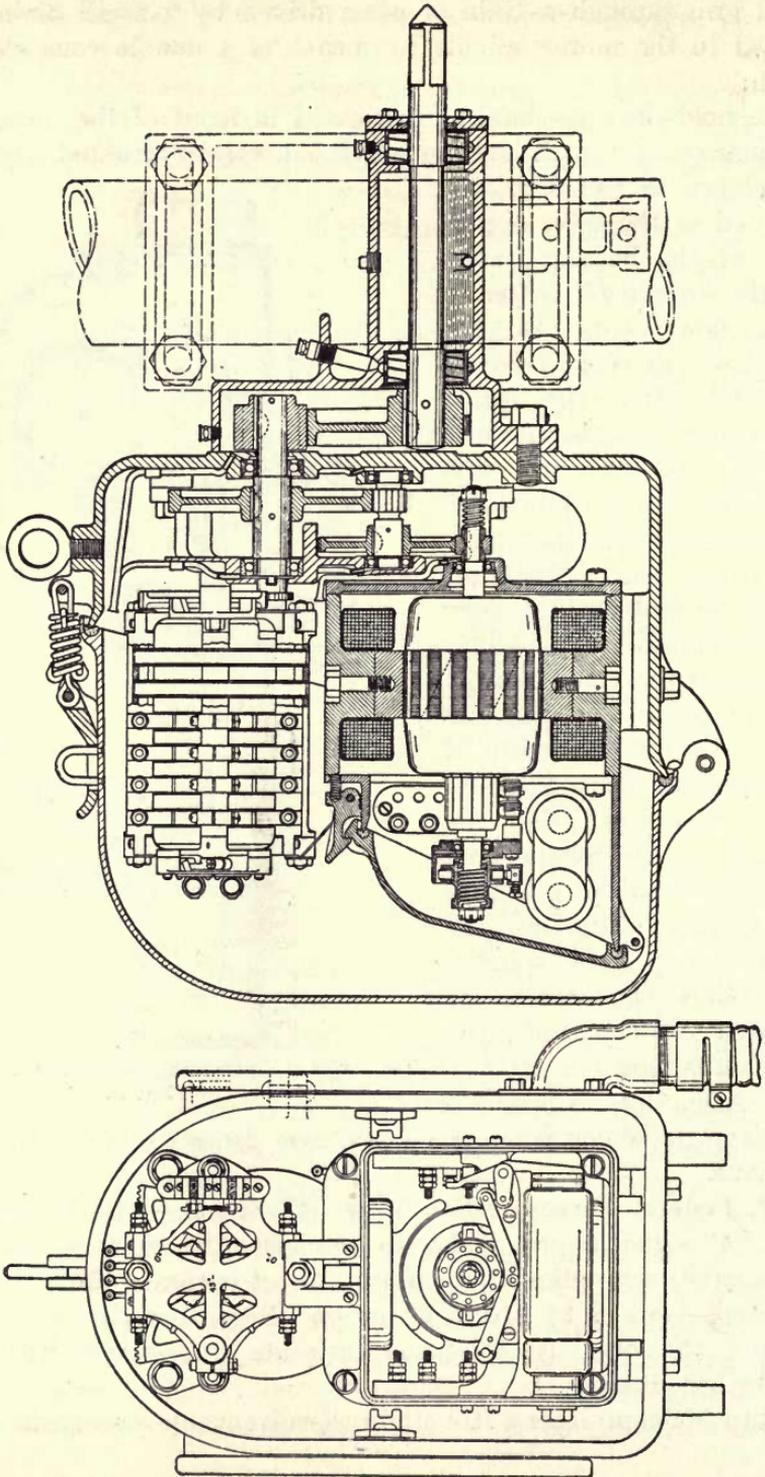
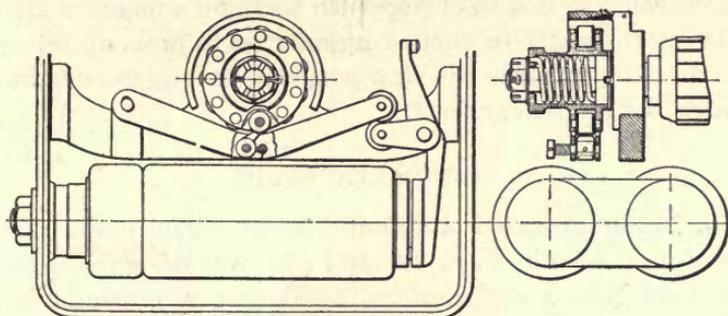
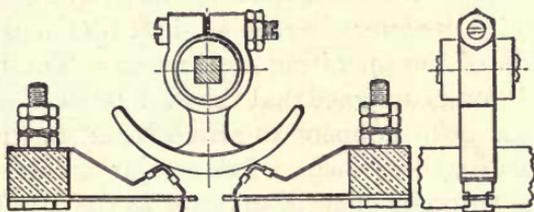


FIG. 306.—Style "L" signal mechanism.

ism. By a train of gears the motor drives the blade to the 45- and 90-degree positions. When the semaphore spindle has



(A)



(B)

FIG. 307.—Hold-clear mechanism and circuit controller for style "L" signal.

reached a position corresponding to proceed, the circuit through the motor is interrupted and a circuit through the hold-clear

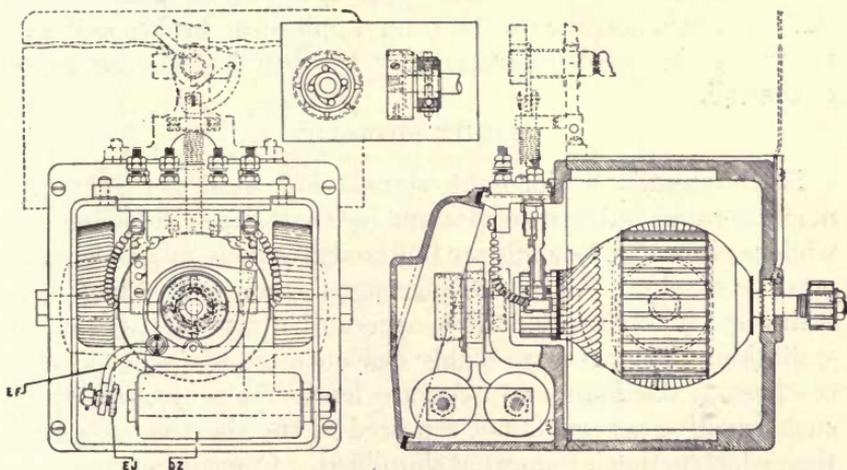


FIG. 308.—Federal type "4" top-post signal mechanism.

magnets is established. The hold-clear magnet for 10-volt direct-current operation is generally wound to a resistance of

500 ohms. As the hold-clear magnet, *DZ*, becomes energized, it attracts the armature *EJ* supported by the arm *EF*. This causes a detent roller or dog to engage with teeth on a member attached to the motor shaft in such a manner as to prevent the motor from rotating towards the stop position, as long as current flows through the hold-clear coils.

#### AUTOMATIC STOPS

**178. Motor-operated Automatic Stops.**—The motor-operated train-stop, shown in Figs. 309 and 310, was designed for use on lines of the New York Municipal Railway Corporation operating in and between New York City and Brooklyn. It is installed between the rails of the track and is operated by a separate tripper arm through the medium of a rocking shaft that may be connected to either side of the operating mechanism. The trip arms are made of cast iron so designed that they will break if any unyielding portion of the train happens to strike them, but not when the train trip arm strikes them. The circuit breaker is operated directly from the main shaft of the stop, as the drawing indicates.

The stops on these lines are used in connection with all signals except dwarfs at interlocking plants, and are governed by the indication of the signals. When a signal is in the stop position, the tripper arm stands above the rail; and if a train attempts to pass the signal set in the stop position, the arm engages a valve that opens the air line on the train, applies the brakes and stops the train. When the signal is clear, the arm drops below the top of the rail.

#### LIGHT SIGNALS

**179. General.**—Color-light signals are built for long- and medium-range outdoor service and for short-range indoor service; while position-light signals are built only for long- and short-range outdoor service. The long-range signals are used for high-speed trains and involve considerable accuracy in construction and installation. They require highly concentrated filament lamps for condensing the light and accurate lenses for projecting it. As such exacting service is not required of the short-range signals, their construction is somewhat simplified. Concerning long-range signals, the following paragraphs are taken from the 1917 *Proceedings* of the Railway Signal Association:<sup>1</sup>

<sup>1</sup>Page 8.

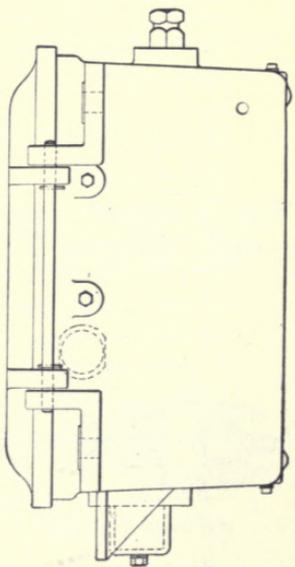
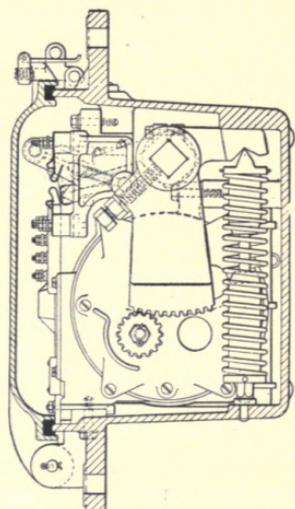
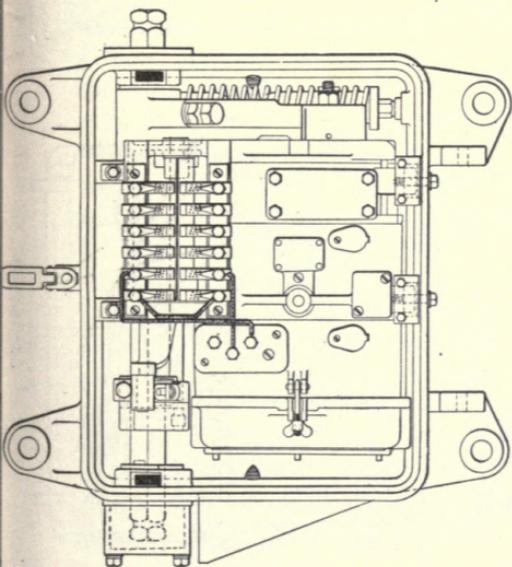
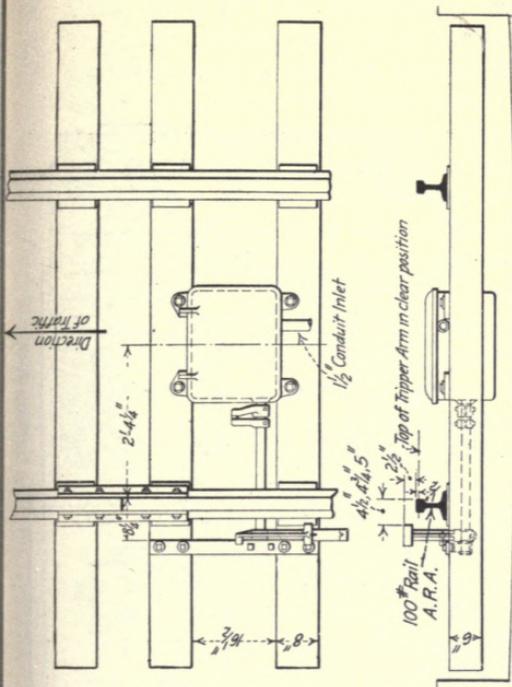
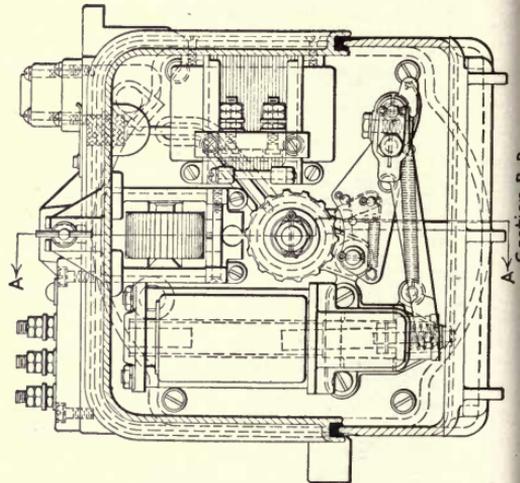
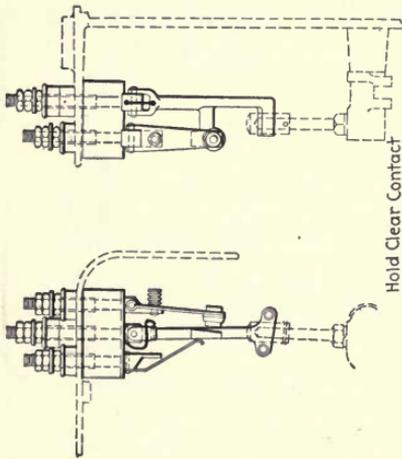
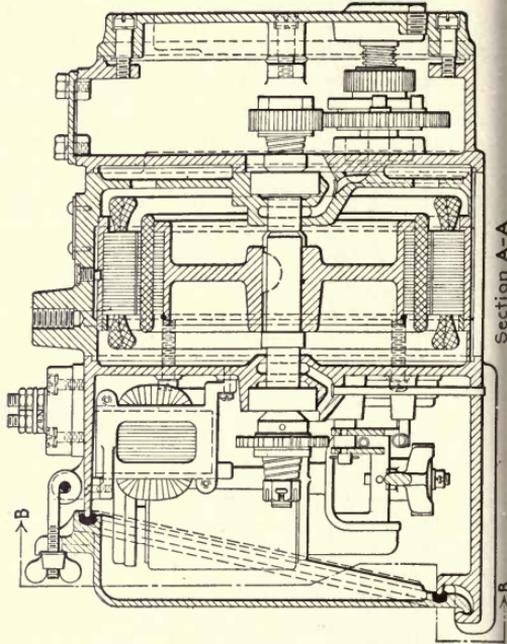
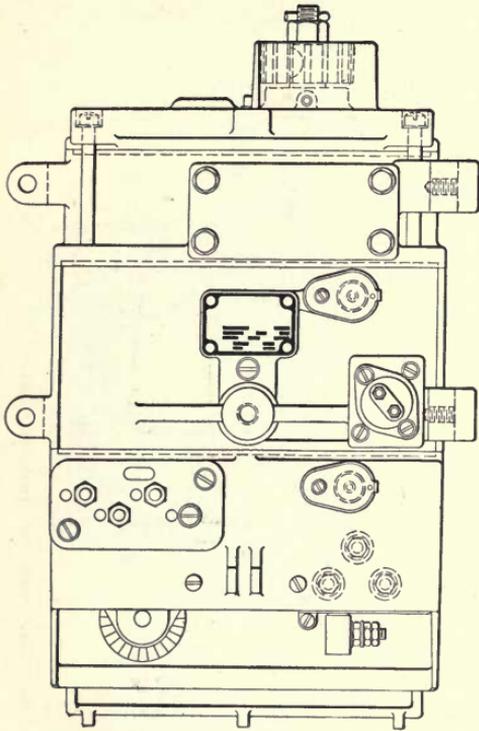


FIG. 309.—Automatic stop. (General Railway Signal Co.)



"In broad daylight, under unfavorable sun and background conditions, there are two alternatives open for the light source: Either a very high wattage lamp must be used, or a lower wattage with a concentrated and accurately located filament. (As illustrating the remarkable influence of concentrating the light source, we refer to the April and May, 1914, numbers of the *Signal Engineer*, where this subject is fully treated. Figure 24 shows that a 24-watt concentrated filament lamp gives a peak candlepower of 65,000, and the same wattage in commercial lamp gives 500 candlepower. To get a long-range indication, it is necessary to project a beam candlepower of 5,000 or 6,000.)

"The concentrated filament requires an accurate basing of the lamps so that they may be interchanged without disturbing the alignment of the signal. The automobile headlight requires refocusing when a new lamp is put in place. This cannot be done with the light signal. It would involve too much work and would also involve the employment of two experienced men to take care of realignment whenever a lamp burned out. Moreover, it is difficult, if not impossible, to obtain any very accurate adjustment for maximum candlepower in the field. Such work is properly done in a dark room. The lamps for high-speed signals are, therefore, rebased in a special jig, which permits the accurate location of the base with respect to the filament.

"If a commercial concentrated filament lamp were to be used, the diameter of the filament would have to be increased to allow for commercial variations in lamp manufacture. It might be possible to design a lamp filament having sufficient concentration and yet having area enough to permit commercial variations, but, as these commercial variations permit nearly  $\frac{1}{8}$ -in. departure in all directions from a theoretical filament location, the lamp wattage would have to be increased eight or nine times at least to maintain the same degree of concentration and consequently the same candlepower.

"The long-range signal has a very small beam spread, on account of the concentrated filament employed. Consequently, these signals have been designed to facilitate accurate alignment by providing separate horizontal and vertical adjustments. When it is still necessary to provide some means of increasing the spread to take care of curved track, a prism lens, which spreads or "fans" the light in the horizontal plane, but which does not increase the vertical spread, is used, and the light is projected in the most efficient manner possible (see page 131 of the May, 1914, *Signal Engineer*). By means of this prism, the maximum possible range on curved track is secured with the minimum possible expenditure of power."

#### COLOR-LIGHT SIGNALS

**180. Long-range Type.**—This type of signal is used principally on steam and high-speed electric roads. A doublet lens is

employed in order to utilize to better advantage the rays of light from the lamp. The outer lens is made of clear glass from  $8\frac{3}{8}$  to 10 in. diameter with approximately 4 in. focal length. The inner lens is colored and is generally  $5\frac{1}{2}$  in. in diameter with a  $\frac{1}{2}$  in. focal length.

Figure 311 shows the Union Style *L*, three-position long-range colored-light signal installed on the electrified portion of

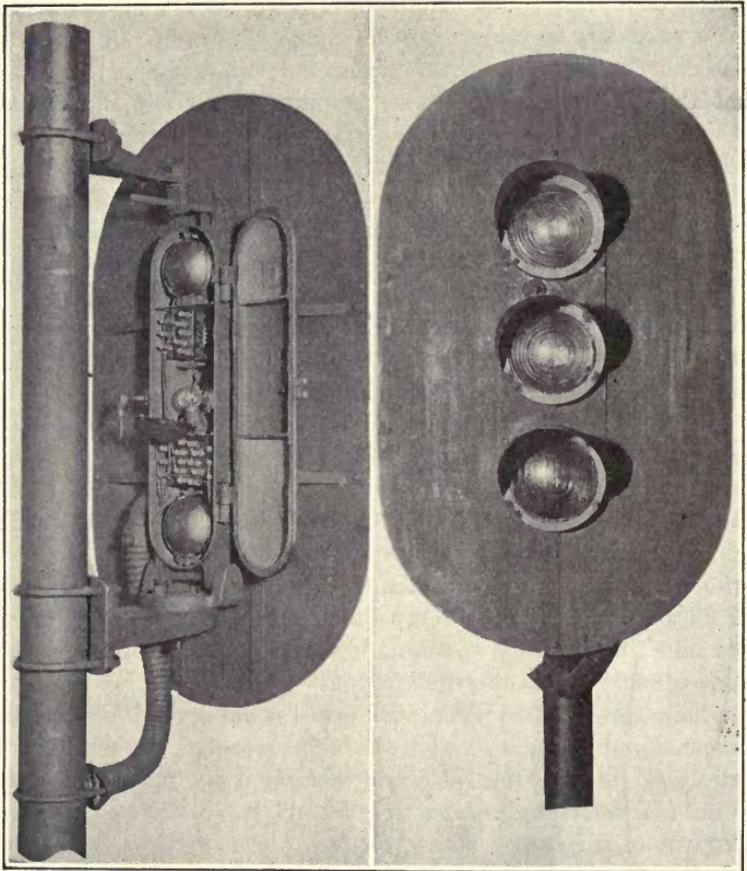


FIG. 311.—Front and back views of Union style "L" light signal.

the C. M. & St. P. R. R. The range of vision on a tangent varies from 2,500 ft. when the sun is shining directly on the lens to 4,000 ft. under more favorable conditions. The three outer doublet lenses, each  $8\frac{1}{2}$  in. in diameter, are provided with an individual hood over each lens. The bottom lens gives the stop indication, the middle one caution, and the top proceed. The main lamps for lighting signals are 6-volt, 28-watt, with con-

centrated filament. On tangents, lenses having a spread of 3 degrees were used, but on curves deflecting prisms of 10 or 20 degrees were used depending upon the amount of curvature of the track and the length of view. A metal background extending entirely around the hood was provided for each signal to intensify the signal indication.

Figure 312 shows a double light signal installed on the Union Traction Company of Indiana by the General Railway Signal Company. The signals governing in each direction are mounted

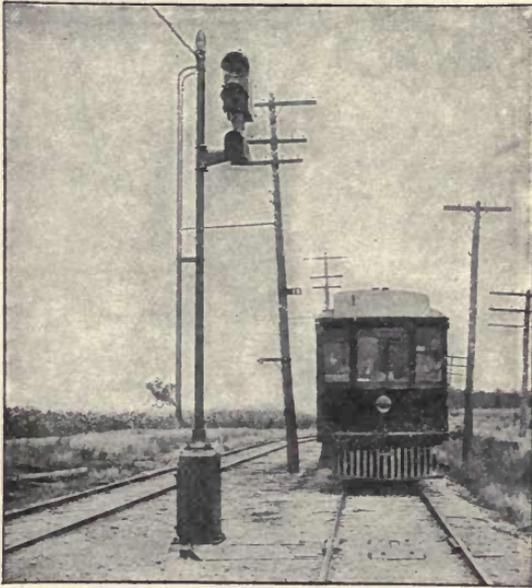


FIG. 312.—A. P. B. light signal.

back to back on a bracket on the same pole. The upper case houses the red and green lamps and the lower the yellow or permissive lamp. This signal is used in the "Absolute Permissive Block System," the red being the absolute indication for opposing movements and the combination of red and yellow being the permissive indication for following movements.

**181. Medium-range Outdoor Type.**—The medium-range signal is provided with a simpler lens, generally  $5\frac{3}{8}$  in. in diameter. The three-position signal shown in Fig. 313 is lighted with two 36-watt 110-volt tungsten lamps connected in multiple. It has a range of vision approximately 1,500 ft. under adverse conditions of sunlight and 2,500 ft. at other times. The design is compara-

tively simple and the signal is used on medium-speed interurban and elevated lines.

Figure 315 is a detail of the interlocking signal shown in Fig. 314 and used on the subway and elevated lines of the New York Municipal Railway Corporation. The signal is semi-automatic, lever-controlled, and has two pairs of lights with three in each

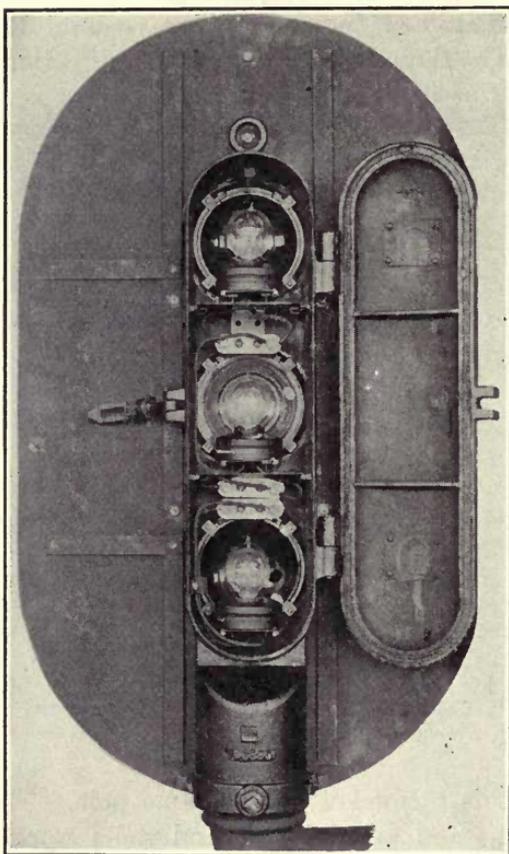
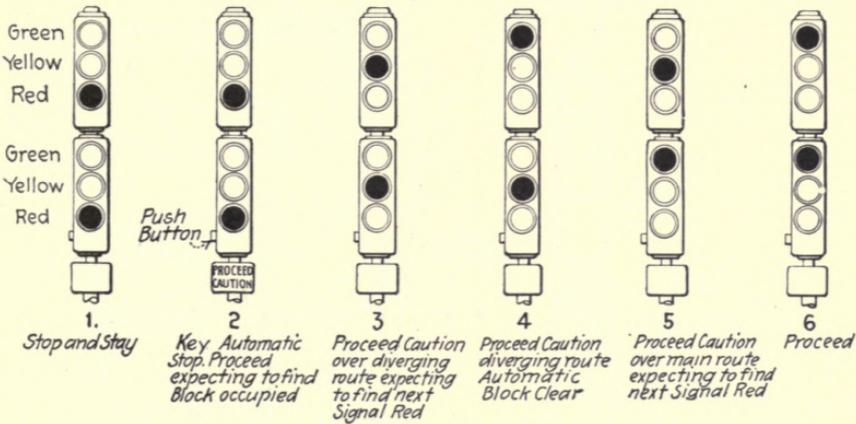


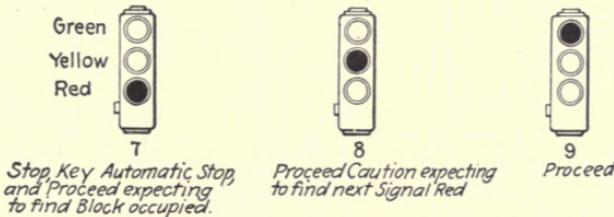
FIG. 313.—Union Model "N" light signal. Rear view.

pair that serve the same purpose as a two-arm semaphore signal. Five-in. doublet lenses with a 30-watt lamp behind each lens, are used on the elevated lines. The subway signal is an exact duplicate of the elevated type, except that a plain lens and a 10-volt 12-watt lamp is used. An emergency signal referred to as a calling-on signal is mounted just below the lower lens of this double signal. When this calling-on signal is displayed the words "Proceed at Caution" are illuminated. The calling-on signal is always

displayed with two red lights showing above and means that the motorman is to press the emergency pushbutton located on the side of the signal. This push-button is used to clear the stop



SEMI-AUTOMATIC INTERLOCKING SIGNAL



AUTOMATIC SIGNALS



INTERLOCKING DWARF SIGNALS

FIG. 314.—Signals used on lines of New York Municipal Railway Corporation. (General Railway Signal Co.)

in case of an emergency when the signal apparatus fails or when it becomes necessary to use the calling-on signal. After the motorman clears the automatic stop he proceeds slowly expecting to find the block occupied or to cross over to another track and

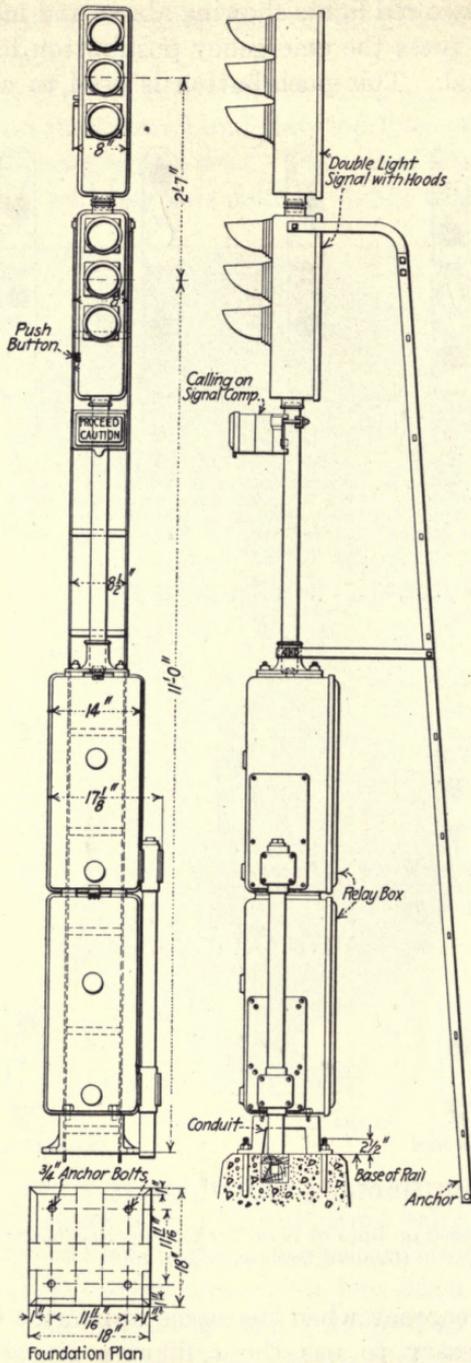


FIG. 315.—Interlocking signal shown in Fig. 314.

move against the normal direction of traffic. A rear home signal is used on these lines for the same purpose as a distant semaphore signal. It is a standard single three-indication signal, semi-

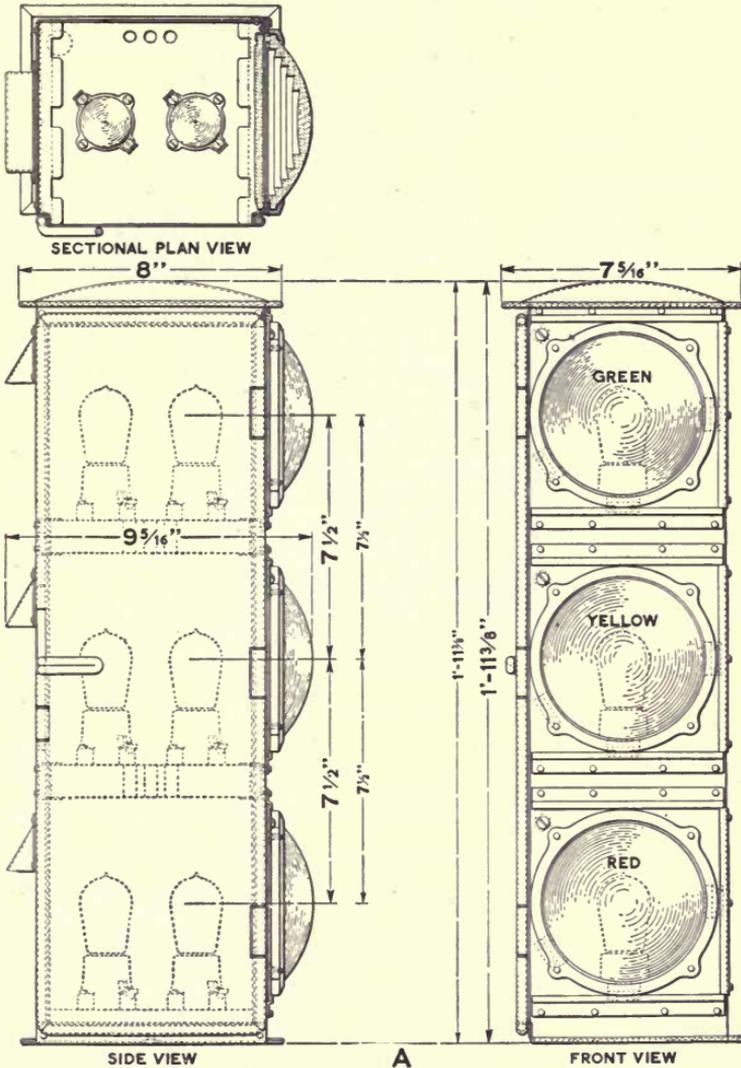
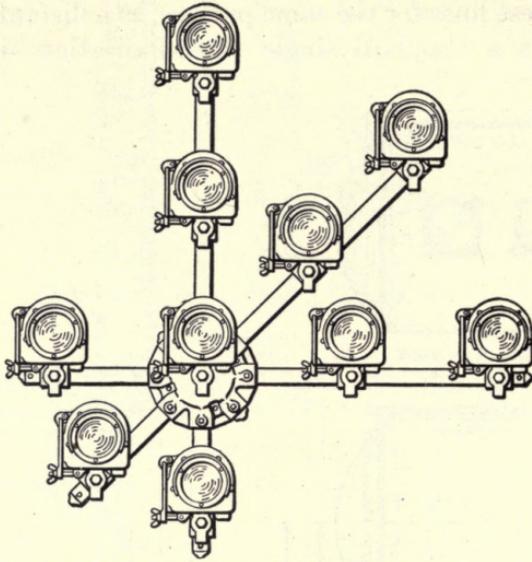


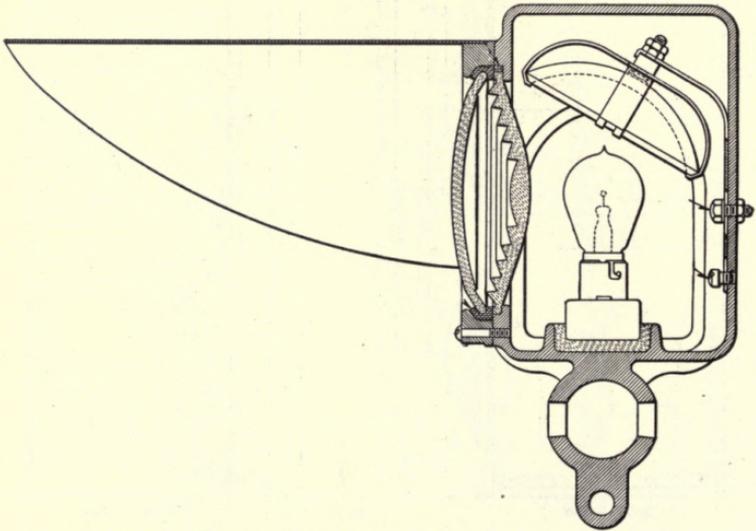
FIG. 316.—Subway and tunnel signal. (Union Switch and Signal Co.)

automatic in its operation. The dwarf signal used at interlocking plants is a non-automatic two-indication signal.

**182. Short-range Subway and Tunnel Type.**—Subway and tunnel signals are simple in design since there is no need of protec-



(A) Signal lamps, background omitted.



(B) Details of signal lamp.

FIG. 317.—Position-light signal. (*Union Switch and Signal Co.*)

tion against sunlight. The hood is unnecessary, the lenses are small, and the lights require less current than the outdoor type. Figure 316 shows the type of signals installed in the Boylston Street Subway of the Boston Elevated Railroad. Each lens has behind it two 4- c.p. 55-volt tungsten lamps.

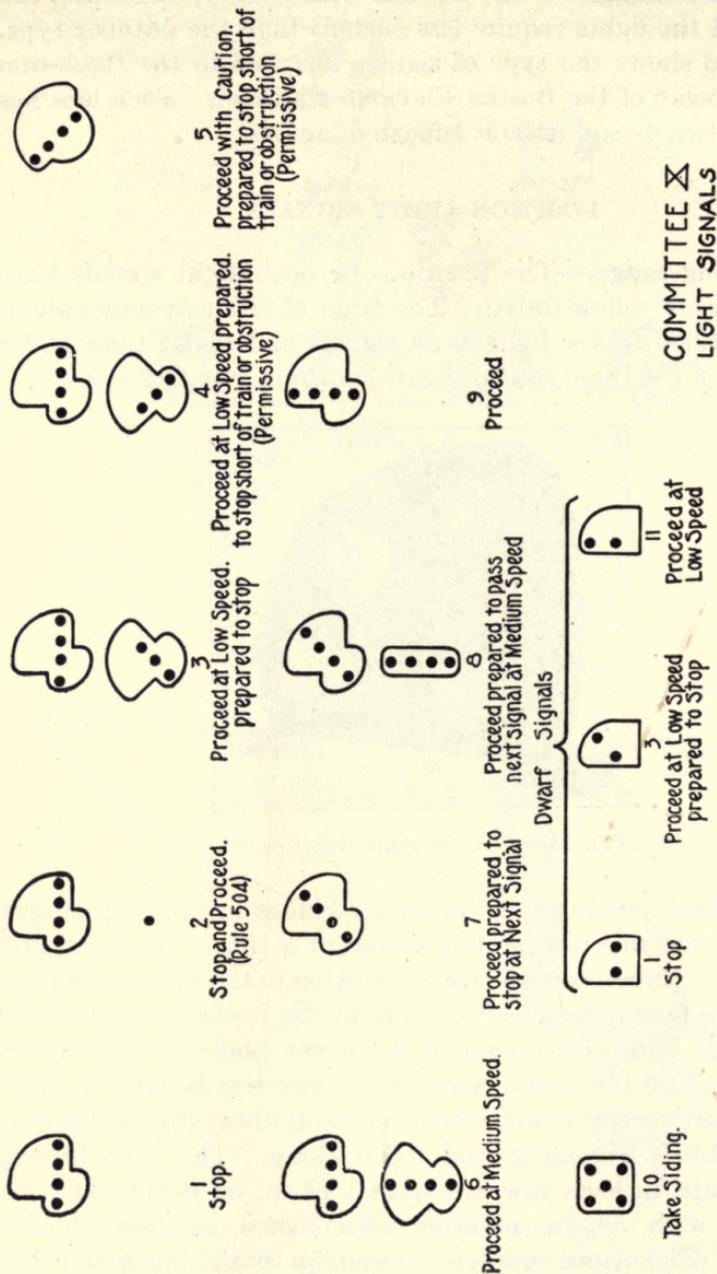
#### POSITION-LIGHT SIGNALS

**183. Long-range.**—The position- or beam-light signals have lenses that are yellow tinted. The range of vision averages about 2,500 to 4,000 ft. for high-speed signals and about 1,000 ft. for dwarfs. Of the three rows of lights shown in Fig. 317 represent-



FIG. 318.—Position-light dwarf signal.

ing the three positions of the upper blades in upper quadrant signaling, only one can be illuminated at a time. The selection is done by a three-position relay operating in the same manner as for a semaphore signal. The lights in the lower portion of the signal, Fig. 319, correspond to the lower blade of a two-arm semaphore, and the combination of the two sets is used to carry out the more recent aspect scheme of the Railway Signal Association for block signaling and interlocking. The four 12-volt 5-watt lamps in each row are spaced 18 in. on centers and are equipped with  $5\frac{3}{8}$ -in. inverted toric lenses, as shown in (B), Fig. 317. The same voltage is used for both day and night indications. The glass reflector placed at an angle just above the lamp tends to throw the light downwards and assists in giving a good short-range indication. Each lens is covered with a deep hood to protect it from the sunlight.



Note. Medium Speed-Not exceeding 30 MPH.  
 Low Speed- " " 15 MPH

FIG. 319.—Position-light indications. (Proceedings R. S. A., 1918.)

CORRECTED TO JULY 26, 1918.

**184. Short-range or Dwarf.**—The dwarf is made with two lights in each row giving the three indications of a semaphore blade in upper quadrant signaling. As the range is shorter, the lenses are not so large and the filament adjustments are not so accurate.

## CHAPTER XVI

### HIGHWAY CROSSING SIGNALS

**185. General.**—In these days of extensive highway travel, it has become the practice to install signals at grade crossings to give warning of the immediate approach of trains. This has become practically a necessity since the advent of the automobile, for it is the common occurrence now for persons to start across country on an overland journey of hundreds and even thousands of miles crossing railroad tracks that they have never seen nor heard of before. It was different in earlier days when all such travel was by buggy or wagon where one seldom went more than 12 or 15 miles from home and knew the details of every railroad crossing within that section. The busiest crossings in the cities are protected by flagman and by gates; but it is impractical to watch every crossing, especially those in outlying and country districts.

Both visible and audible signals have been installed to meet this need. The visible signals are constructed with a plain light, a flash light, a moving light, a wigwag arm, or combinations of such methods of giving indications. On account of the increase in travel by automobile and motorcycle with their attending noises, the visible signal seems to meet the requirement better. Besides, more and more of the automobiles are made enclosed, especially for winter service. The audible signal is essentially the ringing bell. Many manufacturers are making use of both visible and audible signals, combining them in one signal for both day and night indications.

**186. Highway Crossing Signals.**—Figure 320 represents the Union Three Aspect Automatic Flagman. When a train approaches the crossing where such a signal is installed, the red banner swings across the road to give warning. The banner carries a red light and has the letters S-T-O-P painted across the face of the disc. The red lamp is lighted only when the banner is in motion. When there is no train approaching the crossing, the banner is concealed between the two metal screens which

bear the words "Look," "Listen." On top of the post is a gong type of bell that rings while the banner is swinging.

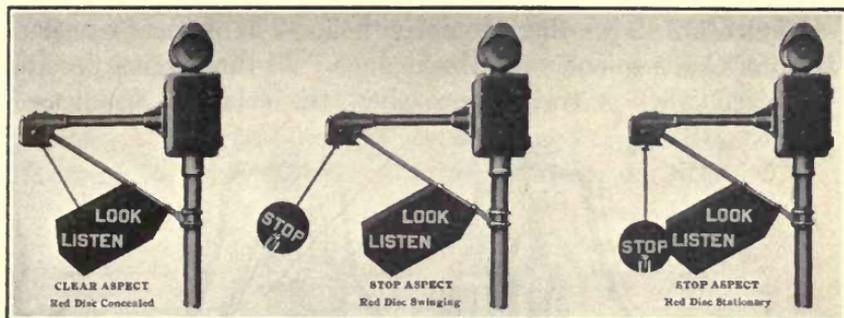


FIG. 320.—The Union three aspect automatic flagman.

The operating equipment consists chiefly of electro-magnets, two pairs of which are operating coils that swing the arm and one pair is a set of holding coils that retain the arm between the screens. The flagman operates on a local circuit of 10 volts direct current requiring 0.4 amp. to swing the arm and 0.4 to light the 5-watt, 12-volt lamp. The holding coils are wound with a resistance of 1,000 ohms, thereby reducing to a minimum the amount of current consumed while the signal is giving the clear indication. The lamp attached to the banner can be either fixed or oscillating. The fixed lamp can be so arranged with an oil burner as to give flashes of light as the arm swings back and forth.

Figure 321 is a highway crossing signal having a crossing sign, a wigwag signal, and a locomotive type of bell. The signal gives warning by ringing the bell and by waving at right angles to the highway, the red wigwag disc, which is 26 in. in diameter. When the signal is in motion, the red lamp in the center of the disc and the words "DANGER," "STOP," are all illuminated both day and night to intensify the indication in giving the warning of an approaching train.

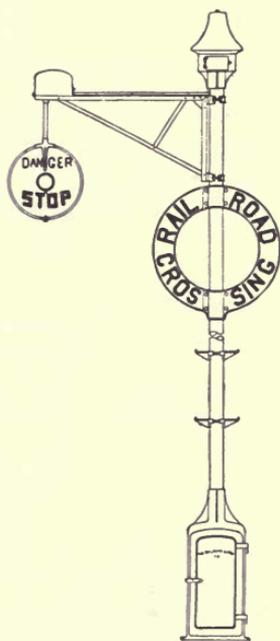
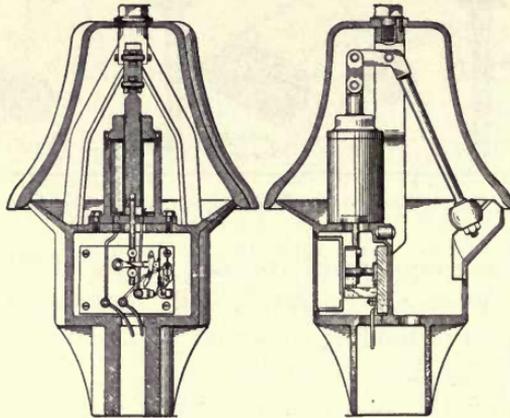


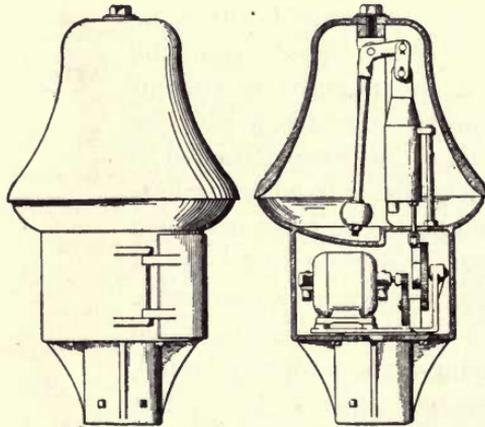
FIG. 321.—Wigwag crossing signal. (Railroad Supply Co.)

The bell ringing at the same time the wigwag is active is an additional means of calling attention to the movement of the train.

Figure 322 shows the locomotive bell. The operating mechanism in (A) is a solenoid electro-magnet. As the magnet becomes energized when a train approaches, the solenoid armature is



(A)



(B)

FIG. 322.—Locomotive types of crossing bells. (*Railroad Supply Co.*)

drawn downward causing the hammer to strike the bell. Just as it is drawn down far enough to make the hammer strike, the current is broken by the snap-switch, and the hammer falls by gravity. When the armature reaches its normal position, it completes the circuit through the snap-switch and energizes the relay to ring

the bell again. The process is repeated 40 to 60 times a minute giving as many blows to the bell. This equipment can be used only with direct current.

The locomotive bell may be operated also by a motor as shown in (B). By means of a train of gears, the motor drives a cam that raises and lowers a weight to which is attached the bell hammer. The weight simply serves to give regularity to the striking of the bell. The motor may operate on either direct or alternating current.

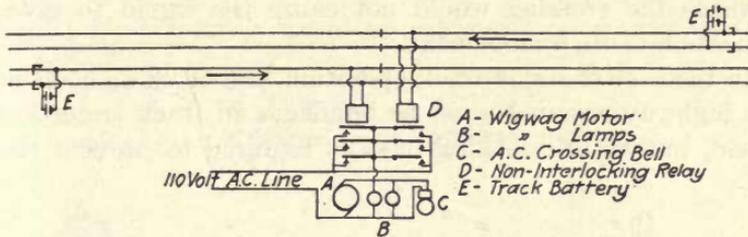


FIG. 323.—110-volt A.C. wigwag circuit. Double track. (Railroad Supply Co.)

**187. Highway Crossing Signal Circuits.**—Figure 323 shows the wiring for operating the motor, lights and bell by 110-volt alternating current. The relays are of the neutral type controlled by simple track circuits. The approach of a train makes back contact with the relay armature and completes the circuit to

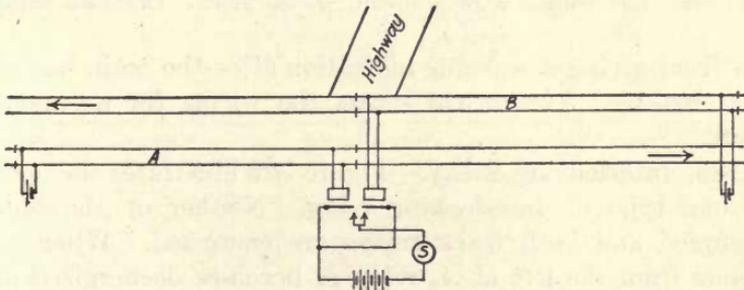


FIG. 324.—Low voltage signal circuit for double-track line.

operate the wigwag and the bell. The wigwag is actuated by a motor connected to it through a train of gears.

Figure 324 shows the wiring for operating highway crossing signals by low voltage on a double-track line. A bonded track section with ordinary track circuits is established for about a half mile on the approach side of each track. Insulated joints

are maintained at each end of each section. Two ordinary relays would meet all of the requirements, but an interlocking relay with the interlocking device removed is sometimes more desirable, for it is equipped with better connections for such service and occupies less space. A train in either section, *A* or *B*, will shunt the relay for that section and cause the signal to operate as long as either of the blocks is occupied. As soon as the train moves out of the block, the relay becomes energized again and the signal resumes its normal position. A train backing up towards the crossing would not cause the signal to give any indication of such movement.

In the case of single-track operation, the block on each side of the highway crossing must be bonded, and track circuits established, but an interlocking relay is required to prevent the sig-

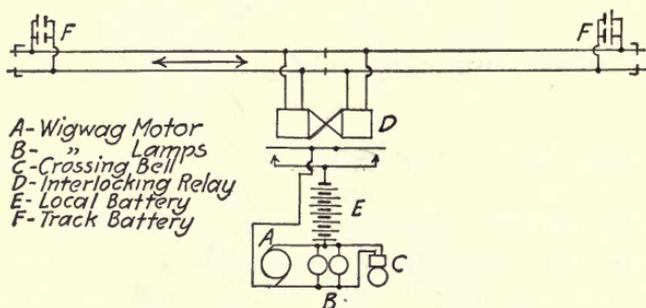


FIG. 325.—Low voltage wigwag circuit. Single track. (Railroad Supply Co.)

nal from giving a warning indication after the train has cleared the crossing. Figure 325 shows the wiring for a single-track road.

**188. Interlocking Relay.**—Figure 326 illustrates the operation of one type of interlocking relay. Neither of the blocks is occupied and both track relays are energized. When a train enters from the left at *A*, relay *K* becomes deenergized and its armature drops away by gravity. The arm *D* strikes pawl *F*, tilting it slightly to the left, while finger *E* makes back contact with *M*, causing the signal to give the warning indication. As soon as the front of the train crosses the insulated joint *B*, the relay *L* becomes deenergized and its armature drops. It cannot make back contact, however, at *N*, for the arm *J* falls into the notch *I* on the other side of pawl *F*. After the train has cleared the crossing the relay *K* becomes energized again and

the signal ceases to give its indication. The arm *J* is still held by the pawl *F*. As soon as the train has passed the insulated joint *C*, the relay *L* becomes energized and lifts its armature.

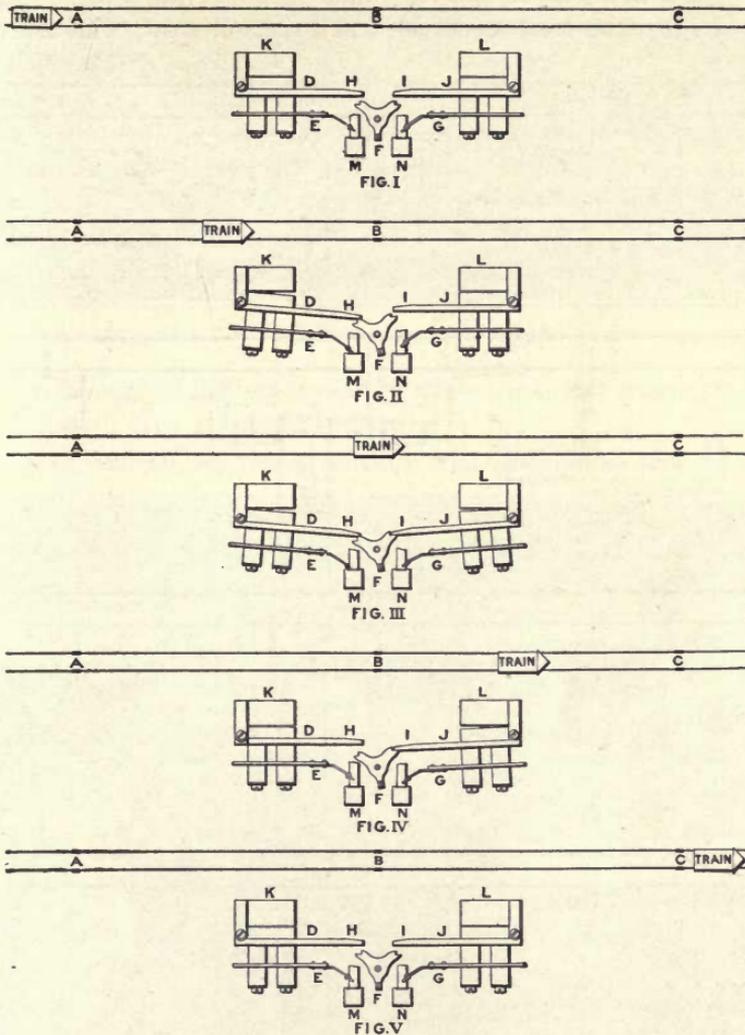


FIG. 326.—Diagram showing operation of Union interlocking relay.

Figure 327 represents a type of interlocking relay in which the interlocking arms form a part of the operating circuit. The diagram shows the operation of the relay as a train passes through the two track circuit sections. In (a), the track circuits *AB* and *BC* are unoccupied and the bell circuit is open. The train has entered track circuit *AB*, in (b), and has deenergized the magnet

*L*. The armature *L-1* has fallen forward causing finger *L-2* to make contact with *M*, closing the circuit and ringing the bell. In (*c*), the train occupies both track circuits *AB* and *BC*. It has deenergized the relay *R* and the finger *R-2* has fallen upon finger *L-2*. In (*d*), the train occupies track section *BC*. The relay *L*

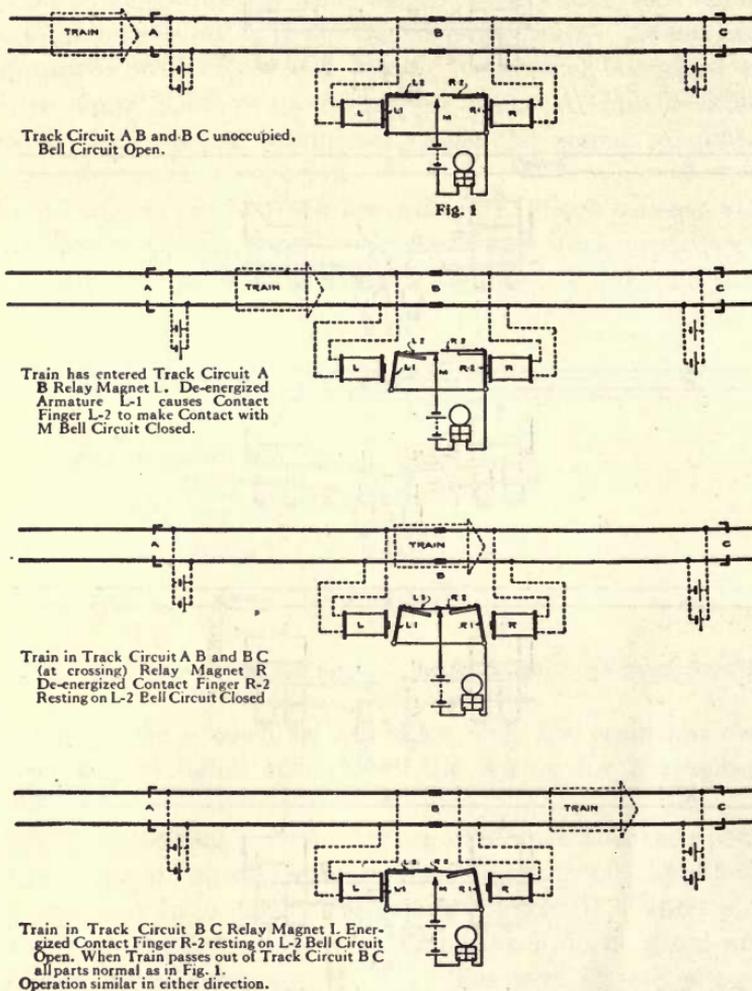


FIG. 327.—Diagrams *a*, *b*, *c* and *d* showing the operation of style "A" universal crossing bell relay. (Chicago Railway Signal and Supply Co.)

has become energized again and its armature has lifted the finger *L-2* clear of contact *M*. This action has opened the bell circuit and has caused the bell to stop ringing.

**189. Hoeschen Bell System.**—Figure 328 represents a Style "A" selective magneto-generator for the Hoeschen system of

crossing signals. The motive power used to operate the bell is obtained from the natural spring of the rail, which is utilized by means of levers placed under the base of the rail. An illuminated

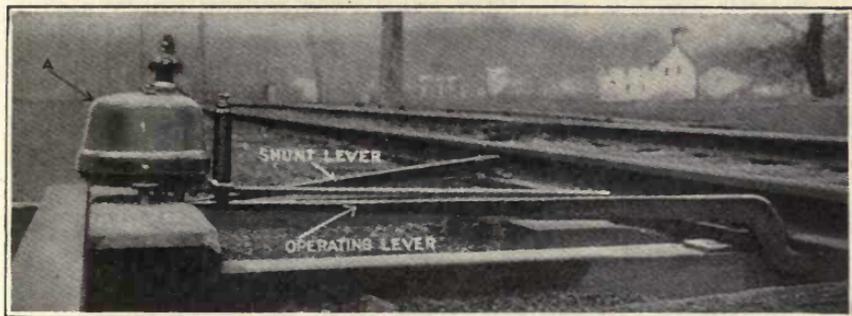


FIG. 328.—Style "A" selective magneto-generator. Hoeschen system.

sign that remains illuminated only while the bell is ringing may be used also to give additional warning.

Figure 329 shows the generator with the cover removed. *B*

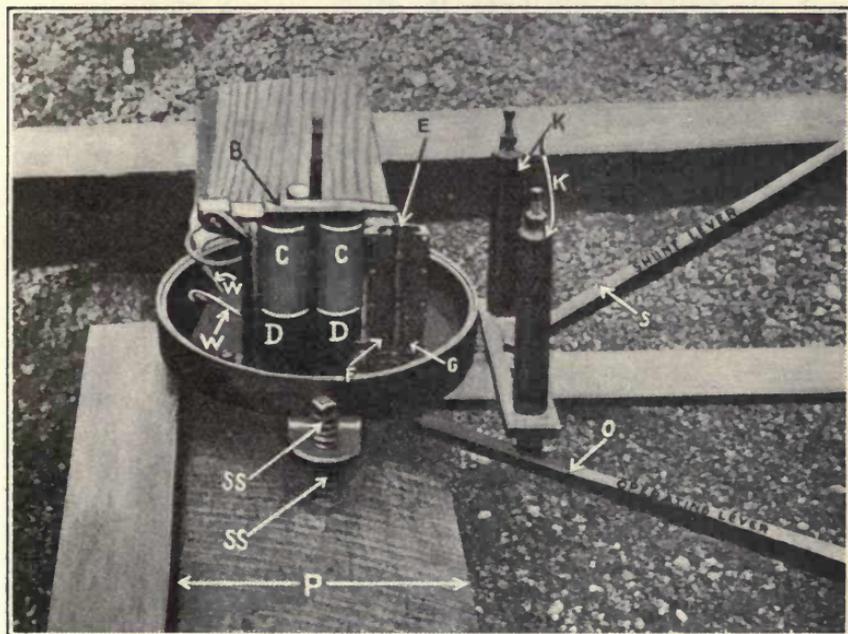


FIG. 329.—Style "A" generator with cover removed.

represents the armature at rest on the induction coils, *C, C*, which are fastened to the poles of a group of three permanent magnets, *D, D*; *E* represents the armature rocker tripping pin,

which rests on the upper ends of the two vertical rods *F* and *G*. These rods are supported on the ends of scale levers *O* and *S*, which are termed "operating" and "shunt," and are placed in a V-shaped position with their outer ends resting firmly against

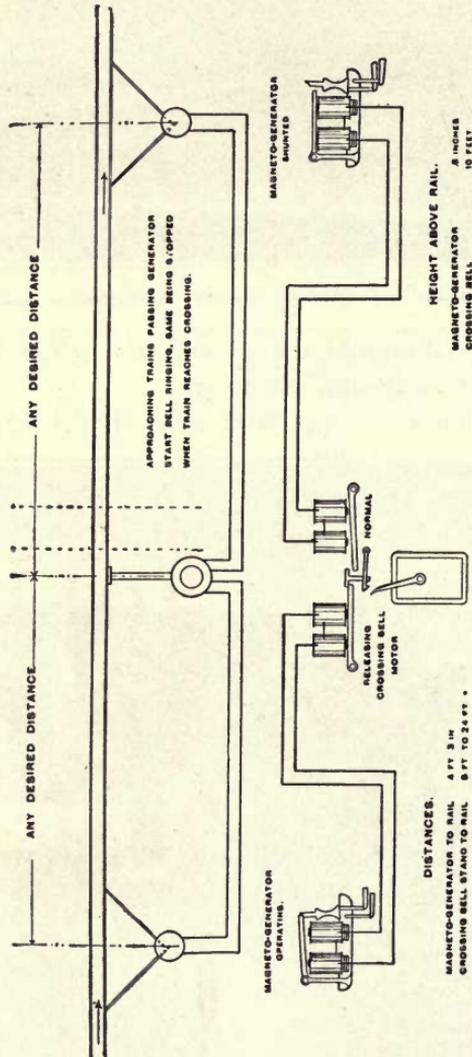


Fig. 330.—Diagram for single-track installation of Hoeschen bell mechanism.

the under side of the rail. These levers being fulcrumed close to the rail multiply the depressions caused by a passing train. As the ratio of the lever arms is 1 to 12, a depression of  $\frac{1}{16}$  in. gives the inner end of levers *O* and *S* an upward stroke of  $\frac{3}{4}$  in., which is sufficient to operate or shunt the generator as may be required.

*K, K* represent the housings for spiral compression springs with plunger resting on scale levers *O* and *S* so as to increase or decrease the tension of these levers. Two wires lead out from the induction coils through a lightning arrester to wires *W, W* and thence to the bell. *SS* represent heavy springs used to protect the mechanism from excessive vibration caused by the passing trains.

Figure 330 represents a diagram for single-track installation of this system. Levers *O* and *S* are so arranged that the operating lever is always depressed slightly in advance of the shunt lever as a car or train, moving towards the crossing, passes over the track opposite the generator. The depression of the operating lever forces the vertical rod *G* upwards, thus imparting both an upward and inward motion to the armature rocker tripping pin *E*. This brings it in contact with the armature *B* with sufficient force to separate the armature quickly from the poles of the induction coils *C, C*, thus generating a momentary current of high voltage that is transmitted to the bell. As the car moves from the crossing, the shunt lever is depressed in advance of the operating lever. The depression of the shunt lever forces the rod *F* upwards, imparting both an upward and an outward motion

to the tripping pin *E*. This allows the pin to pass the end of the armature, and the depression of the operating lever immediately afterwards has no actuating effect.

Figure 331 shows the motor of the signal equipped for single-track operation with both time and automatic contact attachments. The motor consists of a simple gear movement of three wheels used in connection with three powerful motor springs.

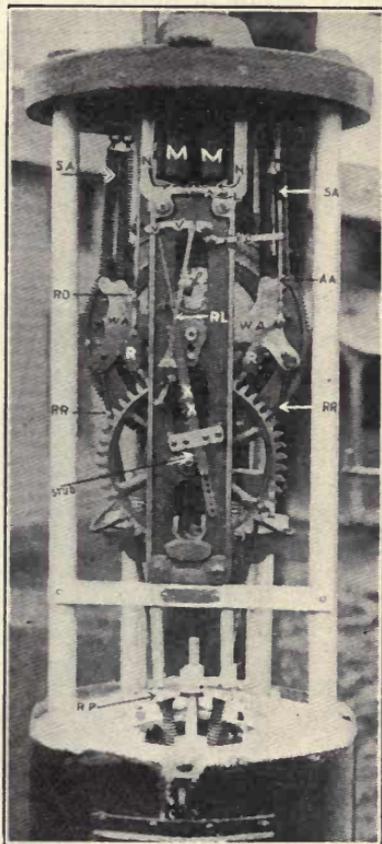


FIG. 331.—Details of Hoeschen bell mechanism.

The selective generators are connected in series with the releasing magnets,  $M, M$ , by separate metallic circuits running each way from the crossing, as shown in Fig. 330. Each pair of releasing magnets is equipped with a pointed armature  $N, N$ , and both these armatures engage the releasing clutch lever  $L$ . This lever  $L$  engages the releasing lever  $RL$  and holds it as shown when the motor is not in motion. When either of the releasing magnets

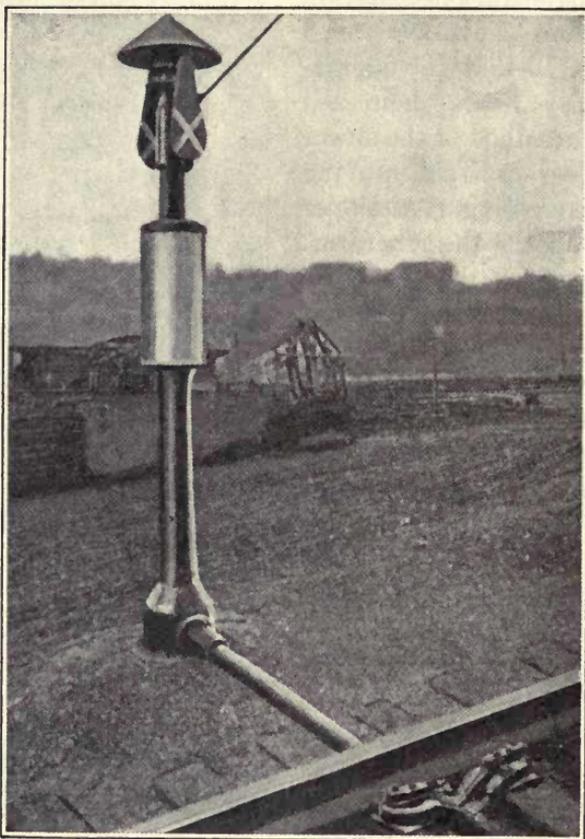


FIG. 332.—Hoeschen crossing signal.

is energized by the operation of the selective generator, its armature  $N$  lifts the clutch lever  $L$ , thus releasing the motor through the lever  $RL$ . As the escapement wheel turns from right to left, it imparts a rocking motion to the rocker  $RR$ , which is connected direct by rod  $RO$  to a pendulum bell hammer that strikes at regular intervals the inner side of a locomotive type of bell, shown in Fig. 332.

The motor is provided with both an automatic and time

stopping device. The time stopping arrangement operates as follows: When a motor is released and the escapement wheel starts to turn from right to left, it exerts a slight pressure on a counterweight that is fastened to the inner end of the *RL* lever shaft directly above the escapement wheel. This movement forces lever *RL* to move slightly to the left, where it is locked by the latch lever *V*; and it remains in this position until released by the sliding sawtooth bar *XX*. As each revolution of the escapement wheel raises this bar one notch or tooth by means of the small stud on the hub of the wheel, it raises the lever *V*, and allows lever *RL* to swing back to normal by force of the counterweight, thus stopping the motor.

The automatic cut-out or stopping mechanism is operated simultaneously with the winding of the motor by a passing train. The slight depression of the rail of  $\frac{1}{32}$  or  $\frac{1}{16}$  in., caused by a passing train, imparts a rocking or reciprocating movement to the bell crank lever resting against the under side of the rail. This motion is transmitted by a connecting rod through the rocker plate *RP* to the two winding arms *WA* which are provided with ratchet dogs on the inner sides that actuate the ratchet wheel and wind the springs. This operation imparts the reciprocating motion of the rod *AA* fastened to the right winding arm *WA* and connected by friction clutch lever *FC* to latch lever *V*, thus releasing the *RL* lever and allowing it to move back to its normal position, thereby locking the escapement crank and stopping the motor.

A small dial with a pointer is shown on the face of the motor. This indicates to the signal maintainer the amount of potential energy stored up ready for service. The motor is always nearly or entirely wound and provision is made to prevent overwinding. When fully wound it will deliver about 20,000 strokes on the bell and will run continuously for an hour and forty minutes.

Figure 333 shows a cross-sectional view of the Style "S" magneto-generator, a newer type designed to meet the demands of "safety first." The mechanism is constructed to operate by the depression of the rail under the wheels of a passing train in practically the same manner as the Style "A" generator. The operation of the generator is made selective, or directional, by the use of a selector instrument designed along the same general lines as the generator. It is installed from 4 to 6 ft. from the generator in the direction from which no operation is desired,



the weight, section and stiffness of the rail determining the spacing between generator and selector. The instrument consists of a simple spring switch that stands normally open which is connected in multiple to the two line wires running from the generator to the bell. A car or train going from the bell or signal passes over the selector, causing the switch to close by means of a plunger and scale lever arranged as in the generator. The selector operates a fraction of a second before the generator, and the current generated by the operation of the magneto is shunted out from the line by the closed switch on the selector. For traffic approaching the crossing the selector remains unaffected, with its shunt switch open, until the generator has operated, thus permitting a closed circuit from the generator to the bell.

**190. AGA Highway Danger Signals.**—Figure 334 illustrates an AGA Highway Danger Signal. The round lamp box at the top is 30 in. in diameter with transparent letters around the face of it and a flasher in the center behind the  $8\frac{3}{8}$ -in. red spread-light lens. The day and night indications are both given by an acetylene light flashing through the red lens and the transparent letters. The center of the lens is  $6\frac{3}{4}$  ft. above the concrete footing. The entire sign is made of cast iron. The lamp-box rests on a housing, which contains the gas cylinder, high- and low-pressure equipment, and the electro-gas valve when the signal is used as a railroad crossing sign.

The cylinder is filled with gas to a pressure of 150 lb. per square inch at a temperature of  $60^{\circ}\text{F}$ . From the cylinder, the gas flows through a regulator that reduces the pressure to less than 1 lb. a square inch, and then it passes on to the flasher shown in Fig. 335. After the gas passes through the pipe *B* of the flasher into the small chamber *C*, a part of it goes to feed the pilot burner *D*, and the remainder passes through opening *E* into the gas chamber *F*. After enough has accumulated in this



FIG. 334.—AGA highway danger signal.

chamber, the pressure forces the diaphragm *G* downward pulling with it the lever *H* and thereby unseating it at *S*. The gas escapes through the passage *I* to the burner *K*, and the pilot *D* ignites it to produce the flash. As the passage *S* is much larger than the opening *E*, the gas escapes faster than it enters; and as soon as the pressure drops sufficiently, the diaphragm and lever return to their original position. The end of lever *H* is magnetized to eliminate any lag in opening and closing the passageway *S*. The frequency of the flash is regulated by the lever *L*.

When used as a highway approach signal, where it stands at the side of the highway, possibly 300 ft. from the crossing, the

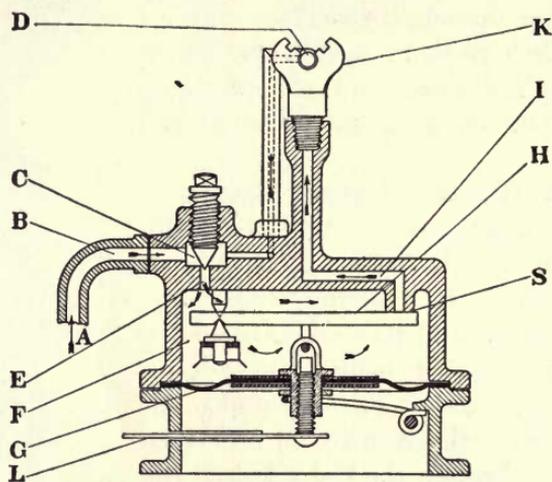


FIG. 335.—AGA signal flasher.

size of the burner is  $\frac{3}{16}$  ft. and gives a flash during one-tenth of the entire frequency cycle. The number of flashes can be whatever desired, but the usual practice is 60 a minute. In 24 hours of continuous operation the signal consumes 0.8 cu. ft. of gas.

When placed on the right-of-way as a grade crossing signal, the flow of gas to the flasher is controlled by an electro-gas valve operated in connection with track circuits, so that the signal flashes only while a train immediately approaches the crossing. The size of the burner is  $\frac{3}{8}$  ft. and gives a flash during one-fourth of the frequency cycle. Outside of the gas consumed by the pilot, which is 0.3 cu. ft. in 24 hours, the total amount used per day varies directly with the amount of train service; but with 30 trains each way a day, allowing three minutes for each movement,

the gas consumption will be only 0.6 cu. ft. per 24 hours including that burned by the pilot. The red light can be seen in daylight for a distance of 600 ft.

The AGA Company has another signal, Style "B," which operates in connection with track circuits, that has two lenses the upper one of which gives continuous green flashes, except,

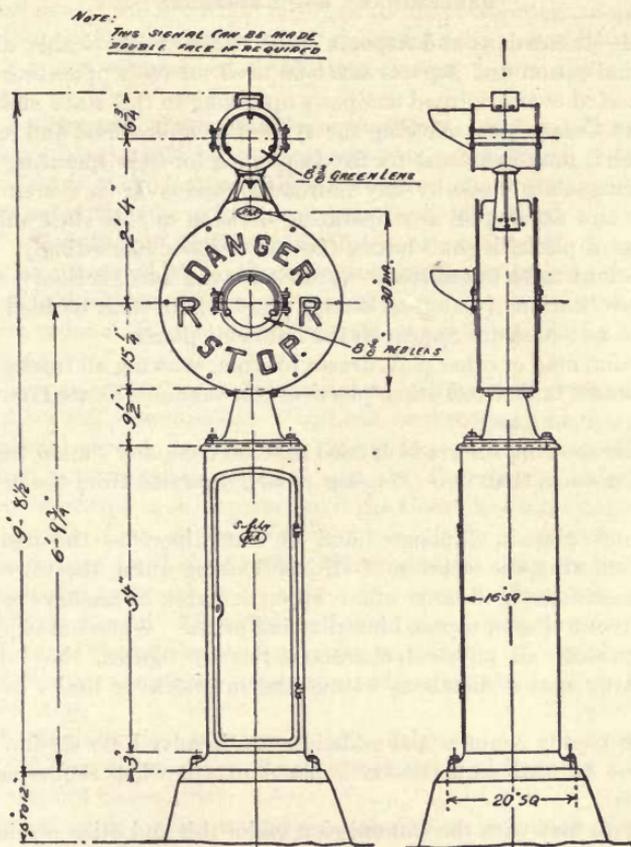


FIG. 336.—AGA two-color highway danger signal.

while a train approaches the crossing, when they are red as before. This type of signal is illustrated by Fig: 336. When a train enters the lighting track circuit the electro-gas valve closes the outlet to the burner in the top lamp and opens the inlet to the burner with the red lens giving a series of red flashes. As soon as the train passes out of the block, however, the flashes become green again.

# APPENDIX A

## RULES

### GOVERNING THE CONSTRUCTION, MAINTENANCE AND OPERATION OF INTERLOCKING PLANTS<sup>1</sup>

#### PRELIMINARY REQUIREMENTS

**Section 1—Indications and Aspects.**—(a) As far as practicable, a uniform system of indication and aspects must be used for each operating division. When requested every railroad company operating in this state shall submit plans to the Commission showing the system of indications and aspects in use, or which it proposes to use for fixed signaling for each operating division.

(b) If changes are made by any railroad company in its system of signal indications and aspects on any operating division in this state subsequent to the filing of plans, it shall notify the Commission accordingly.

**Sec. 2—Plans to be Submitted.**—(a) Prior to the construction, reconstruction or rehabilitation of any interlocking plant, there shall be filed with the Commission as a basis for approval, the following plans:

(b) A station map or other plat, drawn to scale, showing all tracks, bridges, buildings, water tanks, and other physical surroundings located on the right of way of each company.

(c) Profiles showing the grade of each railroad company's main tracks for a distance of not less than two (2) miles in each direction from the crossing or junction.

(d) A track plan in duplicate (and as many more as the roads desire approved) showing the location of all interlocking units, the tower and its general dimensions, and any other appurtenances necessary to show a complete layout of the proposed interlocking plant. When not expedient to locate accurately all physical characteristics by figures, they should be established by scaled distances within the interlocking limits hereinafter specified.

(e) When merely changes and additions are involved, no station maps or profiles need be filed with the track plans except when requested by the Commission.

(f) All plans filed with the Commission under this and other sections must be of light weight paper when in the form of blue prints.

**Sec. 3—Symbols.**—In the preparation of plans, the symbols approved by the Railway Signal Association shall be used to indicate switches, derails, signals and other essential parts of the interlocking plant.

**Sec. 4—Limits of Interlocking Plants.**—The interlocking limits are defined by the home or dwarf signals situated on any specified track and located farthest from the point to be protected. Any appliances operated in

<sup>1</sup> Prepared jointly by the engineers of the Railroad Commission of Wisconsin, the Railroad & Warehouse Commission of Illinois, the Railroad & Warehouse Commission of Minnesota, and the Public Service Commission of Indiana, and adopted by their respective commissions.

conjunction with the interlocking plant, and situated beyond the limits herein designated, are considered as auxiliaries.

**Sec. 5—Approval of Plans.**—(a) When possible, the railway companies concerned should agree on the plans before submitting them to the Commission.

(b) If the preliminary plans are satisfactory, or if in the judgment of the Commission modifications are necessary, the plans will be approved accordingly. Of the plans so approved, one copy will be retained by the Commission, and the duplicate returned to the petitioning company.

(c) The approval herein described will stand for a period of one year. If the work is not commenced within that period, a new approval must be obtained.

**Sec. 6—Physical Changes, Reconstructions and Rehabilitation.**—No interlocking plant shall be reconstructed or rehabilitated, nor shall any change be made in the locking or in the location of any unit, until plans have first been submitted to and approved by the Commission.

**Sec. 7—Conditional Service.**—(a) Upon the completion of any work on interlocking plants which involves changes in the locking, the units must be connected and adjusted, the plant placed in conditional service for not less than twenty-four (24) hours, and remain so until relieved by order of the Commission.

(b) When minor changes are made in locking under plans previously approved by the Commission, it will not be necessary to place the plant in conditional service prior to the time it is ready for inspection; and in cases when permission is received from the Commission in advance, the plant may be placed in full operation, if the Commission is unable to inspect it within twenty-four (24) hours after it is ready for inspection.

(c) Conditional service is hereby interpreted to mean that all units and other apparatus involved be connected and operated from the interlocking machine in the tower. All trains shall come to a stop at the governing home or dwarf signal regardless of its position and that such signal shall not be operated to give a proceed indication until after the train has made the prescribed stop.

**Sec. 8—Petition for Inspection.**—(a) Prior to or accompanying the petition for inspection of completed interlocking plants, the following detailed plans will be required:

(b) A track plan similar to the one referred to in section 2, showing all tracks and interlocking units as actually constructed, the terminal ends of each track to be numbered or lettered for use in connection with the manipulation sheet. A locking sheet and dog chart showing the arrangement of locking in the machine as installed; wiring plans showing in detail all circuits used in connection with the plant; a manipulation sheet with or without track diagrams as required by the Commission, showing in tabulated form the numbers of all levers necessary to be manipulated for any given route designated on the track plan.

(c) A suitable framed manipulation chart and track diagram shall be properly placed in the interlocking tower. The terminal ends of each track on this chart shall be numbered or lettered to correspond with the track plans above mentioned.

(d) The petition for inspection of any interlocking plant, when possible, shall give three (3) days' notice in advance of the time when the plant will be ready for inspection. Upon receipt of such notice, the Commission will endeavor to have the plant inspected within three (3) days after receiving such advice. If the Commission is not able to make the inspection within the time specified, it will authorize the railroad company in charge to place the plant in full operation, subject to future inspection.

(e) If upon the inspection of any interlocking plant by the Commission, it is found to be installed in accordance with the approved plans, a temporary permit will be issued to the railroad company in charge, pending the issuance of formal permits.

#### REQUISITES OF INSTALLATION

**Sec. 9—Type of Signals.**—(a) Except when approved by the Commission, all interlocking signals must be of the semaphore type. The apparatus connected with the operation of these signals must be so constructed that the failure of any part directly controlling the signal will cause it to display its least favorable indication.

(b) Semaphore arms must display indications to the right of the signal post, except where the physical conditions on a road require the display of signal indications to the left.

**Sec. 10—Location of Signals.**—(a) All fixed signals must be located either over or upon the right and next to the track over which train movements are governed, except on roads operating trains with the current of traffic to the left, or where physical conditions require placing the signals to the left of the track.

(b) Bracket post signals may be used on roads operating trains over two (2) or more tracks in the same direction, when such practice is uniform for any specified operating division, or where local conditions require their use.

**Sec. 11—Locking of Signals.**—The locking between the levers of the interlocking machine must be arranged so that a home or dwarf signal cannot be cleared for any given route unless all switches, derails, movable point frogs and other units in the route are in proper position and locked.

**Sec. 12—Home Signals.**—(a) When required by the Commission, all home signals must be equipped with not less than two arms. Unless operated by power all home signals in mechanical plants must be pipe connected except when otherwise approved by the Commission.

(b) When used in connection with automatic train stopping devices, the home signal may be located immediately opposite the means for controlling the apparatus of the train stopping device.

(c) When used in connection with derails and other units the home signal must be located as far in advance of such units as is necessary to secure full protection, but in no case shall it be less than five (5) feet in advance of such units.

(d) When home signals are semi-automatic, or form a part of an automatic block signal system, calling-on-arms or some other means may be used for advancing trains.

(e) All high speed signals located in automatic block signal territory shall be semi-automatic and form a part of the block signal system.

**Sec. 13—Dwarf Signals.**—Dwarf signals indicate slow speed movements and may be used to govern train movements on all tracks other than main tracks, except as hereinafter specified; on main tracks to govern train movements against current of traffic, and when approved by the Commission as intervening signals to facilitate switching movements. When used they must be located and connected in the same manner as home signals.

**Sec. 14—Advance Signals.**—Advance signals may be used when necessary, and must be installed in the same manner as home signals.

**Sec. 15—Distant Signals.**—(a) On level and ascending grades, distant signals shall be located not less than two thousand five hundred (2,500) feet in advance of their respective home signals. On descending grades the minimum distance of two thousand five hundred (2,500) feet shall be increased at the rate of one hundred (100) feet for each one-tenth (1-10th) of one per cent of gradient.

(b) Where conditions justify, the location and character of distant signals or the method of operation may be varied or the signals be omitted, depending upon the conditions surrounding each particular case.

(c) Except as hereinafter provided, all high speed tracks must be equipped with power-operated distant signals having electric locks or other suitable apparatus to prevent changing of the route until such signals have indicated their normal position.

(d) When required by the Commission, distant signals shall be so arranged as automatically to indicate stop when the track between the home and distant signals is occupied, or when any intervening switch is not in its normal position.

**Sec. 16—Switches.**—All switches, derails, movable point frogs and other units within the interlocking limits hereinbefore defined must be incorporated in the plant.

**Sec. 17—Derails on Steam Roads.**—(a) Main Tracks: On level grades facing derails must be located not less than five hundred (500) feet from a drawbridge or the fouling point of a crossing or junction. On descending grades facing derails must be located to give practically the same measure of protection as for level grades, and the minimum distance of five hundred (500) feet must be increased at the rate of ten (10) feet for each one-tenth (1-10th) of one per cent gradient. On ascending grades the minimum distance of five hundred (500) feet may be reduced at the rate of ten (10) feet for each one-tenth of one per cent gradient; but in no case shall such derails be located less than four hundred (400) feet from a drawbridge or the fouling point of a crossing or junction.

(b) Pocket Derails: Where such are used they shall be located so as to derail the first pair of wheels on the ties at a point not less than fifty (50) feet from the fouling point of a crossing or junction.

(c) Back-up Derails: These shall be placed not less than two hundred fifty (250) feet from a drawbridge or the fouling point of a crossing or junction.

(d) Secondary Tracks: All tracks other than main tracks shall be termed secondary tracks. On such tracks derails shall be placed not less than two hundred (200) feet from a drawbridge or from the fouling point of a crossing; and not less than fifty (50) feet from the fouling point of a junction.

(e) The fouling point is where two trains moving toward a common center would come in contact.

(f) Where conditions justify, the location of derails may be varied or they may be omitted, when approved by the Commission.

**Sec. 18—Derails on Electric Roads.**—The location of derails on electric roads shall be determined in the same manner as for steam roads. In placing derails in the tracks of such roads, consideration will be given to speed and character of traffic.

**Sec. 19—Type of Derails.**—Derails must be of an approved pattern, suitable for the purposes intended and so placed with reference to curvature, bridges and other tracks as to secure a maximum of efficiency and safety.

**Sec. 20—Guard Rails.**—Where physical conditions require their use, guard rails shall be installed in connection with derails. When used, they shall be placed between the track rails, parallel to and not less than ten (10) inches distant in the clear therefrom, and must be of sufficient height, length and strength, and be properly secured to the track ties.

**Sec. 21—Automatic Train Control.**—Automatic train stopping devices which are a part of a system of automatic train control approved by the Commission, may be used in lieu of derails. In such devices, the means for automatically applying the train brakes shall be located a sufficient distance in advance of the fouling point as to insure a safe braking distance.

**Sec. 22—Locks.**—(a) In mechanical plants all facing switches, split point derails in main tracks and all slip switches and movable point frogs, must be locked with facing point locks. All other derails, switches and other units must be locked either with facing point locks or with switch and lock movements.

(b) In plants equipped with mechanical signals, all derails must be provided with bolt locks; also all switches, movable point frogs and other units, where conditions require them.

(c) In power plants, the arrangement must be such that the signals operating in connection with derails, facing point switches and other units cannot be operated unless these units are in proper position.

**Sec. 23—Detector Bars.**—(a) Unless otherwise provided, all derails, switches, movable point frogs and other units shall be equipped with detector bars of approved design not less than fifty-three (53) feet in length, or longer if required.

(b) Except as hereinafter provided, all crossings shall be equipped with detector bars of suitable length, so interlocked as to insure a clear crossing before an opposing route can be set up or a proceed signal given.

(c) Crossing detector bars will not be required where electric locking is installed; nor at outlying crossings of simple character where no switching is performed, when the plant is equipped with time locks.

**Sec. 24—Time Locks.**—Unless equipped with electric locking, time locks must be installed to prevent the changing of high speed routes, until after the home signal has displayed the stop indication a predetermined time.

**Sec. 25—Electric Locking.**—Electric locking may be provided in place of time locks and crossing bars. When used, the circuits must be arranged so as to prevent the changing of a route until the train has passed through the interlocking limits or through a predetermined part of the plant.

**Sec. 26—Detector Circuits.**—When a railway company is equipped with sufficient maintenance forces for properly maintaining electric detector circuits, such circuits may be used in place of mechanical detector bars.

**Sec. 27—Machines.**—(a) All mechanical interlocking machines shall be equipped with locking of the preliminary type.

(b) All power interlocking machines shall have the locking so arranged as to be effective before the operating conditions of any circuit directly controlling a unit can be changed. Suitable indicating and locking apparatus shall be provided to prevent the placing of a lever in complete normal or reverse position until the unit controlled has completed the intended operation, except that signals shall indicate the normal position only.

**Sec. 28—Locking of Levers.**—(a) The locking must be so arranged that conflicting routes cannot be given at any stage in the setting up of a route, nor a proceed indication given until all switches, derails, movable point frogs, facing point locks and other units in the route affected are in proper position.

(b) When a separate lever is used to operate distant signals the locking between the home and distant signals shall be so arranged as to prevent the distant signals from giving the proceed indication until the home signals operating in connection with such distant signals are in the proceed position.

**Sec. 29—Locks and Seals.**—(a) All interlocking machines must, when practicable, be provided with means for locking or sealing the mechanical locking and indication apparatus in such a manner as to prevent access to any except authorized employes.

(b) All power interlocking cabinets, time locks, time releases, emergency switches, indicator and relay cases must be provided with suitable covers and fastenings and be properly sealed or locked, and must not be opened by any but authorized employes.

**Sec. 30—Cross Protection.**—(a) As far as practicable, cross protection apparatus must be provided in connection with electric interlocking plants to prevent the operation of any unit by cross or grounds.

(b) Low voltage circuits, as far as practicable, must be designed to prevent the operation of apparatus by cross or grounds.

**Sec. 31—Annunciators.**—When operating conditions require annunciators, they shall be installed.

**Sec. 32—Signal Towers.**—(a) Signal towers shall be so placed and be of such height and size as to best serve the purpose for which they are intended.

(b) The use of interlocking towers for purposes other than interlocking, dispatching and block work is undesirable.

(c) If work other than interlocking is carried on in the tower, a suitable partition or railing must be provided to prevent outsiders from having access to interlocking apparatus, and interfering with the duties of the operator or towerman.

**Sec. 33—Tower Lights.**—The tower lights must be screened off so that they cannot be mistaken for signals exhibited to control train movements.

**Sec. 34—Material and Workmanship.**—Material and workmanship must be first-class throughout. When complete, the interlocking plant must be in every way suitable and sufficient for the purposes intended.

## MAINTENANCE AND OPERATION

**Sec. 35—Maintenance and Operation.**—(a) Interlocking plants must at all times be properly maintained and efficiently operated. Any rules or regulations that the railway companies may have adopted for the guidance of employes in operating and maintaining interlocking plants must be appropriately framed and conveniently placed in interlocking towers.

(b) When an interlocking plant is taken out of service the Commission must be notified immediately. Under such circumstances train movements must not be governed by interlocking signals but by the usual precautions prescribed by statute governing train movements over and across railway grade crossings, junctions and drawbridges.

**Sec. 36—Interlocking Reports.**—Reports for each interlocking plant shall be filed with the Commission by each railroad company concerned, which reports must be filed in manner and form prescribed by the Commission.

## APPENDIX B

### PART I

#### SIGNAL ASPECTS

The following memorandum on the essentials of signaling, incorporated in the report of the Committee on Transportation of the American Railway Association, May, 1911, is copied from the Manual of the Railway Signal Association:

"The reports of various Committees of the Railway Signal Association and of the American Railway Engineering Association on the subject of signaling have been submitted to this Committee, with the request that the essentials of signaling be outlined or defined for the future guidance of their Committees.

The subject has been carefully analyzed and considered. There are three signals that are essential in operation and therefore fundamental, viz:

- (1) Stop.
- (3) Proceed with caution.
- (3) Proceed.

The fundamental, "proceed with caution," may be used with the same aspect to govern any cautionary movement; for example, when:

- (a) Next signal is "stop."
- (b) Next signal is "proceed at low speed."
- (c) Next signal is "proceed at medium speed."
- (d) A train is in the block.
- (e) There may be an obstruction ahead.

There are two additional indications which may be used where movements are to be made at a restricted speed, viz:

- (4) Proceed at low speed.
- (5) Proceed at medium speed.

Where automatic block system rules are in effect, a special mark of some distinctive character should be applied at the stop signal.

The Committee therefore recommends:

#### Signal Fundamentals

- (1) Stop.
- (2) Proceed with caution.
- (3) Proceed.

#### Supplementary Indications to be Used Where Required

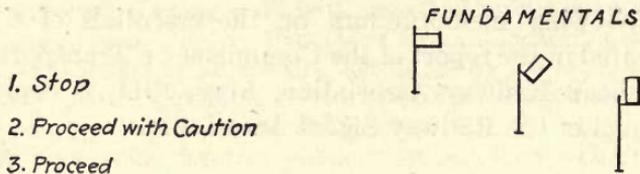
- (4) Proceed at low speed.
- (5) Proceed at medium speed.

Stop signals operated under automatic block system rules should be designated by some distinctive mark to be determined by each road in accordance with local requirements."

## Recommendations of Committee I

Your Committee submits for approval the following two schemes of signaling in conformity with the recommendations of the Committee on Transportation.

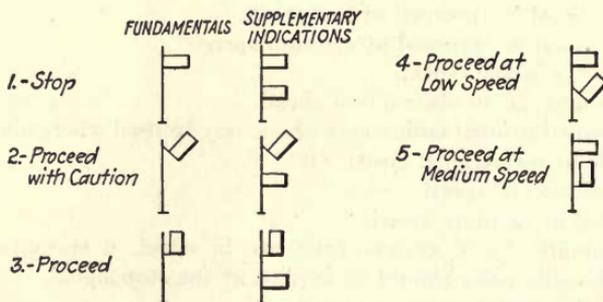
## Scheme No. 1



As means of designating stop signals operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or
2. The use of a red marker light below and to the left of the active light; or
3. The use of a pointed blade, the blades of other signals giving the stop indication having square ends; or
4. A combination of these distinguishing features.

## Scheme No. 2



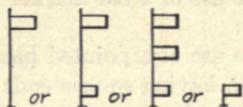
As means of designating stop signals operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or
2. The use of a red marker light below and to the left of the active light; or
3. The use of a pointed blade, the blades of other signals giving the stop indication having square ends; or
4. A combination of these distinguishing features.

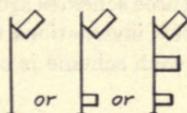
Having in view the practice of indicating diverging routes by several arms on the same mast, the Committee submits for approval the following to establish uniformity in this practice:

## Scheme No. 3

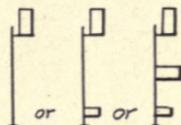
1. Stop



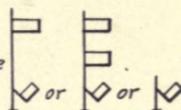
2. Proceed with Caution



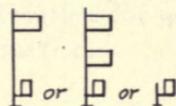
3. Proceed



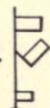
4. Proceed with Caution on the Low-Speed Route



5. Proceed on the Low Speed Route



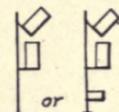
6. Proceed with Caution on Medium-speed Route



7. Proceed on the Medium-Speed Route



8. Reduce to Medium Speed



As means of designating stop signals operated under automatic block system rules, the following are suggested:

1. The use of a number plate; or
  2. The use of a red marker light below and to the left of the active light;
- or
3. The use of a pointed blade, the blades of other signals giving the stop indication having square ends; or
  4. A combination of these distinguishing features.

The above three schemes are submitted, after an earnest effort to carry out the Committee's instructions to submit a uniform scheme of signaling, with the idea that each scheme is complete in itself.

**PART II**  
**SYMBOLS**

The following plates, 1-13, are symbols recommended  
by the Railway Signal Association for use  
in railway signal practice.

OPERATING.		NON-AUTOMATIC.		SLOTTED (MECH.)	SEMI-AUTOMATIC (POWER)		AUTOMATIC (POWER)	SPECIAL REQUIRES REFERENCE TO NOTES.	
		MECHANICAL	POWER		STICK.	NON-STICK			
	CHARACTERISTICS								
TWO POSITION SIGNALING.	2-POSITION. 0 TO 60-0 TO 70 0 TO 75-0 TO 90								
	THREE POSITION SIGNALING.	2-POSITION. 0 TO 90							
	2-POSITION. 0 TO 45								
	2-POSITION. 45 TO 90								
	3-POSITION. 0 TO 45 TO 90								

**NOTE:** ARMS SHOULD ALWAYS BE SHOWN IN NORMAL POSITION.



**SPECIAL - 3 POSITION NON-AUTOMATIC, 0 TO 45.**  
**SEMI-AUTOMATIC STICK, 45 TO 90.**



**SPECIAL - 3 POSITION NON-AUTOMATIC, 0 TO 45.**  
**SEMI-AUTOMATIC NON-STICK, 45 TO 90.**



**ABSOLUTE STOP SIGNAL.**



**DISTANT SIGNAL.**



**PERMISSIVE STOP SIGNAL.**



**TRAIN ORDER SIGNAL.**

ENDS OF BLADES IN SYMBOLS ARE TO BE OF THE ACTUAL FORMS USED BY THE ROAD CONCERNED. IF NOT SPECIFIED THE ABOVE FORMS WILL BE USED ON PLANS.



**FIXED ARM.**



**UPPER QUADRANT SIGNAL.**



**LOWER QUADRANT SIGNAL.**

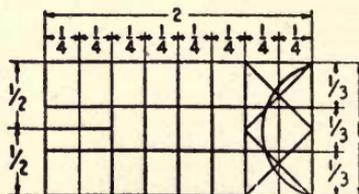


**VERTICAL**



**STAGGERED**

**MARKER LIGHTS.**



**DIAGRAMS OF PROPORTIONS FOR MAKING SYMBOLS FOR SIGNAL BLADES.**

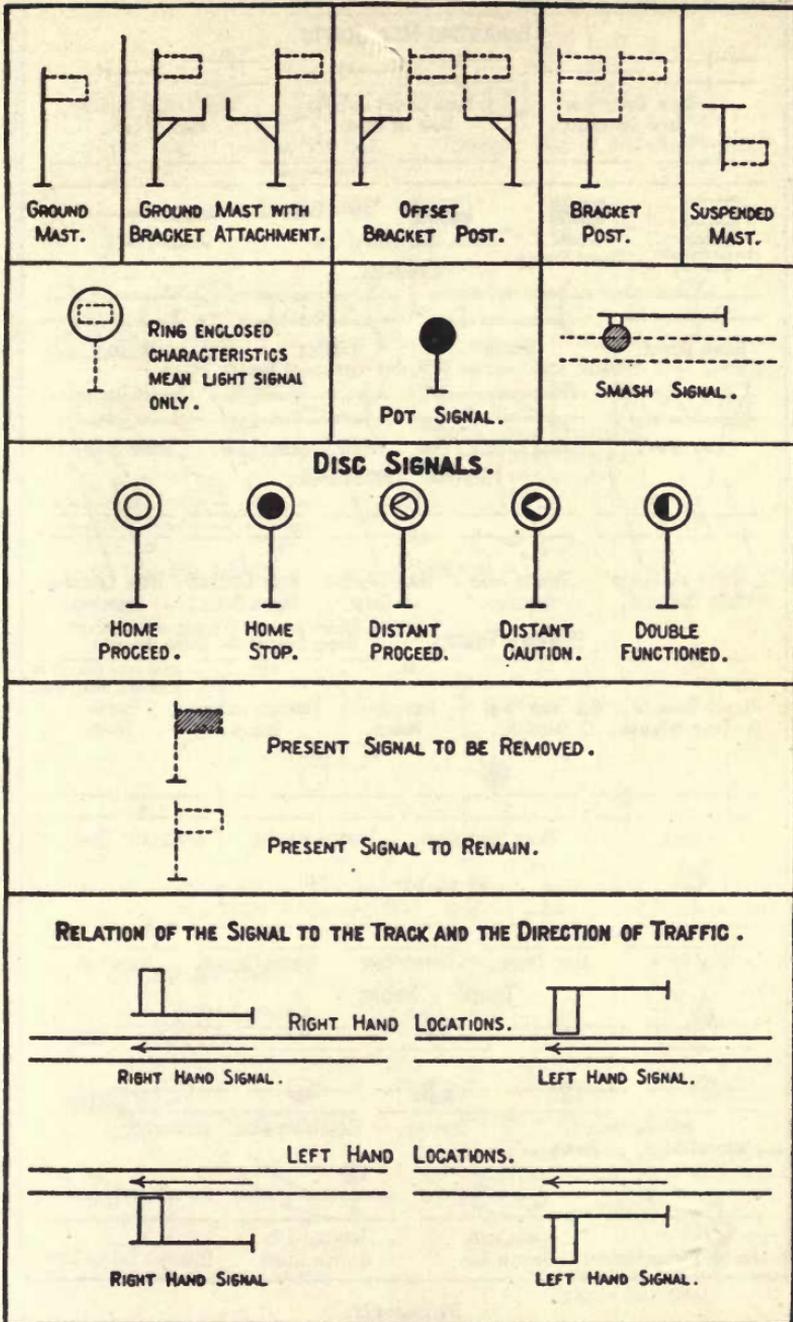


PLATE II.

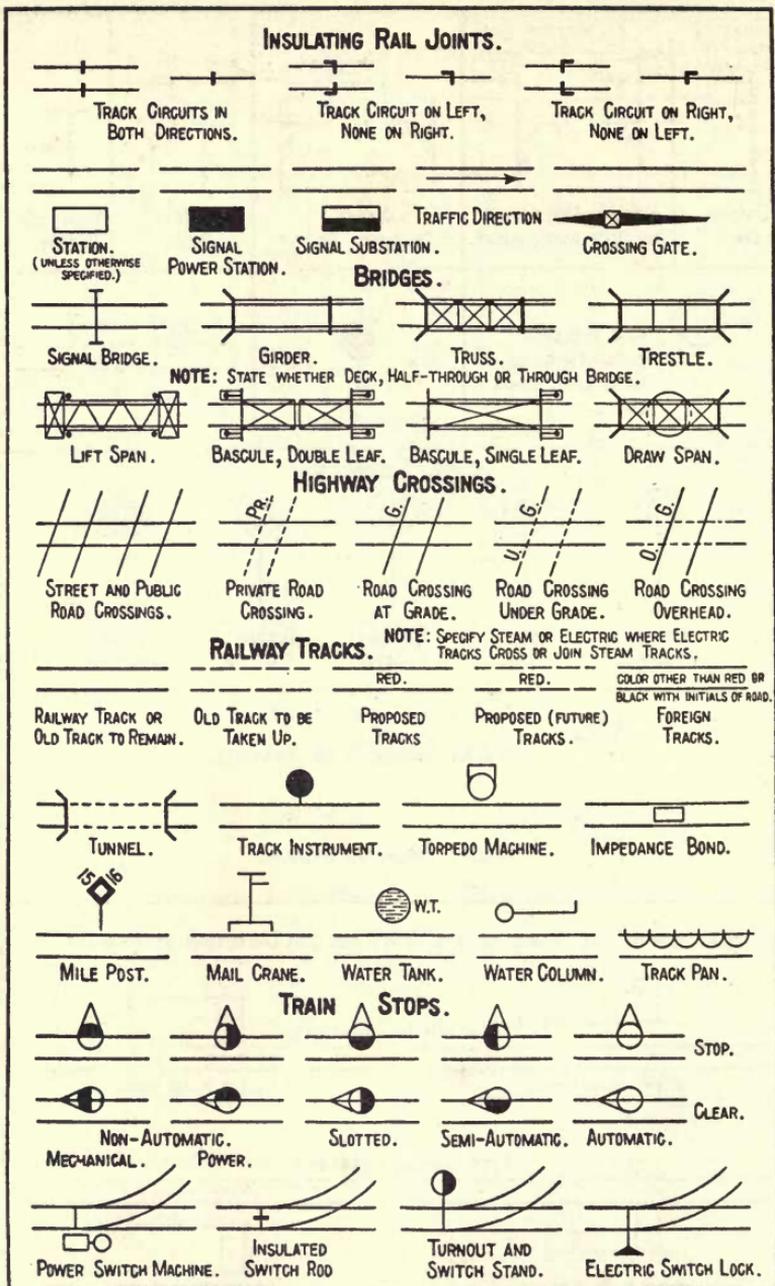


PLATE III.

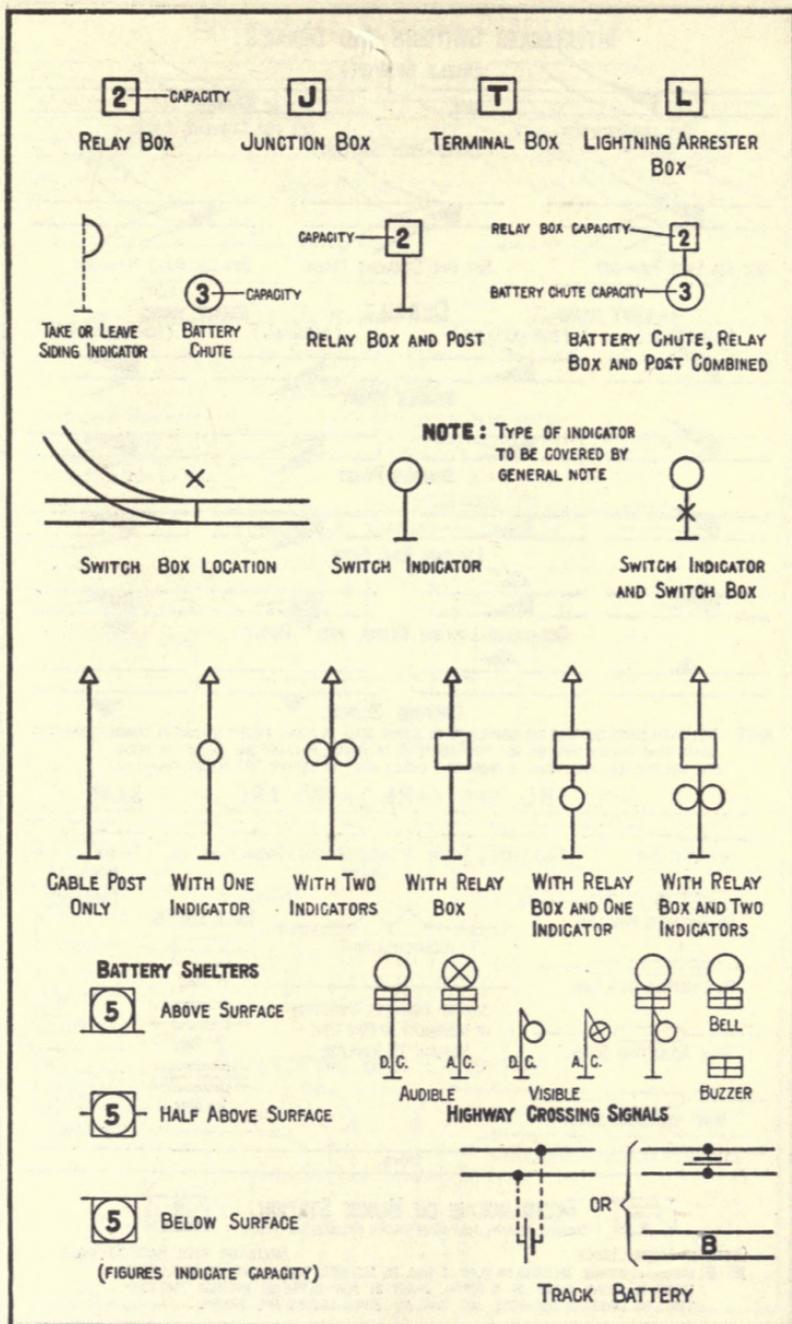


PLATE IV.

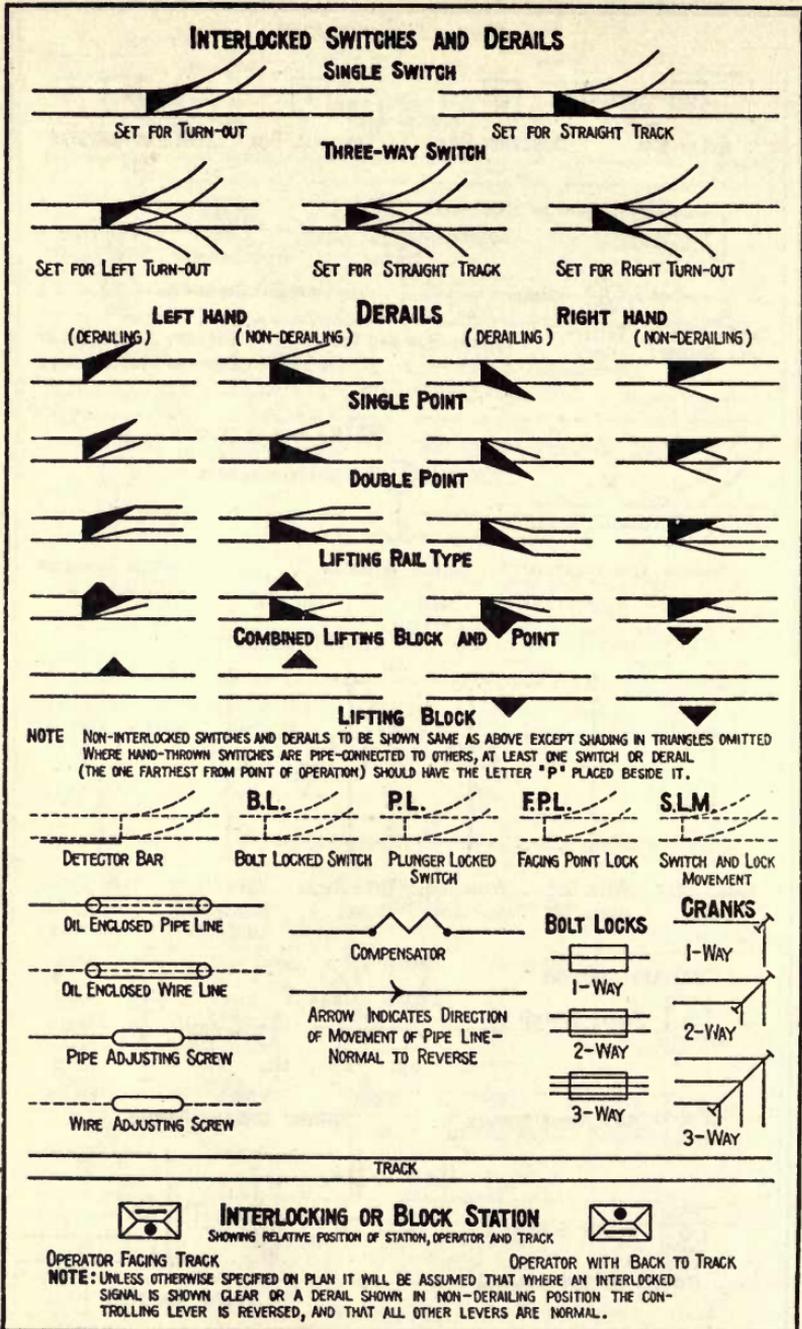
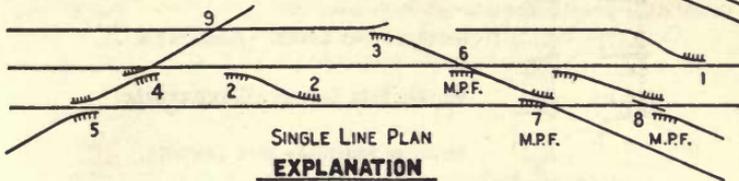
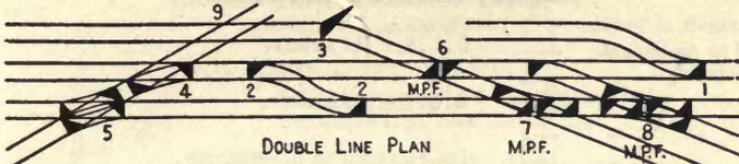


PLATE V.

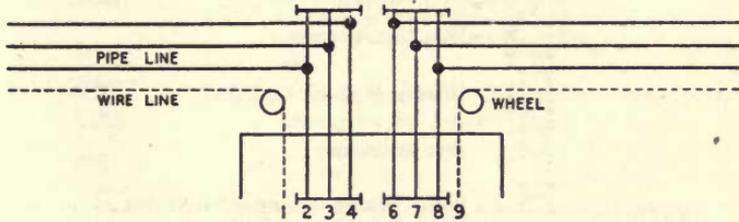
**INTERLOCKED SWITCHES, DERAILS, ETC.**



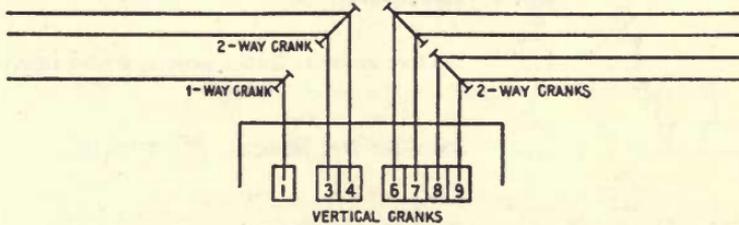
**EXPLANATION**

- |                           |  |
|---------------------------|--|
| 1 - SIMPLE TURN-OUT       | 5 - DOUBLE SLIP SWITCH                   |
| 2 - SIMPLE CROSS-OVER     | 6 - MOVABLE POINT CROSSING FROG (M.P.F.) |
| 3 - DERAIL - SINGLE POINT | 7 - SINGLE SLIP SWITCH WITH M.P.F.       |
| 4 - SINGLE SLIP SWITCH    | 8 - DOUBLE SLIP SWITCH WITH M.P.F.       |
|                           | 9 - RIGID CROSSING FROG                  |

**ROCKING SHAFT LEAD-OUT**



**CRANK LEAD-OUT**



**DEFLECTING BAR LEAD-OUT**

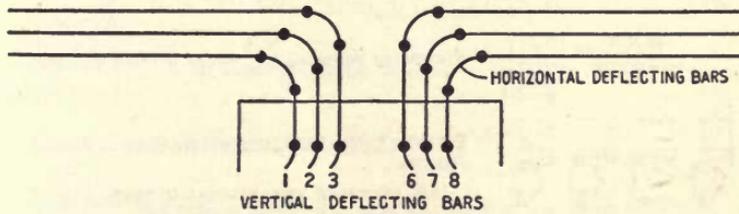


PLATE VI.

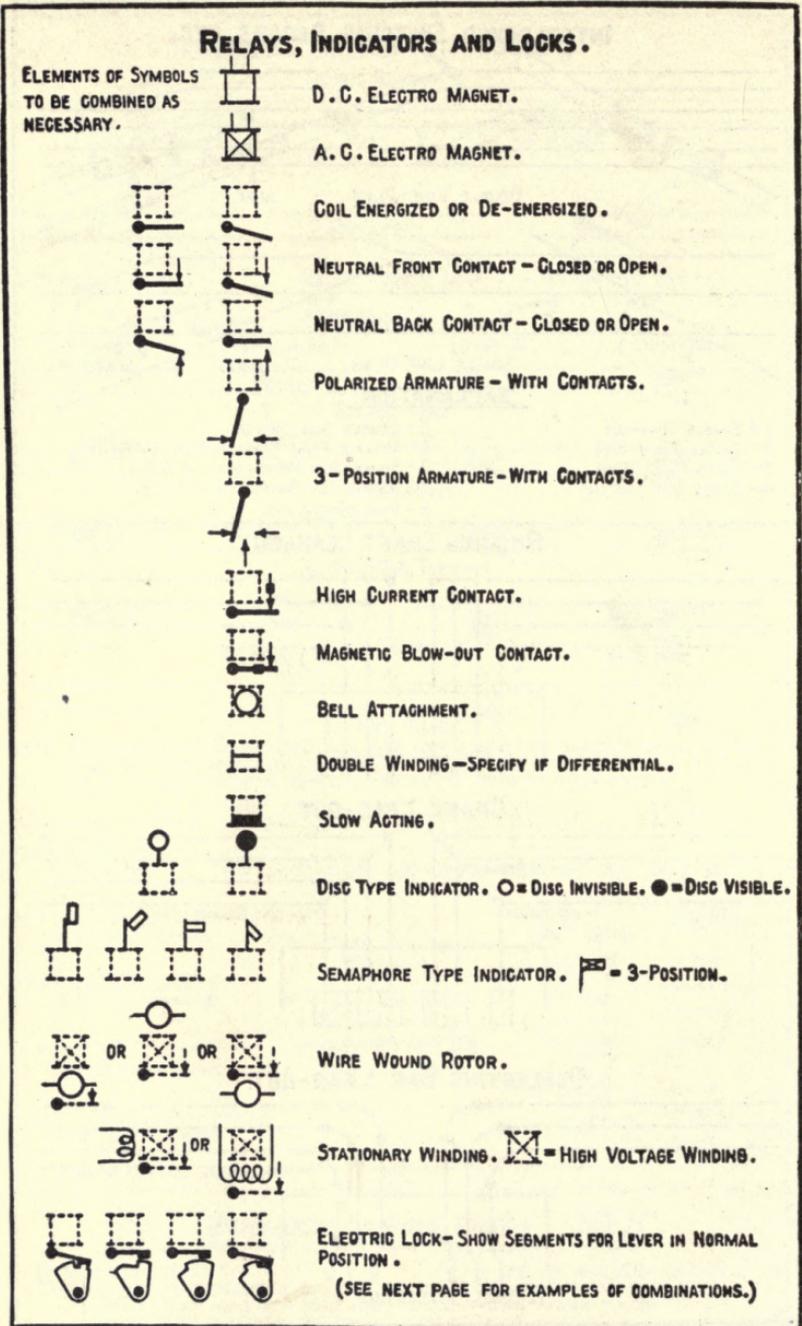
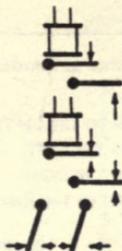


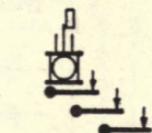
PLATE VII.

**RELAYS, INDICATORS AND LOCKS.**

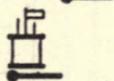
EXAMPLES OF COMBINATIONS.



D.C. RELAY— NEUTRAL— ENERGIZED —  
 ONE INDEPENDENT FRONT CONTACT CLOSED —  
 ONE INDEPENDENT BACK CONTACT OPEN.



D.C. RELAY— POLARIZED— ENERGIZED —  
 TWO COMBINATION FRONT AND BACK NEUTRAL CONTACTS —  
 TWO POLARIZED CONTACTS CLOSED —  
 TWO POLARIZED CONTACTS OPEN.



D.C. INDICATOR— SEMAPHORE TYPE— ENERGIZED —  
 THREE FRONT CONTACTS CLOSED —  
 BELL ATTACHMENT.



D.C. INDICATOR— SEMAPHORE TYPE— ARM HORIZONTAL —  
 ENERGIZED— WITHOUT CONTACTS.

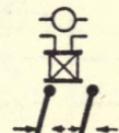
**NOTE:** INDICATORS (OR REPEATERS) WITHOUT CONTACTS SHOULD BE SHOWN WITH ARMATURES TO INDICATE WHETHER ENERGIZED OR DE-ENERGIZED.



A.C. RELAY— ONE ENERGIZING CIRCUIT TYPE (SINGLE PHASE)  
 ENERGIZED— ONE FRONT CONTACT.



A.C. RELAY— TWO ENERGIZING CIRCUIT TYPE— ENERGIZED —  
 WIRE WOUND ROTOR —  
 TWO NEUTRAL FRONT CONTACTS.



A.C. RELAY— TWO ENERGIZING CIRCUIT TYPE— ENERGIZED —  
 WIRE WOUND ROTOR —  
 TWO POLARIZED CONTACTS.



A.C. RELAY— TWO ENERGIZING CIRCUIT TYPE— ENERGIZED —  
 STATIONARY WINDINGS —  
 ONE NEUTRAL FRONT CONTACT —  
 TWO 3-POSITION CONTACTS.



D.C. INTERLOCKED RELAY.



D.C. ELECTRIC BELL.

DESIGNATE RESISTANCE IN OHMS OF ALL D.C. RELAYS, INDICATORS AND LOCKS.

PLATE VIII.

**CIRCUIT CONTROLLERS OPERATED BY LEVERS.**

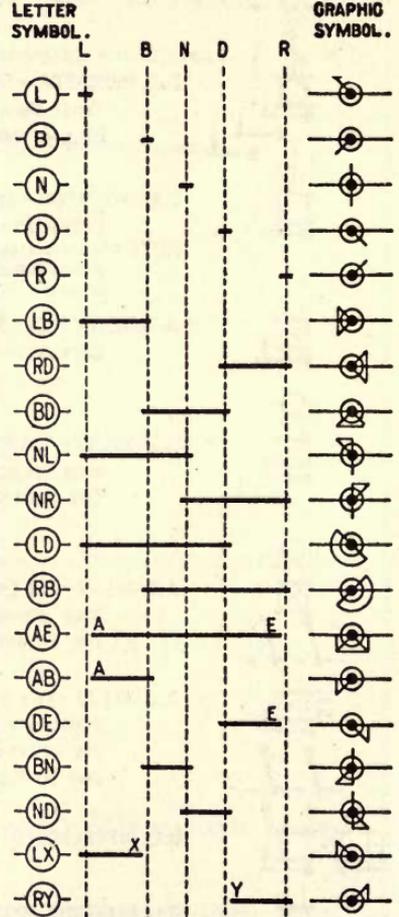
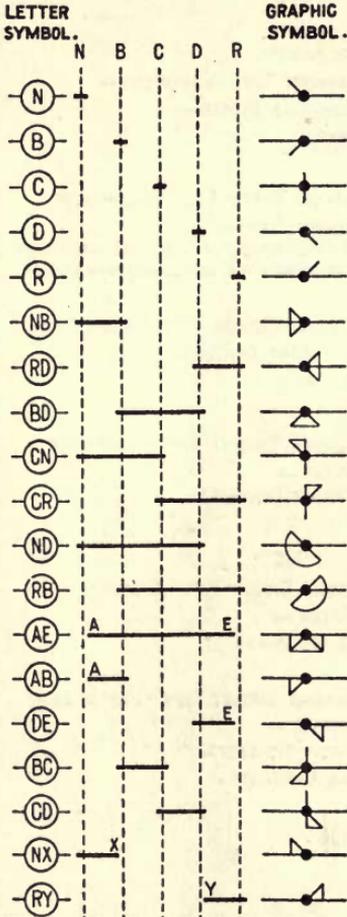
USE EITHER LETTER SYSTEM OR GRAPHIC SYSTEM.

LEVERS WITH EXTREME END POSITION AS NORMAL.

- N-FULL NORMAL POSITION OF LEVER
- B-NORMAL INDICATION POSITION.
- C-CENTRAL POSITION.
- D-REVERSE INDICATION POSITION.
- R-FULL REVERSE POSITION.

LEVERS WITH MIDDLE POSITION AS NORMAL.

- N-NORMAL POSITION.
- L-FULL REVERSE POSITION TO THE LEFT.
- B-INDICATION POSITION TO THE LEFT.
- D-INDICATION POSITION TO THE RIGHT.
- R-FULL REVERSE POSITION TO THE RIGHT.



**NOTE:** HEAVY HORIZONTAL LINES INDICATE PORTION OF CYCLE OF LEVER THROUGH WHICH CIRCUIT IS CLOSED.

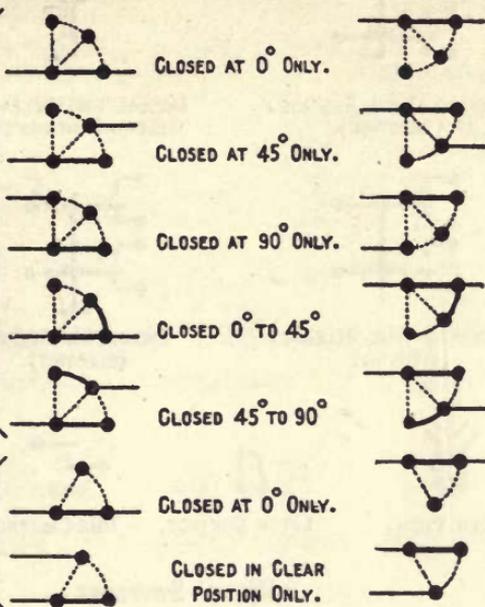
**CIRCUIT CONTROLLERS OPERATED BY SIGNALS.**

UPPER QUADRANT.

LOWER QUADRANT.

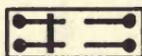
3-POSITION SIGNALS.

60°-70° OR 75° SIGNALS.



CLOSED.

OPEN.

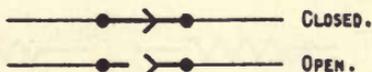


SWITCH CIRCUIT CONTROLLER.

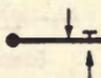
CIRCUIT CONTROLLER OPERATED BY LOCKING MECHANISM OF A SWITCH MOVEMENT.



POLE CHANGING CIRCUIT CONTROLLER.



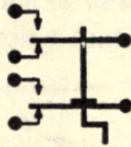
BRIDGE CIRCUIT CONTROLLER.



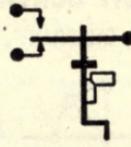
SPRING HAND KEY OR PUSH BUTTON.



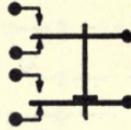
CIRCUIT SWITCH.



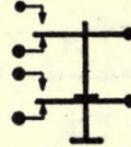
MANUAL TIME RELEASE.  
(ELECTRIC)



MANUAL TIME RELEASE.  
(ELECTRO-MECHAN'L.)



AUTOMATIC TIME RELEASE.  
(ELECTRIC)



EMERGENCY RELEASE.  
(ELECTRIC)



FLOOR PUSH.



LATCH CONTACT.



OPEN.



CLOSED.

TRACK INSTRUMENT CONTACT.

**KNIFE SWITCHES.**



RHEOSTAT.



SINGLE POLE. SINGLE THROW.



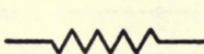
DOUBLE POLE. SINGLE THROW.



SINGLE POLE. DOUBLE POLE. DOUBLE THROW.



QUICK ACTING CIRCUIT CONTROLLERS MAY BE DISTINGUISHED BY THE LETTER "Q"



FIXED RESISTANCE.



VARIABLE RESISTANCE.



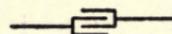
FUSE.



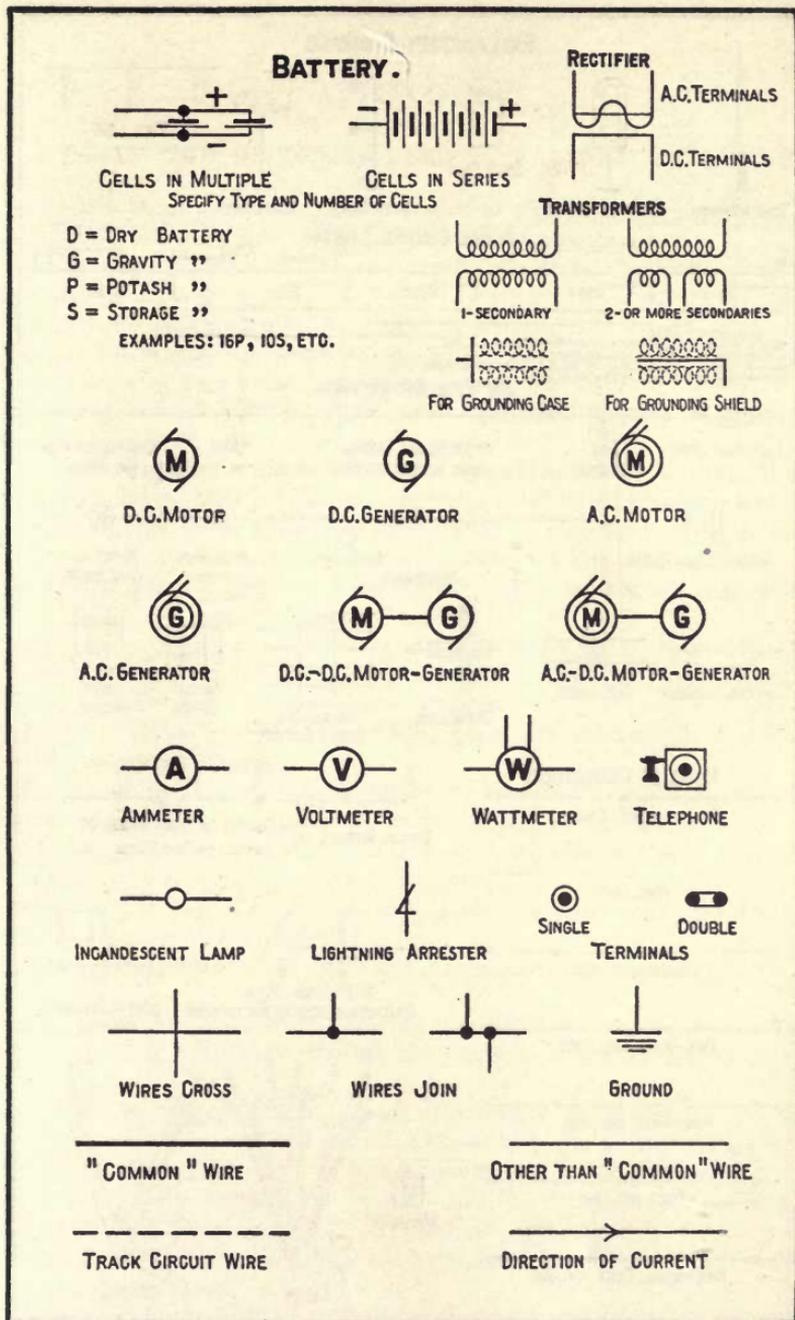
IMPEDANCE WITHOUT IRON CORE.



IMPEDANCE WITH IRON CORE



CONDENSER.



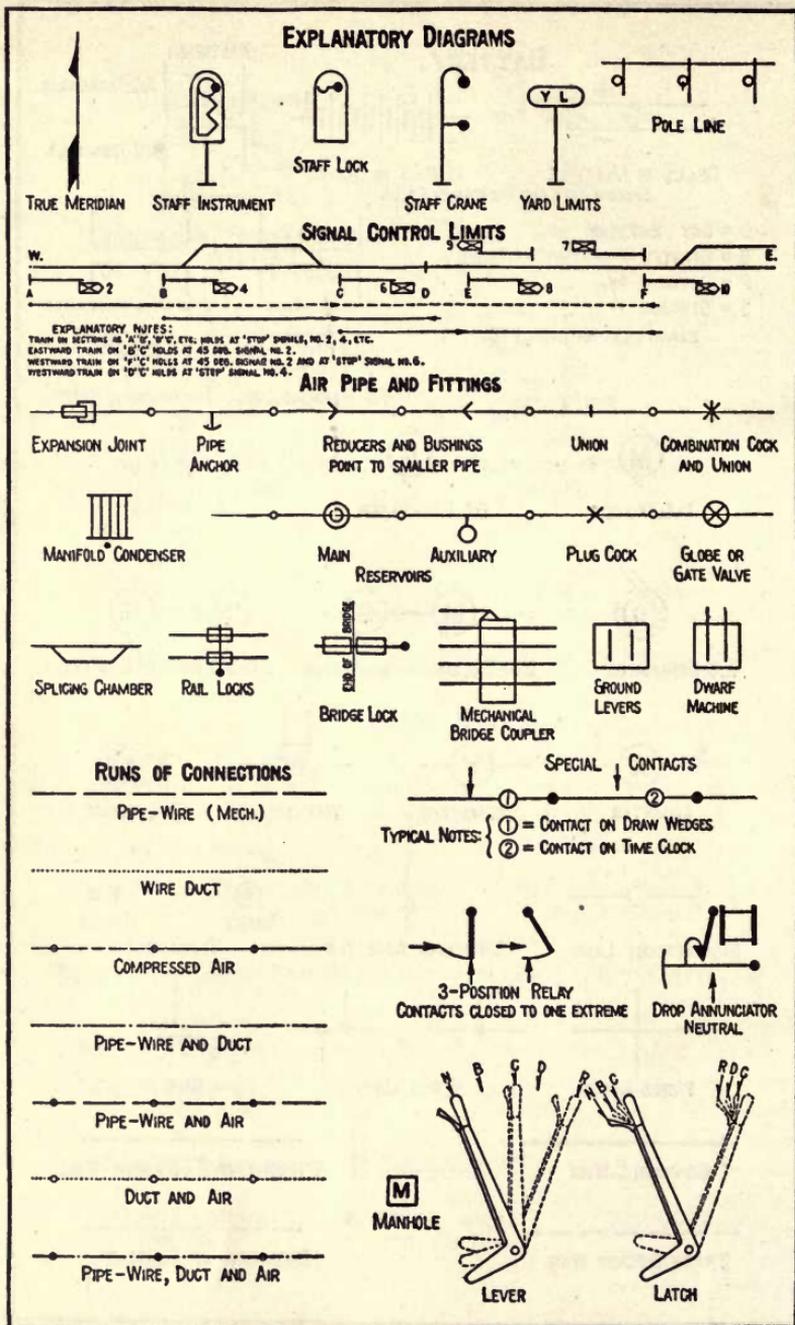


PLATE XIII.

## APPENDIX C

### A DEFINITION OF TERMS USED IN RAILWAY SIGNALING<sup>1</sup>

**Absolute Block Signaling.**—The method of signaling which requires that no train be admitted to a block while another train occupies it.

**Acute Angle Crank.**—A two-arm crank, the arms of which subtend an angle of less than 90 degrees.

**Adjustable Link.**—A link, the length of which can be varied.

**Adjusting Screw.**—A screw for regulating the relative positions of parts of apparatus, or for changing the tension in a wire line.

**Advance.**—The condition of being in an advance position, as a signal in relation to a train approaching it.

**Advance Signal.**—A signal having the same function as, but placed some distance in advance of, the home signal at a block or interlocking station to provide a short block section in which a train may be held so as not to interfere with the movements of trains in the adjacent block sections.

**Advance Block Signal.**—A fixed signal used in connection with a home block signal to sub-divide the block ahead.

**Air Gap.**—Any space occupied by air in a magnetic or electric circuit.

**Alarm.**—Any sound or information intended to give notice of approaching danger; a warning sound to arouse attention.

**All-air Interlocking.**—An interlocking plant the units of which are operated by compressed air only.

**Annunciator.**—A device to announce by an audible or visual indication, usually in an interlocking or block station, the approach of a train.

**Answer-back Signal.**—A signal arranged to give a visual or audible indication of the completion of a movement.

**Anti-friction Pipe Carrier.**—A pipe carrier in which the movable parts carry the pipe without friction.

**Approach Indicator.**—An indicator which announces the approach of a train.

**Approach Locking.**—Electric locking effected by the approach, or released by the passing, of a train, through the medium of a track circuit or track instrument.

**Arm.**—The principal movable part of a semaphore, consisting of a blade of wood or metal fastened to a casting which turns on a supporting pivot.

**Arm Casting.**—The part of a semaphore arm to which the blade is fastened, and which contains the bearing and the spectacles for holding the glasses through which the night color indications are given.

**Arm Sweep.**—The portion of a circle included between any two positions of a semaphore arm.

**Aspect.**—The position of a signal arm usually considered in its relation to the signal mast or a perpendicular thereto. The appearance of a signal

<sup>1</sup> *Proceedings, Railway Signal Association, 1914.*

conveying an indication as viewed from the direction of an approaching train.

3 **Audible Signal.**—A signal giving an audible indication.

4 **Automatic.**—A term applied to signals which assume their various aspects through the exercise of inherent power, as distinguished from those in which the changes are made manually.

5 **Automatic Block Signal.**—A block signal having an inherent power of motion which is controlled by the passage of a train into, through, and out of, the block section which the signal governs, and by the integrity of the track within that block.

6 **Automatic Block Signal System.**—A series of consecutive blocks, the use of which by trains is controlled by automatic block signals.

7 **Automatic Block System.**—A series of consecutive blocks controlled by block signals operated by electric, pneumatic, or other agency, actuated by a train or by certain conditions affecting the use of a block.

8 **Automatic Stop.**—An apparatus which, under certain conditions, operates in conjunction with an outside agency to stop a train automatically by shutting off the motive power, or applying the brakes, or both.

## B

**Back Light.**—A light showing through a small glass-covered opening in the back of a signal lamp.

**Back Lock.**—See Indication Lock.

**Back Locking.**—That part of the mechanical locking in a "Standard" interlocking machine, which acts back of the tappets.

**Back Spectacle.**—A small casting containing a roundel at one end and fastened at the other to the semaphore shaft of a signal in such manner as to change the visible color of the back light when the signal is moved.

**Back Tail Lever.**—The tail lever of a mechanical interlocking machine which projects towards the back of the machine.

**Back Wire.**—A wire connected to the back tail lever of a mechanical interlocking machine and to a signal so that it will insure that the signal will assume its normal position when the lever is put normal.

**Balance Lever.**—A lever which carries a signal counterweight.

**Banjo Signal.**—A term commonly applied to the enclosed disk signal because in general appearance it resembles a banjo.

**Banner Signal.**—A common name for the clock work signal.

**Battery Chute.**—A small receptacle for batteries, commonly made of cast iron and sometimes of reinforced concrete or fiber, and usually cylindrical in shape, designed to hold two or more battery cells.

**Battery Elevator.**—An arrangement of shelves in a supporting frame by means of which batteries may be lowered into, held in position in, and raised out of, battery chutes.

**Battery Vault.**—A term commonly used for battery well.

**Battery Well.**—A container for batteries, usually made of reinforced concrete.

**Bell Code.**—A code in which the strokes of a bell have a predetermined significance.

**Bell Crank.**—A common name for a crank.

**Blade.**—The extended part of a semaphore arm, which gives the day indication. 9

**Blade Grip.**—The part of a semaphore arm to which the blade is secured.

**Block.**—A section of track of defined limits, the use of which by trains is controlled by block signals.

**Block End.**—The end of a block.

**Block Indicator.**—An electro-magnetic device controlled by the track circuit of a track section, or by track instruments, to indicate, within a signal tower, whether or not that track circuit is occupied by a train. *Important !?*

**Block Instrument.**—The instrument used in controlled manual block signaling to compel the coöperation of the operators at both ends of a block in allowing a train to enter from either end.

**Block Length.**—The length of a block.

**Block Office.**—An office from which the use of a block section is controlled.

**Block Section.**—A section of track of defined length, the use of which by trains is regulated by a fixed signal, at the entering end on double track, and at each end on single track.

**Block Sheet.**—The sheet on which movements of trains are recorded at a block station.

**Block Signal.**—A fixed signal at the entrance to a block section, used to give indications regulating the movement of trains into that block. 10

**Block Signaling.**—The method of regulating the movements of railway trains, so as to maintain an interval of space between them.

**Block Station.**—A place from which block signals are operated.

**Block System.**—A series of consecutive blocks.

**Bolt Lock.**—A lock so arranged that if a switch is not in the proper position for a train movement the signal governing that movement cannot be cleared, and will prevent a movement of the switch while the signal is in the clear position.

**Bond.**—A common name for a rail bond.

**Bonding Tube.**—A tapered metal tube used for fastening a bond wire to a rail.

**Bond Wire.**—A common name for a part of a rail bond.

**Bonding Plug.**—A piece of metal resembling a rivet in shape and used to fasten the wire of a rail bond to a rail.

**Bootleg.**—A short piece of the wooden trunking, conduit, or conduit encased in concrete, used at the point where a track circuit connection is made with the rail to enclose a part of the wire which extends from the rail to a battery or relay box.

**Box Crank.**—Two or more cranks assembled in a common frame, each crank having an independent bearing.

**Boxing.**—A wooden covering for pipe or wire lines.

**Box Wheel.**—Two or more chain wheels assembled in a common frame, each wheel having an independent bearing. A group of chain wheels mounted in one frame.

**Bracket Mast.**—A signal mast above and supported on the cross piece or deck of a bracket post.

**Bracket Post.**—An arrangement for supporting two or more signals side by side on a single foundation.

**Bracket Signal.**—A signal supported on a bracket mast.

**Bridge Circuit Controller.**—A device for connecting and disconnecting circuits at the ends of a movable bridge span.

**Bridge Coupler.**—A device for engaging and disengaging the interlocking connections crossing a movable bridge span.

**Bridge Lock.**—A device for locking a movable span of a drawbridge in its closed position, so interlocked with the signals governing the approach to the bridge that they cannot be cleared unless the bridge is in the closed position and locked.

**Bridge Mast.**—The upright mast on a signal bridge.

**Bus Bar.**—A common conductor on a switchboard or other terminal from which taps may be made for taking off current for any purpose.

**Butt End.**—A term applied to a jaw or bar the end of which is cut off without tang or thread.

## C

**Cab Signal.**—An arrangement for producing visual or audible indications on moving engines or cars or in the cab of a locomotive to give information concerning the condition of the track in advance or of the fixed signals along the track.

**Calling-on Arm.**—A semaphore arm used to permit a train to move past a home signal when the principal arm of the signal has to be left at "stop."

**Cantilever Bracket Post.**—A type of bracket post so constructed that a signal mast thereon will be located in proper relation to the track governed.

**Capping.**—The covering for trunking.

**Caution.**—A term used for the caution indication. See caution indication.

**Caution Card.**—A form of written order issued to a train to permit it to enter a block which is not clear.

**Caution Signal.**—A signal giving a caution indication denoting that a train may proceed under some restrictions as to the speed of running.

**Chain Wheel.**—A wheel used in transmitting the motion of one part of a wire line to another part which extends in a different direction.

**Chain Wheel Stand.**—A casting or frame carrying one or more chain wheels.

**Channel Pin.**—A device in the shape of a truncated cone, in which is cut a longitudinal slot, and which is used to fasten a wire to a rail by wedging the wire in a hole in the rail.

**Check Locking.**—A method of interlocking, electrically, the levers in two adjacent interlocking plants to permit train movements between them to be made safely against the current of traffic and as the result of coöperation in each movement by the operators at the interlocking stations concerned.

**Check Lock Lever.**—In an interlocking machine, a separate lever which is used for check locking.

**Choke Coil.**—A reactance used in connection with lightning arresters and placed in series with the line to be protected.

**Choke Coil Lightning Arresters.**—A lightning arrester working on the choke coil principle.

**Clear** (*verb*).—To cause a signal to assume the aspect which indicates that a train may proceed.

**Clearance Card.**—In block signaling, a written order issued by a signalman to authorize a train to enter a block when the signal cannot be cleared.

**Clearance Point.**—The point within the angle included between converging tracks, at which the clearance lines of those tracks intersect.

**Clear Signal.**—A term used to indicate the aspect of a signal which indicates proceed.

**Clockwork Signal.**—A disk signal revolving on a vertical spindle and operated by clockwork.

**Common Wire.**—A wire which is used to form a part of the paths of current in two or more electric circuits. Usually applied to the common return wire.

**Compensator.**—A device for taking up the effects of temperature so as to maintain a constant length in a line of pipe or wire.

**Compound Relay.**—A relay having double-wound coils, or separate windings, insulated from each other.

**Concrete Bootleg.**—A bootleg made from concrete and conduit and used in place of wooden trunking, for enclosing the signal wire of a track circuit, which leads down to the horizontal wire leading to the battery or relay box.

**Conduit.**—A tube of wood, clay, iron or fiber, enclosing electric wires, usually underground.

**Contact Rail.**—In automatic train-stopping or cab-signaling systems, a bar of metal fixed on the ties parallel to the rails of the track in such a way as to be rubbed by an electrical conductor carried by the engine or train.

**Control Circuit.**—In interlocking, a circuit used to control an operated unit or its immediate controlling apparatus; and in block signaling, a circuit used to control a signal at some distance from another signal. 12

**Controlled Manual Block System.**—A block system in which the signals are operated manually by mechanisms so constructed that the displaying of a clear signal is dependent upon the coöperation of the signalmen at both ends of the block, or upon the absence of a train, or, in some cases, certain other obstructions, in the block, or both. 13

**Control Wire.**—A wire which carries current from its source to an operated unit or its immediate controlling apparatus.

**Convertible Lamp.**—A signal lamp equipped for the use of either oil burners or bulbs.

**Copper-clad Wire.**—An electrical conductor made with a steel center, surrounded by copper.

**Counterweight.**—In a semaphore, a weight so arranged that, in case of breakage of the wire, or the pipe controlling the signal, the weight will pull the signal to the stop position.

**Counterweight Lever.**—A lever on a signal or interlocking machine for the support of a counterweight.

**Crank.**—A lever, the arms of which form an angle, with the fulcrum at the vertex of the angle, which is used to transmit the motion of one part of a line of pipe to another part which extends in a different direction.

**Crank Stand.**—A frame in which one or more cranks are supported.

**Cross.**—The accidental electrical contact of conducting wires.

**Crossing Bar.**—A detector bar operated from a lever in an interlocking machine and used to prevent the changing of a route over a railway crossing while that crossing is occupied by a train.

**Crossing Gate.**—A gate which is lowered on either or both sides of a railway line across a public highway, to close the highway against traffic while a train is passing.

**Crossing Protection.**—Any arrangement of signaling or interlocking facilities designed to prevent collisions at a railway crossing.

**Cross Lock.**—A part of the locking, in a machine of the Saxby & Farmer type, which is moved by a locking dog in a direction at right angles to the movement of the dog.

**Cross Locking.**—The arrangement of the cross locks in an interlocking machine of the Saxby & Farmer type.

**Crossover.**—A short track leading from one to the other of two parallel tracks.

**Cross Protection.**—The arrangement of electrical conductors and instruments to prevent damage to, and improper operation of, electrical apparatus from the effects of a cross, or to allow only such operations as are necessary to obviate the possibility of danger.

**Crowfoot Zinc.**—A form of zinc plate used in a gravity cell, with a vertical stem and several radiating spokes or toes, resembling the foot of a bird.

**Current of Traffic.**—The normal movement of trains in a given direction.

**Cut Section.**—A track circuit section which requires, at a point within its length, the relaying of the effect of a change in its condition.

**Cycle.**—In an alternating current a complete change in direction from any given value through zero to an equal value in the opposite direction and back.

## D

**Danger.**—A term formerly used to denote the stop indication of a signal (obsolete).

**Dash Pot.**—A device, comprising a cylinder in which a fluid acts as a cushion for a falling weight attached to a piston within the cylinder.

**Deflecting Bar.**—A device which, by means of a curved bar sliding endwise between rollers, transmits the motion of one part of a line of pipe to another part which extends in a different direction.

**Derail** (*noun*).—Any device in a fixed location for throwing train wheels off the track to prevent them from running into a dangerous situation.

**Derailing Switch.**—A switch designed to turn train wheels off the track to prevent them from running into a dangerous situation.

**Detector Bar.**—A device for preventing the movement of a switch under a train, by means of a strip of metal mounted alongside the track rail and connected with a lever or an operated unit in such a way that the lever or unit is prevented from being moved or unlocked as long as the presence of train wheels prevents the bar from being raised.

**Detector Bar Driving Piece.**—A device bolted or riveted to a detector bar, to which the driving rod is attached.

**Detector Bar Link.**—A short link supporting a detector bar, and so pivoted on a clip fastened to a track rail that the detector bar in moving longitudinally must also move upward and above the top of the rail.

**Detector Bar Stop.**—A lug fastened to a track rail, on which the detector bar rests when its stroke is completed.

**Differential Relay.**—A relay having two sets of coils so arranged that each may work in a predetermined relation to the other.

**Disk Signal.**—A signal in which the day indications are given by the color, or by the absence or presence, of disks. 17

**Distant Block Signal.**—A fixed signal located in the rear of one or more home, or home and advance block signals, so controlled by them that it gives the indication "prepare to stop," when any controlling signal indicates stop, and may give the proceed indications only when all controlling signals are clear (or, in some cases, also when they give the caution indication); and used to convey information as to the indications of such signals before the trains reach the home block signals. 18

**Distant Indication.**—An indication which is conveyed by the aspect of a distant signal.

**Distant Signal.**—A fixed signal used in connection with a home signal to regulate the approach thereto. 19

**Distant Switch Signal.**—A signal used to indicate the position of the points of a switch.

**Dog Chart.**—A diagrammatic representation of the mechanical locking for an interlocking machine; used as a working plan in making up and fitting the locking. 20

**Doll.**—A term used sometimes to designate a short signal post, as the bracket mast of a bracket signal.

**Double Jaw.**—A special form of jaw for making an intermediate connection to a pipe line.

**Double-slip Switch.**—A diagonal crossing of two tracks, with switch points and frogs so arranged that a train on either track, in either direction, can proceed on either track beyond the crossing.

**Double Slot.**—A combination of two slots in one case for the control of two signal blades on one mast.

**Drawbridge Lock.**—A mechanical device to lock in alignment the rails on a drawbridge.

**Drop-away.**—The point in the gradual reduction of the amount of current flowing through the coils of an electro-magnet at which the amount or value of the current is such as to permit the armature to drop away from the cores of the magnet coils.

**Dummy.**—A bracket mast on a bracket signal bearing no signal arm and designed merely to aid by its location relative to the other bracket mast in showing to which of two or more tracks a signal applies.

**Dwarf Interlocking Machine.**—An interlocking machine of small proportions, commonly used in the open.

**Dwarf Signal.**—A low fixed signal. Similar to and having the same functions as a standard home signal. 21

## E

**Electric Bolt Lock.**—An electric lock which insures that the switch and the signal governing movements over it are in their proper relative positions before either can be moved.

**Electric Bridge Coupler.**—A device, one part of which is placed on a drawbridge, with the other part on the abutment, and which is operated, directly

or indirectly, by a lever, and is so arranged that a number of circuits passing through it can be closed only when the bridge is closed and locked.

**Enclosed Disk Signal.**—A signal in which a colored disk is displayed behind a glass front in a closed case to form the stop or caution aspect, and withdrawn from sight to form the proceed aspect of the signal.

**Electric Lock.**—A device which locks the lever of an interlocking machine to prevent its movement, until it is released by an electro-magnet.

**Electric Interlocking.**—Interlocking in which the operated units are operated and controlled by electricity.

**Electric Motor Signal Mechanism.**—A signal mechanism operated by an electric motor which is controlled by electric apparatus.

**Electric Selector.**—An electro-mechanical device by which the electric circuit of any one of a number of audible or visible signals or other devices may be controlled from a distant point without affecting any of the other apparatus or devices.

**Electric Slot.**—A device in which the connection between a signal arm and its operating mechanism is controlled by an electro-magnet, the connection being broken when the magnet is deenergized, and established when the parts are in proper mechanical relation and the magnet energized.

**Electric Switch Lock.**—An electric lock controlled from a signal cabin and attached to the operating connection of an outlying switch to prevent the switch from being moved without the knowledge and consent of the signalman in the cabin.

**Electric Train Staff System.**—A method of regulating the movements of trains in which the possession of a metal staff or a part thereof gives permission to a train to enter a block, the staffs being kept in machines at the ends of the block, which are so electrically locked between adjacent stations that only one staff and the sections thereof can be out of the two machines at one time.

**Electro-gas Signal.**—A semaphore signal worked by compressed carbonic acid gas which is controlled by electric apparatus.

**Electrolyte.**—The exciting fluid surrounding the plates or elements of an electric cell, containing in solution the chemicals which act on the elements to produce an electro-chemical current.

**Electro-magnet.**—A device comprising one or more coils of insulated wire wound around a soft iron or steel core, and depending for its magnetic action upon the passage of an electric current through the wire.

**Electro-mechanical Slot.**—A device consisting of an electro-magnet with levers and rods enclosed in a case and placed on the signal post so that it controls the connection between the signal arm and its operating mechanism, and used to prevent a signal from being cleared, or to cause the signal to move to the stop position when the route governed by the signal is obstructed.

**Electro-pneumatic Interlocking.**—Interlocking in which the units are operated by compressed air, the application of which is controlled by electricity.

**Electro-pneumatic Signals.**—Signals which are operated by compressed air, the application of which is controlled by electricity.

**Escapement Crank.**—A crank, used in a “switch and lock” movement, by means of which a single stroke of a lever performs the three operations of raising the detector bar and unlocking a switch; moving a switch; and lowering the detector bar and locking the switch.

## F

**Facing Point Lock.**—A lock for an interlocked switch, derail or frog, comprising a plunger which engages a lock rod attached to the switch points to lock the switch in its normal or reverse position.

**Facing Point Switch.**—A switch, the entering end of which is toward an approaching train.

**False Clear Signal.**—A signal which fails to indicate when the condition of the block governed by it is such as to make it unsafe to proceed.

**Fixed Blade Signal.**—A signal of fixed aspect, serving as a marker of location, having no moving parts and permanently indicating caution or stop.

**Fixed Signal.**—A permanent signal of fixed location with reference to the track, indicating condition affecting the movements of trains, as distinguished from signals given by a motion of the hand or by a flag or lamp.

**Floor Push.**—An electric circuit closer fixed in the floor so that a circuit may be made by pressure on a plunger.

**Fouling Bar.**—A detector bar, placed at or near a fouling point to prevent the movement of a unit while a train is on the bar.

**Fouling Point.**—See clearance point.

**Foundation.**—A fixed support, usually set in the ground, for carriers, cranks, compensators, wheels, signals and other like devices.

**F.P.L.**—The abbreviation for facing point lock.

**Frequency.**—The number of double alternations or periods made by an alternating electric current relay, so made that it will act effectively only when energized by an alternating current of given frequency.

**Frequency Relay.**—An alternating current relay, so made that it will act effectively only when energized by an alternating current of the given frequency.

**Front Contact.**—A part of a relay against which, when the relay magnets are energized, the current-carrying portion of the armature is held so as to form a continuous path for current.

**Front Rod.**—A rod attached to the extreme point of a switch and to which, in turn, the lock rod is fastened.

**Front Spectacle.**—The spectacle of the semaphore signal which holds the blade. See blade casting.

**Full Normal.**—The condition of being in, and latched in, the normal position, as applied to the lever of an interlocking machine; or of being in, and locked in, the normal position, as applied to an operated unit.

**Function.**—The activity appropriate to the performing or discharging of a duty or purpose. See Operated Unit.

**Fusee.**—An auxiliary signal consisting of a tube of chemical compound which will burn for a predetermined length of time with a colored light, generally red or yellow, and which is equipped with a sharp point so that it can be thrown to stand upright in the track.

## G

**Gravity Cell.**—A two-fluid primary cell, in which the electrolytes are kept separate by the difference in their specific gravity, the denser liquid resting at the bottom of the jar while the lighter solution stays on top.

**Ground Machine.**—An interlocking machine so constructed and arranged that it can be placed on the surface of the ground.

**Ground Mast.**—A signal mast with its base at or near the surface of the ground. Usually supported on a foundation.

## H

**Half-reversed.**—The condition of being midway between full normal and full reverse as applied to the lever of an interlocking machine or current breaker of a lever or signal.

**Half-reverse Lock.**—An electric lock applied to the lever of an interlocking machine to prevent the lever from going to its full normal position until certain operations have been performed, such as the passing of a train over a track circuit, or the operations of a hand release.

**Hand Release.**—A device, used in connection with an interlocking machine to insure that after a route has been set up or a lever movement made, an interval of time must elapse before the route can be changed or the lever manipulated.

**Head Block.**—One of the end ties on which the points of a switch and the switch stand rest.

**Head Rod.**—That one of the rods which connect the two points of an interlocked switch which is used for throwing the switch.

**High Signal.**—A full-sized semaphore mounted on a mast, bridge, building or other structure above the level of the top of a car or locomotive.

**High-voltage Signal.**—A signal operated by a current of usually 110 volts or more.

**Highway Crossing.**—The intersection, at the same elevation, of a public highway and a railway line.

**Highway Crossing Protection.**—An arrangement of one or more highway crossing signals.

**Highway Crossing Signal.**—An audible or visual signal at a highway crossing, designed to warn the users of the highway that it is unsafe to proceed over the railway line.

**Hold Clear Attachment.**—An attachment to a signal mechanism for holding the signal in the clear position.

**Home Block Signal.**—A fixed signal, located at the entrance of a block.

**Home Interlocking Signal.**—A fixed signal at a point at which trains are required to stop when the route is not clear.

**Home Signal.**—A fixed signal located at the point at which trains are required to stop, as distinguished from a distant signal, at which the maximum limitation on speed is a response to a caution indication.

**Home Track Circuit.**—A track circuit situated between a home signal and the advance block signal, which governs the indication of the home signal.

**Hookgear.**—A device by which one lever operates one of two pipe-connected signals, depending upon the position of the switch.

**Horizontal Chain Wheel.**—A chain wheel, the axis of which is vertical.

**Horizontal Locking.**—Locking, a cross section of which lies in a horizontal plane.

## I

**Impedance Bond.**—A low-resistance bond, making a continuous path for return propulsion current, while impeding from one track circuit to another the flow of the alternating current used in signaling, and confining the flow of that current to one track circuit. 25

**Impedance Coils.**—A term sometimes applied to choking coils or reactance coils.

**In Advance of.**—Ahead of, as related to an approaching train.

**Indication.**—The information or command conveyed by the aspect of a visual signal. The information conveyed to the operator of an interlocking machine that the movement of an operated unit has been completed, and that the unit is in the full normal or full reverse position.

**Indication Lock.**—An electric lock fitted to a lever of an interlocking machine for the purpose of preventing the return of that lever to its full normal latched position until it is released through an impulse of current in the lock coils.

**Inductive Bond.**—See impedance bond.

**Insulated Rail Joint.**—A rail joint in which insulating material is placed between the ends of two rails and around the parts of the joint so as to prevent the passage of electric current from one rail to the other.

**Interlocking.**—An arrangement of switch, lock and signal appliances so inter-connected that their movements must succeed each other in a pre-determined order. 26

**Interlocking Machine.**—An assemblage of levers and locking in a frame, with connections arranged so that the levers can be moved or unlocked only in a certain predetermined order, and so that a movement of a lever, or its unlocking preparatory to its movement, may be made to lock any or all other levers in the frame.

**Interlocking Plant.**—An assemblage of switch, lock, and signal appliances interlocked.

**Interlocking Relay.**—A relay comprising two sets of coils and their armatures, so arranged that either armature may be made to prevent the other from closing or opening a circuit through a back or front contact.

**Interlocking Signals.**—The fixed signals of an interlocking plant.

**Interlocking Signal Oil Pipe.**—A pipe which is filled with oil and provided with stuffing boxes to prevent the escape of the oil, and containing an operating pipe or wire used in mechanical interlocking.

**Interlocking Station.**—A place from which an interlocking plant is operated.

**Interlocking Unit.**—Any signal, switch, derail, lock or crossing bar operated separately or in combination with any other constituent part of an interlocking system.

## J

**Jaw.**—A forked attachment on a pipe line for making a pivotal connection to another pipe line, or to any device.

**Jaw Rod.**—A rod having a jaw at either or both of its ends as an integral part thereof.

**Johnson Interlocking Machine.**—An interlocking machine with the locking bars and tappets arranged in a vertical plane beneath it.

**Jumper.**—A temporary shunt or short-circuit in a series-connected circuit, commonly used in track-circuit work to preserve the continuity of the track circuit past a section of track such as a crossing or electrified tracks where the wires cannot be suitably insulated.

**Junction Box.**—A box to which are run a number of electrical conductors for convenient connection, disconnection, or inspection.

## L

**Lag.**—The phase difference of one alternating current behind another, or of one function of an alternating current behind another, as current and voltage.

**Lap Sidings.**—An arrangement of two side tracks the ends of which overlap each other.

**Latch Block.**—A block fastened to the lower extremity of a latch rod, and which engages with a square shoulder of the segment or quadrant of a mechanical interlocking machine to hold the lever in position.

**Latch Foot.**—The connection on the lower end of the latch rod in a mechanical interlocking machine by means of which the rocking link is actuated.

**Latch Handle.**—The part of a lever latch which is grasped by the hand to operate the latch.

**Latch Locking.**—The arrangement of mechanical locking in which the locking bars are driven by means of and through connections to the latches of the levers.

**Latch Rod.**—The rod extending between the latch handle and the latch block on the lever of a mechanical interlocking machine.

**Latch Shoe.**—The casting by means of which the latch rod and the latch block are held to a lever of a mechanical interlocking machine.

**Lattice Post.**—A signal mast or post built up of several uprights which are fastened together by diagonal pieces of iron.

**"Lazy Jack" Compensator.**—A compensator in which an arm of an acute-angle crank is so connected to an arm of an obtuse-angle crank that the two connected arms move in the same general direction in overcoming the effects of expansion and contraction in lines of pipe connected to the opposite arm.

**Leadout.**—The arrangement of apparatus by means of which the motions of the levers in a mechanical interlocking machine are transmitted to the pipe and wire lines outside the interlocking station.

**Lever Latch.**—A spring-actuated mechanical device attached to the lever of an interlocking machine to hold it in the normal or reversed position.

**Lever Locking.**—The arrangement of mechanical locking in which the locking is connected directly to the levers.

**Lever Shoe.**—The casting which serves as a bearing for the lever of a mechanical interlocking machine, and also as a socket for one or more tail levers.

**Line Circuit.**—The wires or other conductors in the main line of a circuit.

**Lightning Arrester.**—A device to prevent or reduce the possibility of damage to electrical apparatus from discharges of lightning.

**Link.**—A short piece of  $1\frac{1}{4}$ -in. iron with a solid jaw at one end and a screw jaw at the other.

**"Lock-and-block."**—A common name for the controlled manual block system.

**Locking.**—A mechanical arrangement of locking bars, dogs, and cross-locking by means of which the interlocking is effected between the levers of an interlocking machine and the order of their movement is determined.

**Locking Bar.**—A bar to which locking dogs are attached and which extends lengthwise in an arrangement of mechanical locking.

**Locking Bracket.**—A bracket which is part of a locking bed and forms one of the supports of an arrangement of mechanical locking.

**Locking Dog.**—A block which is attached to a locking bar or tappet, by means of which the locking between bars is accomplished.

**Locking Filler.**—A filler, placed in a spare space of a locking guide to prevent the buckling of the locking bar or bars in the adjacent space.

**Locking Frame.**—The whole supporting frame of an arrangement of mechanical interlocking.

**Locking Plunger.**—A plunger of a mechanical locking device which passes through an opening in a lock rod.

**Locking Sheet.**—A statement in tabular form of the locking operations provided for a given interlocking machine. 2

**Lock Rod.**—A rod which is connected to switch points through which a locking plunger extends when the points are in the full normal or full reverse position.

**"Locking-up" Track Circuit.**—A track circuit used to take away the unlock when a train passes an advance block signal into the block ahead.

**Lower Quadrant.**—One of the quarters of a vertical circle below its horizontal axis.

**Lower Quadrant Signal.**—A semaphore signal, the arm of which is inclined downwardly from the horizontal to give indications.

## M

**Machine Frame.**—The support for an interlocking machine.

**Machine Framing.**—The frame in an interlocking station on which the interlocking machine rests; usually set on a foundation separate from that which supports the wall of the building.

**Maintain.**—To keep in satisfactory condition.

**Maintainer.**—A person whose duty it is to keep signaling apparatus in its proper working order.

**Manual Block System.**—A block system in which the block signals at a block station are moved by hand by an attendant, on information conveyed to him from adjacent block stations. 28

**Mast.**—The upright from which signals are displayed.

**Mechanical Bolt Lock.**—A mechanical device connected to a unit in order to insure that one or more other units are in their proper relative positions.

**Mechanical Interlocking.**—Interlocking in which the units are operated manually.

**Mechanical Locking.**—*See* Locking.

**Mercury Contact Relay.**—A relay, the armature of which closes one or more circuits by making a contact through mercury.

**Mechanical Slot.**—A device placed in the connections to a signal which requires the movement of more than one operating lever to clear the signal.

**Mechanical Time Lock.**—A mechanical device in connection with an interlocking signal lever to insure a time interval between throwing the signal to stop and moving a derail or switch over which that signal governs.

**Mechanical Trip.**—A term used to denote a trip—as used in apparatus for stopping trains without the intervention of an engineman—which is actuated or controlled by mechanical means as distinguished from apparatus in which electricity or magnetism is employed for the same purpose.

**Mechanism.**—A general term for any mechanical or power operated device for operating a signal or interlocking function or accessory device, from a distance.

**Mechanism Case.**—The housing for a signal mechanism.

## N

**Neutral Relay.**—A relay in which the flow of current in either direction through the magnet coils has the same effect on the armature.

**Normal.**—The position in which a lever in an interlocking machine stands when the corresponding switch or signal is in its normal position.

**Normal Danger.**—A term used to express the normal condition of the signals in a system in which the indication to proceed is given only upon the approach of a train to an unoccupied block.

## O

**Obtuse-angle Crank.**—A two-arm crank, the arms of which subtend an angle of more than 90 degrees.

**Opposing Train.**—A train running in a direction contrary to that of any specified train

**Outlying Switch.**—A switch not connected with an interlocking plant.

**Overlap.**—An extension of track circuit control of the signal at the entrance to a block through a portion or all of the block in advance.

**Overstroke.**—The excess throw in a pipe or wire line.

## P

**Permissive Block Signaling.**—The method of signaling which permits one or more trains in the same direction to enter a block section before the last preceding train has passed out.

**"Pick Up."**—The point in the gradual increasing of the amount of current flowing through the coils of an electro-magnet at which the amount or value of the current is such as to overcome the force of gravity on the armature, and attract it against the cores of the magnet coils.

**Pinnacle.**—A casting, usually ornamental, which is placed on top of a signal mast.

**Pipe Adjusting Screw.**—A device, used in a pipe line for changing its length.

**Pipe Carrier.**—A device, comprising a grooved roller working in a stand for supporting a pipe line at an interlocking plant in such a manner as to permit of its longitudinal movement.

**Pipe Carrier Bearing Plate.**—A plate or bar to which pipe carriers are fastened.

**Pipe Carrier Side Plate.**—A part of a pipe carrier which passes down the side of the pipe and is secured to the foundation to form a support for the rollers.

**Pipe Carrier Stand.**—The supporting frame of a pipe carrier.

**Pipe Connected.**—The condition of being connected together by, or arranged for operation by means of, a pipe line.

**Pipe Line.**—A line of pipe connecting a mechanically operated switch, or signal, or other operated unit to its lever in an interlocking machine.

**Pipe Plug.**—A plug, consisting of a short section of rod which is inserted in and riveted to the contiguous ends of pipe at a joint in a pipe line.

**Pipe Run.**—An assemblage of pipe lines with their carriers and foundations in a common course.

**Pit.**—A depression below the floor level of an interlocking station, in which part of the leadout apparatus is situated.

**Plunger.**—The bar which, by entering a hole in the lock rod, effects the locking in a facing point lock.

**Plunger Box.**—The casting or guide in which the plunger of a bridge lock or holt lock moves.

**Plunger Casting.**—A stand and guide for facing point and bridge lock plungers and lock rods.

**Plunger Release Track Circuit.**—A track circuit by means of which the plunger of a block signal instrument or controlling apparatus is released.

**Plunger Stand.**—That part of a facing point lock which is secured at a certain fixed distance from the switch point, and through which the plunger moves.

**Pneumatic Interlocking Diaphragm Valve.**—A valve controlling the admission of compressed air from an operating pipe into a switch or signal cylinder.

**Pneumatic Interlocking.**—Interlocking in which the units are operated and controlled by compressed air.

**Point Lug.**—A lug bolted to the web of a switch point rail to which the switch rods are attached.

**Point Rail.**—Either of the two movable rails in a "split" switch, as distinguished from the immovable "stock" rails.

**Polarized Relay.**—A relay, the operation of which is controlled by the direction of the flow of current through its magnet coils.

**Polarized Track Circuit.**—A track circuit in which the direction of current is used to govern the polarity of magnetism in relay magnets for the controlling of apparatus.

**Pole Changer.**—A device by which the direction of current flow in an electrical circuit may be changed.

**Pole Piece.**—That part of the core of an electro-magnet which projects beyond the coil, and adjacent to which the armature is placed.

**Polyphase Relay.**—A relay designed to respond to polyphase alternating current.

31 **Position Signaling.**—A scheme of signaling whereby the information to be delivered by a signal is shown by the relative position which the moving part of a signal bears to a certain fixed part.

**Pot Signaling.**—A low revolving signal, turning on a vertical axis, and used either as a switch target for indicating the position of the switch to which it is attached, or as a dwarf signal for low-speed movements.

**Power Interlocking.**—Interlocking, the units of which are operated by some form of power other than manual.

**Preliminary Latch Locking.**—Mechanical locking so arranged that the locking of a lever to prevent it from being moved in conflict with another lever is fully effected before that other lever begins to perform its function.

**Propulsion Bond.**—A rail bond which will carry the return current used for propulsion purposes on an electric railway.

**Pusher Attachment.**—An attachment to electric train-staff apparatus designed to protect, in addition to the regular train movement, the movement of a pusher engine when, after being detached from the rear of the train, it is to be run back to its starting point.

## Q

**Quadrant.**—The fourth part of a circle. A part of a mechanical interlocking machine which is bolted to the machine frame, and by means of which all levers that are locked by another lever in either its normal or reversed position, are held locked while that lever is being moved.

## R

**Radial Arm.**—A device used for changing the direction of a pipe line.

**Rail Bond.**—A metallic connection between the adjacent ends of contiguous rails in a track to insure the continuity of that line of rails as an electrical conductor.

**Rail Clip.**—A metal support bolted or clamped to a rail, for carrying a detector bar.

**Railway Crossing.**—The intersection at the same elevation of two or more railway tracks.

**Ramp.**—A bar with an inclined upper surface fixed on the ties of a railway track and designed to raise a vertically moving member of a cab-signaling or a train-stopping system depending from a passing locomotive.

**Reactance.**—In an alternating current circuit, the component of impedance or total effect retarding the flow of current which is out of phase with

or 90 degrees from the phase of the current. The ohmic effect due to the induction in the circuit.

**Reactance Coil.**—A coil for producing a difference of phase. A magnetizing coil surrounded by a conducting covering or sheathing which opposes the passage of rapidly alternating currents less when directly over the magnetizing coil than when a short distance from it.

**Rear.**—The condition of being behind, as a train in relation to a signal which it is approaching. A term used to describe the location of a signal which, with reference to another signal, is in its rear when it is in such position as to be passed first by an approaching train.

**Relay.**—An electro-magnetic device responsive to direct and alternating current which is designed to repeat in one or more electric circuits certain effects of changes in, or completion or interruption of the circuit in which it is placed.

**Relay Armature.**—~~The movable part of a relay, the positions of which are~~ 32  
controlled by the condition of the magnet coils according to the presence or absence of current therein.

**Relay Post.**—A post set in the ground to support a relay box.

**Relay Shelter.**—An arrangement for housing a relay.

**Release.**—An arrangement for the purpose of releasing either electrically or mechanically any apparatus which has previously become locked.

**Release Route Locking.**—An arrangement for releasing the route locking at an interlocking plant.

**Reverse** (*verb*).—To move a lever or unit in an interlocking machine from its normal to the opposite position.

**Right-angle Crank.**—A two-arm crank, the arms of which subtend an angle of 90 degrees.

**Riser Plate.**—An iron plate riveted to a tie plate at a switch and used to support the switch points.

**Rocker.**—*See* rocking shaft.

**Rocking Shaft.**—A shaft, used in an interlocking plant supported on two or more bearings, and rotated about its axis by means of an arm at one end, thus transferring the movement to an arm at the other end. A shaft which is so supported as to transmit motion by means of a rotary movement through less than a circle.

**Rocking Link.**—That part of an interlocking machine by means of which the latch movement is transmitted to the locking bars.

**Roundel.**—A piece of glass used to give the colors to the night indications of semaphore signals.

**Roundel Clip.**—A device made of rubber for holding a roundel in place between the semaphore casting and the roundel ring.

**Roundel Ring.**—The ring by means of which a roundel is held in place in a spectacle casting.

**Route.**—Any path or course which can be taken by a train passing from one point to another.

**Route Locking.**—The electric locking of switches, drawbridges, etc., in a route, or the signals of a conflicting route, to maintain the integrity of a route during the movement of a train over it.

## S

**Screw Jaw.**—A jaw fastened by means of a screw connection to the pipe or device with which it is used.

**Screw Release.**—A form of hand release operated by a screw.

**Selective Despatching System.**—A system in which a number of audible or visible signals located along a railway line are connected to a telephone, telegraph or other circuit, and in which any one of such signals may be operated by means of an electric selector without interfering with other signals associated with such circuit.

**Selector.**—A device by means of which the position of one or more operated units may be made to determine which of several others shall be operated.

**Selector Coil.**—A coil which when energized will attract and hold in place an armature which, in turn, will permit a predetermined movement to be made.

33 **Semaphore Arm.**—The principal movable part of a semaphore, consisting of a blade fastened to a casting which turns on a pivot.

**Semaphore Bearing.**—The bearing which supports the pivot of a semaphore arm.

**Semaphore Blade.**—That part of the semaphore arm which by its form and position gives the day signal indications.

34 **Semaphore Signal.**—A signal in which the indications are given by the positions of a movable arm.

**Semi-automatic.**—The condition in which a part of the operation of a mechanism or device is accomplished through the exercise of inherent power of motion.

**Semi-automatic Signal.**—A signal which has inherent power to assume the stop position after it has been cleared by other means.

5 **Signal.**—A means of conveying information to a train.

**Signal Bracket.**—A column or post with an offset support for signal masts.

**Signal Bridge.**—A bridge which spans one or more railway tracks for the purpose of supporting one or more signals.

**Signal Control.**—The arrangement through which the operation of a signal is governed.

**Signalman.**—The attendant at a block or interlocking station.

**Signal Marker Light.**—A light used to distinguish certain fixed signals.

**Signal Mast.**—The upright part of a signal which is used to support the parts of the signal that give the indication.

**Signal Mechanism.**—The apparatus, which in a power-operated signal directly operates to change the aspect of the signal.

**Signal Repeater.**—An indicator which shows in a cabin the changes in position in the arm or movable disk of a fixed signal.

**S. L. M.**—The abbreviation for switch and lock movement.

**Slot.**—A disconnecting device inserted in the connection between a signal arm and its operating mechanism.

**Slotted Signal.**—A signal in which the connection from the lever or other operating mechanism is controlled by a mechanical or electric slot.

**Slow-acting Relay.**—A relay in which a predetermined time interval is made to elapse between the opening of a circuit through the magnet coils and the consequent dropping of the armature.

**Slow Board.**—A sign to warn the enginemen of trains to reduce speed at a certain point.

**Slow-releasing Slot.**—An electric slot for an automatic signal, so constructed as to consume an appreciable interval of time between the breaking of a circuit and the consequent releasing of the holding mechanism.

**Solenoid Relay.**—A relay in which the magnet coils are solenoids with movable cores upon which contacts are mounted.

**Smash Signal.**—A signal used at particularly dangerous points, such as drawbridges, designed to be broken when overrun.

**Solid Jaw.**—A special form of jaw rigidly connected to a pipe line.

**Space Interval System.**—The method of operating trains so as to maintain certain definite relations of distance between them. 36

**Spare Lever.**—A lever in an interlocking machine to which no unit is connected.

**Spare Space.**—A lever space in an interlocking machine in which there is no lever.

**Spark Gap.**—The air space or gap through which a disruptive discharge passes.

**Special Locking.**—The locking on an interlocking machine arranged for special conditions.

**Spectacle.**—The casting which holds the glass or glasses through which the night indications are given on a semaphore signal.

**Speed Control.**—The control of an automatic train-stopping apparatus by a means which is operative or inoperative according to whether the speed of the train is or is not above a certain predetermined rate.

**Spindle Slot.**—An electro-mechanical slot attached to the semaphore shaft of a signal.

**Staff.**—The part of the apparatus, used in the electric train staff system, the possession of which gives enginemen permission to enter a block. 37

**Staff Catcher.**—A mast equipped with a device for receiving a staff from a moving train or for holding a staff so that it can be picked up by a moving train.

**Standard Code.**—The code of interlocking, block signal, and train rules adopted by the American Railway Association.

**Stick Relay.**—A relay so connected that a circuit through the magnet coils, originally closed at an outside point, is held closed through a contact of the relay.

**Stock Rail.**—Either of the two immovable rails as distinguished from the movable "point" rails in a split switch.

**Straight-arm Compensator.**—A compensator which is in the form of a straight connection between two parallel parts of a pipe line.

**Suspended Signal.**—A signal suspended from an overhead signal bridge, or other high structure.

**Switch Adjustment.**—An arrangement placed on the front rod of a switch or derail so as to provide for taking up any extra motion which the pipe line might tend to impart to the switch or derail.

**Switch Circuit Controller.**—A device for opening and closing electric circuits of block and interlocking signals, operated by a connecting rod attached to the switch points.

**Switch Box.**—A common name for a switch circuit controller.

**Switch Indicator.**—An electro-magnetic device controlled by a track circuit, to indicate whether or not the track section is occupied by a train.

**Switch and Lock Movement.**—An arrangement by means of which a single stroke of a lever in a mechanical interlocking plant unlocks a switch, moves it and locks it again.

**Switch Box.**—A circuit controller which is operated in conjunction with the movements of a switch and is usually directly connected to the switch points.

**Switch Point Lug.**—A lug attached to a switch point to which the front rod is connected.

## T

**Tag.**—A label, usually in the form of a disk or small flat piece of wood, fiber, leather, or metal, used to identify wires, wiring connections, or parts of apparatus.

**Tail Lever.**—The part of the lever of a mechanical interlocking machine to which the operating pipe or wire is connected.

**Tang End.**—A projection on the end of, and of smaller diameter than, a jaw or rod, used to stiffen the joint between the pipe line and the jaw or rod.

**Tappet.**—A bar which is operated directly or indirectly by the lever or lever latch in an interlocking machine with vertical locking and which actuates the locking bars and is locked by them. A pivot or swing-dog which is attached to the locking bar in an interlocking machine with horizontal locking, and which is actuated or locked by the cross-locking.

**Tappet Circuit Controller.**—A circuit controller attached to a tappet and usually operated by the movement of a lever latch handle.

**"T" Crank.**—A crank with three arms, one of which is at right angles with the other two arms.

**Telegraph Block System.**—A block system in which the signals are operated manually, upon information by telegraph.

**Terminal.**—Either end of an electrical circuit, or the device or apparatus to which it is attached. The end of a line or system of railway.

**Three-light Spectacle.**—A semaphore spectacle which has three openings for light indications.

**Three-position Automatic Block Signals.**—A system of automatic block signals designed to provide the protection of distant signals without the duplication of signal arms usually involved, and in which each signal is so arranged that it may be made to present any one of three different aspects.

**Three-position Signal.**—A semaphore signal arranged to give three different indications.

**Throw Rod.**—The rod attached to the head rod of a switch, connecting the switch to a switch stand, pipe line, or other operating device.

**Time Interval System.**—The method of operation under which trains are run where there is no block system.

**Time Release.**—*See* Time Lock.

**Time Lock.**—A device for automatically releasing electric locks or interlocking levers after the expiration of a predetermined time interval.

**Torpedo.**—An auxiliary stop or caution signal consisting of an explosive cap to be fastened to the top of the rail of a track, and exploded by the pressure of a wheel of an approaching locomotive or other vehicle.

**Torpedo Placer.**—An apparatus for placing torpedoes in position to be exploded by the passage of a wheel of a locomotive or other vehicle.

**Torque.**—The movement of force causing rotation; the product of the force and the distance from the point of application of the force from the center of rotation.

**To the Rear of a Signal.**—The section of track occupied by a train before it has passed a signal.

**Tower.**—The common name for the building from which interlocking and signals are operated. *See* Interlocking Station.

**Track Circuit.**—An electric circuit of which the rails of a track form a part.

**Track Circuit Locking.**—Electric locking which is accomplished through the medium of one or more track circuits.

**Track Indicator.**—A map-like reproduction of railway tracks, controlled by track circuits so arranged as to indicate automatically, for defined sections of track, whether or not such sections are occupied.

**Track Instrument.**—A lever fixed in relation to the rails of a track so that its deflection by passing train wheels may be made to open or close one or more electric circuits.

**Track Model.**—*See* Track Indicator.

**Track Relay.**—A relay to be placed in and operated by a circuit of which the track rails are an integral part.

**Train-order Signal.**—A fixed signal used at telegraph offices to indicate to a train whether or not it must stop to receive orders.

**Train-order Station.**—A station where train orders are received for delivery to trains, and where trains may report for orders. 41

**Transverse Pipe Carrier.**—A pipe carrier designed to guide pipe across track.

**Trip.**—In automatic train-stopping apparatus, the bar, lever, or other device, fixed on or near the track or roadway, which when in a certain position trips or releases the apparatus on the vehicle, by which release the stopping of the vehicle is directly or indirectly effected.

**Trunking.**—The wooden casing used to protect both electrical conductor wires and those wires used to operate signal arms when they lie on or near the surface of the ground.

**Trunnion.**—A cylindrical projection on a revolving part for supporting it in a bearing.

**Tunnel Signal.**—A signal designed to be placed in or to guard a tunnel.

**Two-light Signal Aspect.**—A semaphore signal which shows at night at least two lights.

## U

**Under Control.**—A condition in which an engineer is prepared to stop within the distance he can see the track to be clear ahead of him.

**Up-and-down Rod.**—A common name for the movable vertical rod connecting the semaphore signal arm with the operating device at the base of a signal mast.

**Upper Quadrant.**—One of the quarters of a vertical circle above its horizontal axis.

**Upper-quadrant Signal.**—A semaphore signal the arm of which is inclined upwardly from the horizontal to give other than stop indications.

**Universal Link.**—The crank arm by means of which motion is transmitted from the rocking link to the rocking shaft in an interlocking machine.

## V

**Vane Relay.**—A type of alternating-current relay in which a light metal disk, or vane, is caused to move the pole pieces of magnets to close contacts when the magnets are energized.

**Vertical Locking.**—Mechanical Locking arranged in a vertical plane.

## W

**Wheel Stand.**—The frame in which chain wheels are supported.

**Wire Adjusting Screw.**—A device in a wire line, used for changing its length.

**Wire Carrier.**—A device, comprising a roller or pulley, supported in a frame, used as a support and guide for a wire line.

**Wire Compensator.**—A device for automatically keeping the length of a wire uniform under variations in temperature.

**Wire Run.**—In an interlocking plant, an assemblage of wire lines, with their carriers and foundations, in a common course.

**Wood Capping.**—The covering for wooden trunking.

## Z

**“Z” Armature.**—An armature of an electro-magnet shaped like the letter Z and used in enclosed disk signals, indicators, and other apparatus.

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