The TYPE "F" SYSTEM of ELECTRIC INTERLOCKING

Bulletin 100

Union Switch & Signal Co.

SWISSVALE, PA.

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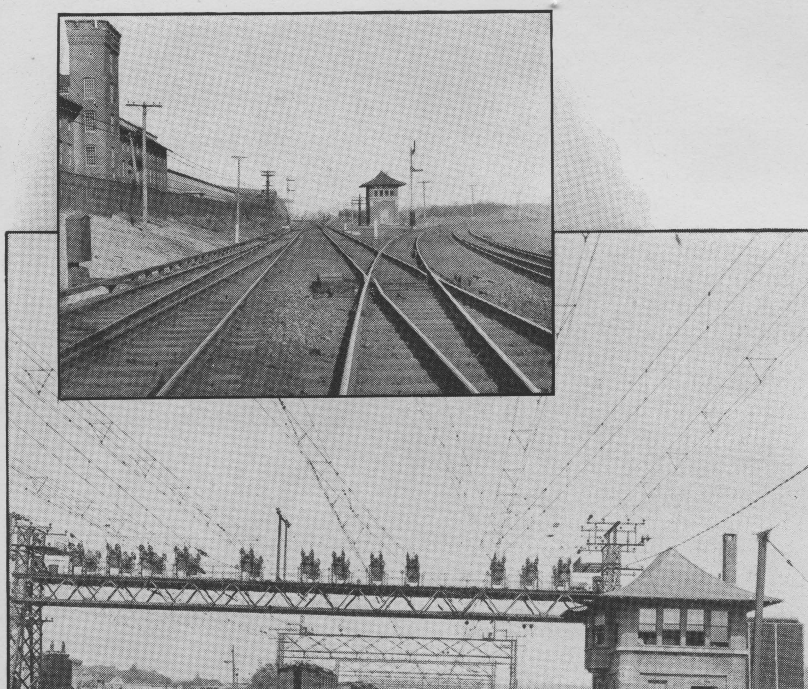


Type "F" Electric Interlocking—N. Y. N. H. & H. R. R.

The Type "F" Electric Interlocking System

The Union Switch & Signal Company manufactures and installs both the Electro-Pneumatic and Electric types of power interlocking. The following is a description of the Union Company's system of Electric Interlocking which is generally known as the "Type "F" System."

General Scheme

The motors for operating both switches and signals in the Type "F" Electric Interlocking System are supplied with energy by a pair of bus-mains, which extend the entire length of the interlocking and carry energy direct from the source of supply at the tower or station to all units. These two feeders are the *only* large wires in the interlocking and serve the same purpose as does a transmission line in the distribution of electrical energy throughout a city; a water main in supplying water to various residences; or the main air line in an electro-pneumatic interlocking system. It is from these two feeders that the energy for *operating* the various switches and signals is taken.

Each unit is *controlled* by a local relay or its equivalent, constituting a part of the switch or signal layout, and governed in position by two separate and independent wires leading direct from the control lever in the tower. Energy can reach a unit only from the bus-mains through contact points of the control relay.

Two distinctly separate wires carry the *indication* current from a switch which has completed its movement to the indication relay which determines the energization of the lock magnet on the lever by which the switch is controlled. The indication that a signal has assumed its most restrictive position is carried directly to its indication lock magnet. The control and indicating devices, requiring but little energy for their actuation, may be supplied with current over small size wires, while an assurance of there always being a high voltage available at the unit for its operation is secured by the use of heavy wires for the bus-mains. Thus, there is in the Type "F" System a separation of circuits by their relative power requirements, which division, being basically correct, lends itself to the maximum degree of protection as well as economical application.

General Principles

The Type "F" System of Electric Interlocking is based upon five fundamental principles:

1. Absolute separation of control, operation, and indication.

2. Continuous indication, and consequently continuous control of signals by the switches.

3. No commons.

4. Polarized controls wherever possible.

5. Concentration of most of the apparatus entering vitally into the safety and reliability of the system, in the tower.

By separating the functioning of power interlocking along the natural lines of control, operation, and indication, the use of cross protective devices is avoided.

In the electric interlocking field, the Type "F" System has acquired an enviable reputation by reason of the following outstanding features which it incorporates:

SAFETY, because:

1. *Complete isolation of operating, control, and indicating circuits one from another* and their appropriate polarization with the elimination of a common return, nullifies the effect of crosses and grounds.

2. Final and *continuous* check on the position of every switch over which a signal governs train movement is secured by the SS system of control, this in itself constituting the greatest modern advancement in the interlocking field.

SIMPLICITY, because:

1. Complicated, dual-functioning circuits are eliminated.

2. Auxiliary safety devices are not required.

3. Selection of circuits is accomplished under ideal conditions by utilizing simple contacts in the interlocking machine; this simplifies outside wiring and eliminates extra circuit controllers at the track switches.

4. The various units employed are standard parts used in other classes of signal work.

RELIABILITY, because:

1. Circuits are simple and apparatus is free from complication and possible derangement as a result thereof.

2. Practically normal voltage is available at the units operated no matter how far distant from the tower, this insuring consistently satisfactory operation under all conditions of weather and the response of the units to their levers quickly and with surety.

FLEXIBILITY, because:

1. Principles employed permit the use of direct or alternating current, or a combination of the two.

2. Signal mechanisms are in all respects similar to those used in other classes of signal and interlocking work, thus insuring interchangeability.

3. Special control and locking easily applied as conditions demand.

4. Inter-control with other signaling is easily accomplished.

Elements

The elements involved in the Type "F" Electric Interlocking System are:

1. A source of power serving as a central energy supply for the entire interlocking.

2. A means of distributing energy to the various units for control, operation, and indication.

3. The interlocking machine which places all units within the limits of the plant under the control of a leverman.

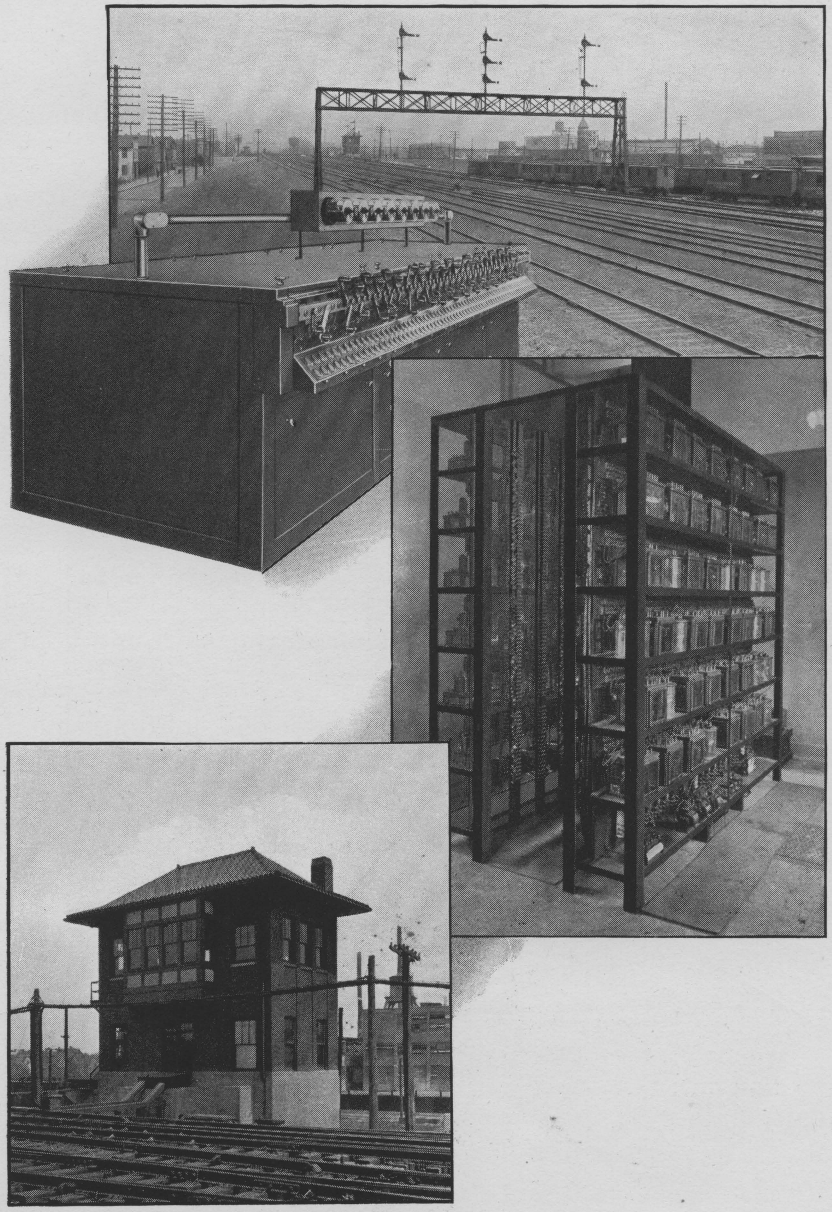
4. Motor-operated switch and lock mechanisms for unlocking, throwing, locking, and indicating the positions of various switches.

5. Mechanisms for clearing signal blades in response to lever movements.

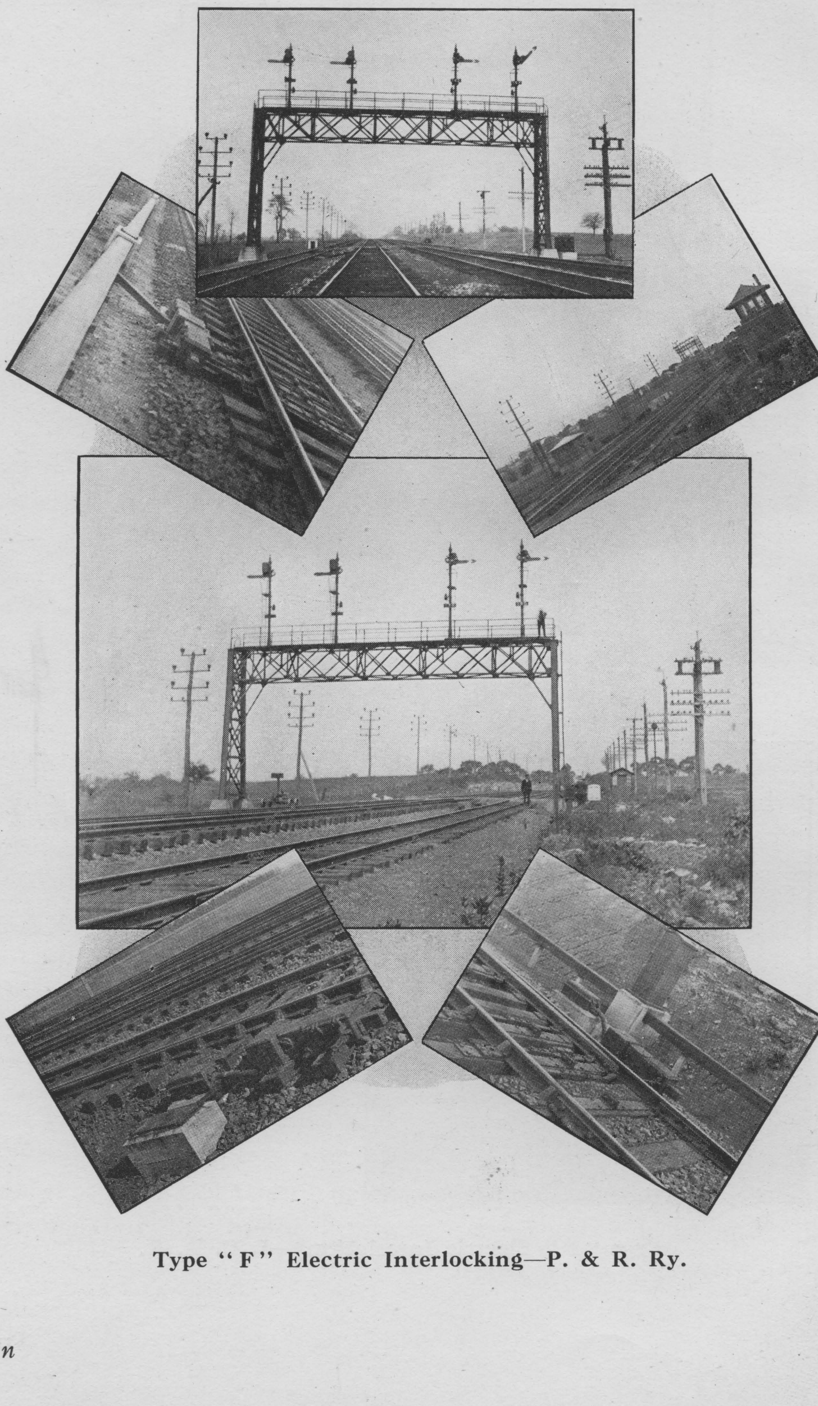
6. Auxiliary devices such as tower indicators, track model, time releases, etc.

7. Automatic electric control exercised through the agency of track circuits, approach, route and detector locking.

Type "F" Electric Interlocking



Type "F" Electric Interlocking—I. C. R. R.



Type "F" Electric Interlocking—P. & R. Ry.

Type "F" Direct Current Electric Interlocking

Power Supply

Either direct current or alternating current may be used for all or any part of the Type "F" Interlocking System. The direct current Type "F" System will first be described in detail. The power requirement of an electric interlocking of ordinary size is limited, but it is essential that there be no interruption of traffic so that either the source of power must be infallible or arrangement be made for emergency supply.

Generation—Energy may be obtained from a commercial source or be generated at the interlocking plant. The former constitutes the usual practice. When commercial power is not available, either steam or gas engine driven direct-current generators may be used. For an average plant, the generator will be from 2 to 3.5 kw., the exact capacity depending upon the storage battery used. Power obtained from a commercial source is nearly always in the form of alternating current.

Transformation and Conversion—A line transformer will reduce the transmission voltage to either 110 or 220 at the interlocking tower. Alternating current at this voltage can be readily converted to direct current by means of either a motor generator or a rectifier. Standard outfits for converting alternating current to direct current are available in the capacities required.

Storage Battery—An average plant will require either 55 cells of lead-type battery or 90 cells of nickel-iron-alkaline battery, the capacities varying from 120 to 200 ampere hours in either case. The generating equipment and battery are ordinarily housed in the lower story of the tower.

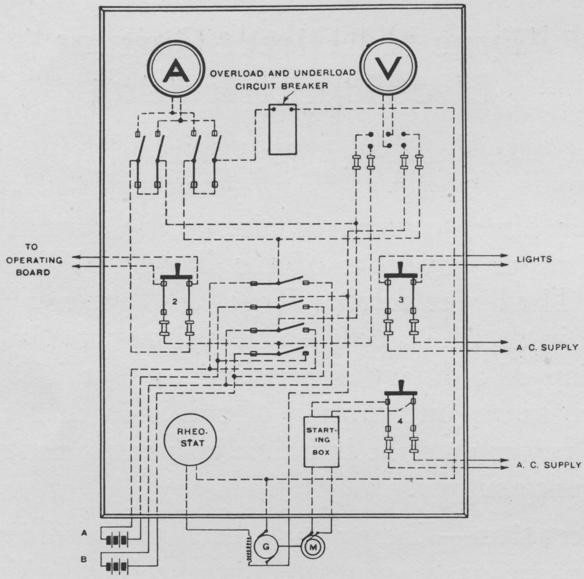


Fig. 1—Power Switchboard

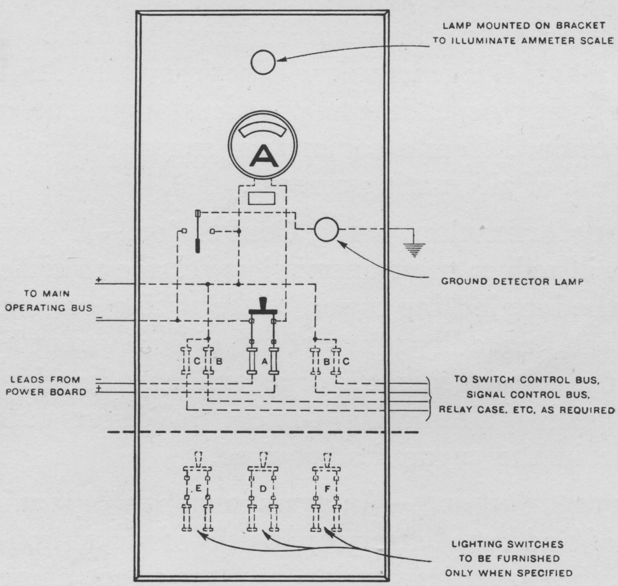


Fig. 2—Operating Switchboard

Switch Boards—Ordinarily the power board is located adjacent to generator or converting equipment and battery. A typical power board is shown as Fig. 1. The Type "F" standard operating switch board, Fig. 2, is located in the operating room where it can be observed by the leverman. The power and operating boards are ordinarily of one small panel each. The entire scheme of power supply and distribution will be readily understood by referring to Fig. 3, which is typical of the ordinary direct current plant.

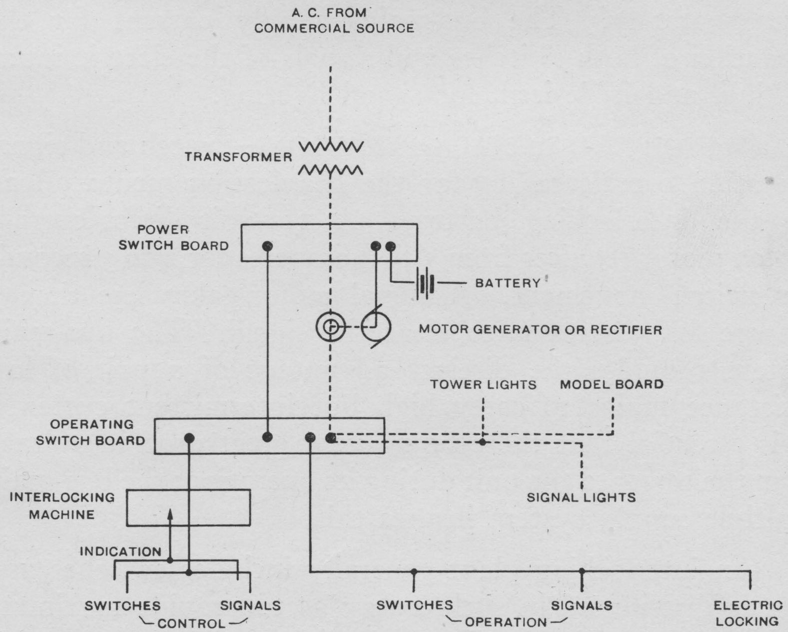


Fig. 3—Diagram of Power Supply, D.C. Interlocking

Power Distribution

Bus-Mains—The greater part of the energy for the Type "F" System of electric interlocking is distributed by means of bus-mains which extend throughout the plant. These are of heavy wire of low resistance, providing practically normal voltage for the operation of each unit, no matter how remotely located. This provides a wide margin of safety against failure due to run-down battery or other cause. Copper is saved because the larger portion of the interlocking load is carried by the bus-mains, allowing all other wire runs to be of No. 16 A. W. G. wire in cable, or the minimum size necessary for mechanical strength when run separately. The bus-mains supply current for the operation of both switches and signals of the electric interlocking, and if desired, for signal lighting.

SWITCH AND SIGNAL OPERATION—Switch and signal operation constitutes by far the heaviest momentary load on the interlocking battery. A 110-volt direct current switch motor requires from 3 to 4 amperes for 2 to 3 seconds per switch movement. A signal motor takes less than 1 ampere for 5 seconds to clear the signal. The bus-main system provides the distinct advantage of a pair of low resistance mains to carry high but intermittent currents. It is essential that there be no very great drop in voltage from the tower to the unit during its operation; the bus-main multiple supply system insures this.

An interlocking plant generally includes switches and signals distributed in such a way as to provide maximum facility in handling traffic, and with obviously no regard to their concentration in such a manner as to secure the same drop in voltage during the operation of one unit as another. Were separate wires run for the operation of each unit, these would have to vary in size in order to provide a fairly constant voltage at the motors. Such a provision precludes standardization, limits changes in switch and signal location without running new wire lines and opens up the plant to serious results from possible mistakes in the estimates of distance and calculation of wire sizes. The two bus-mains used in the Type "F" System are made sufficiently large to provide practically constant voltage throughout the entire plant, thus allowing for the same adjustment to be made at all switches and signals with no concern on the part of the maintainer as to their receiving the desired voltage.

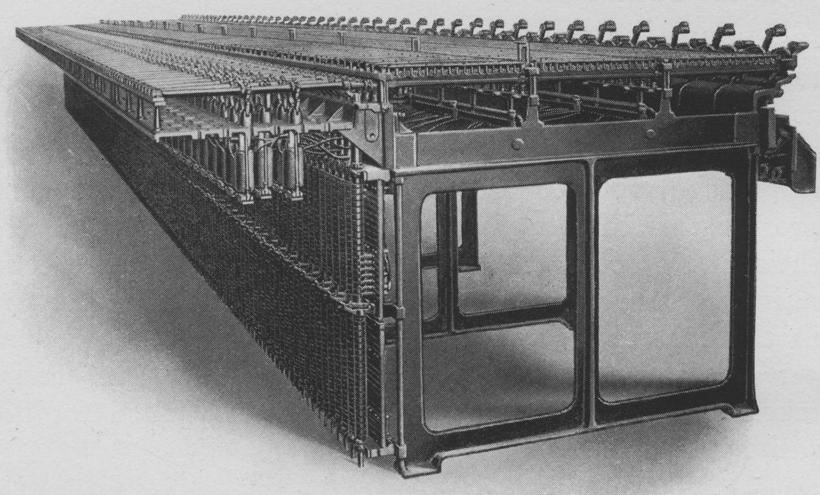
SIGNAL LIGHTING—Power for signal lighting is ordinarily supplied by separate lines leading from the operating switch board, but if desired, signals can be lighted from the bus-mains.

ELECTRIC LOCKING—Modern interlocking incorporates all the safe-guards in the form of electric locking as are necessary to insure the safe passage of trains at such speed as the physical condition of the track will allow. Approach, route or sectional route, and section locking provide this. Most of the electric locking relays receive their energy from the bus-mains. Relays of 1000-ohm resistance are connected in series with 9000-ohm resistors to the 110-volt wires. Although the power requirement per unit is not of material consequence, the total energy taken is a considerable portion of that required for the entire interlocking.

Track Circuits—Individual primary or storage batteries located near the ends of the track circuits ordinarily supply them with energy. A means less frequently used is a low-voltage battery located in the interlocking tower, which may supply all track circuits, feeding these through individual resistors.

Alternating current track circuits are often installed at direct current interlocking plants. This type of track circuit is described in the section on "Type "F" Alternating Current Electric Interlocking."

Interlocking Machine—Power for the control of switches and signals is supplied to the interlocking machine from the operating switch board and is distributed throughout the plant over lever contacts as occasion may require. Current is also brought to the machine from the units controlled, to indicate their positions.



Model 14 Power Interlocking Machine, case removed

Interlocking Machine

The underlying principle of interlocking requires that before a signal can be cleared for the movement of a train, all switches, derails and frog points, over which the signal governs train movement, shall be in proper position and locked. To secure such protection for train movement it is desirable to concentrate the control of the various switches and signals at one point. The mechanism in which this concentration of control is secured is called an interlocking machine.

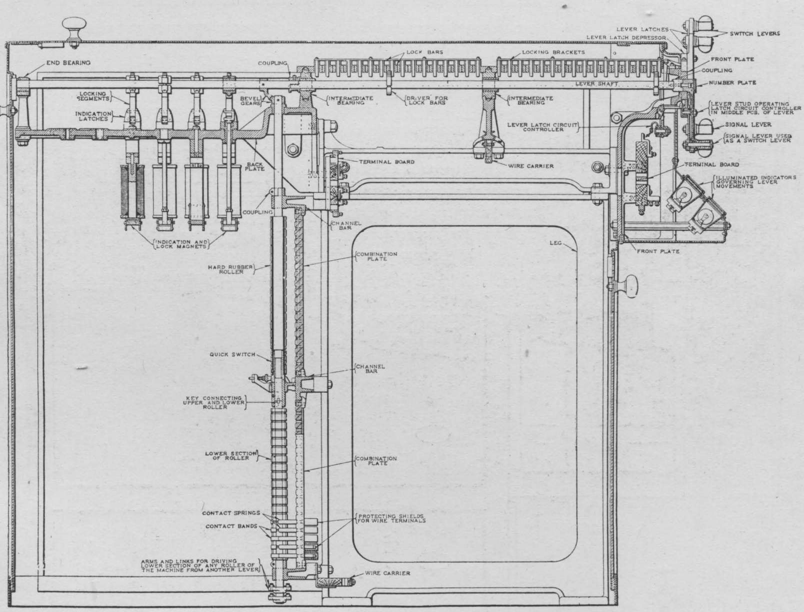


Fig. 4—Model 14 Power Interlocking Machine, end view

The Model 14 interlocking machine, illustrated in Figs. 4 and 5, is the same as has been used for many years in the electro-pneumatic system of interlocking, except in minor details. This machine consists of small hand-thrown levers, compactly located in a frame and arranged for the operation of circuit controllers, but restricted in their movement by

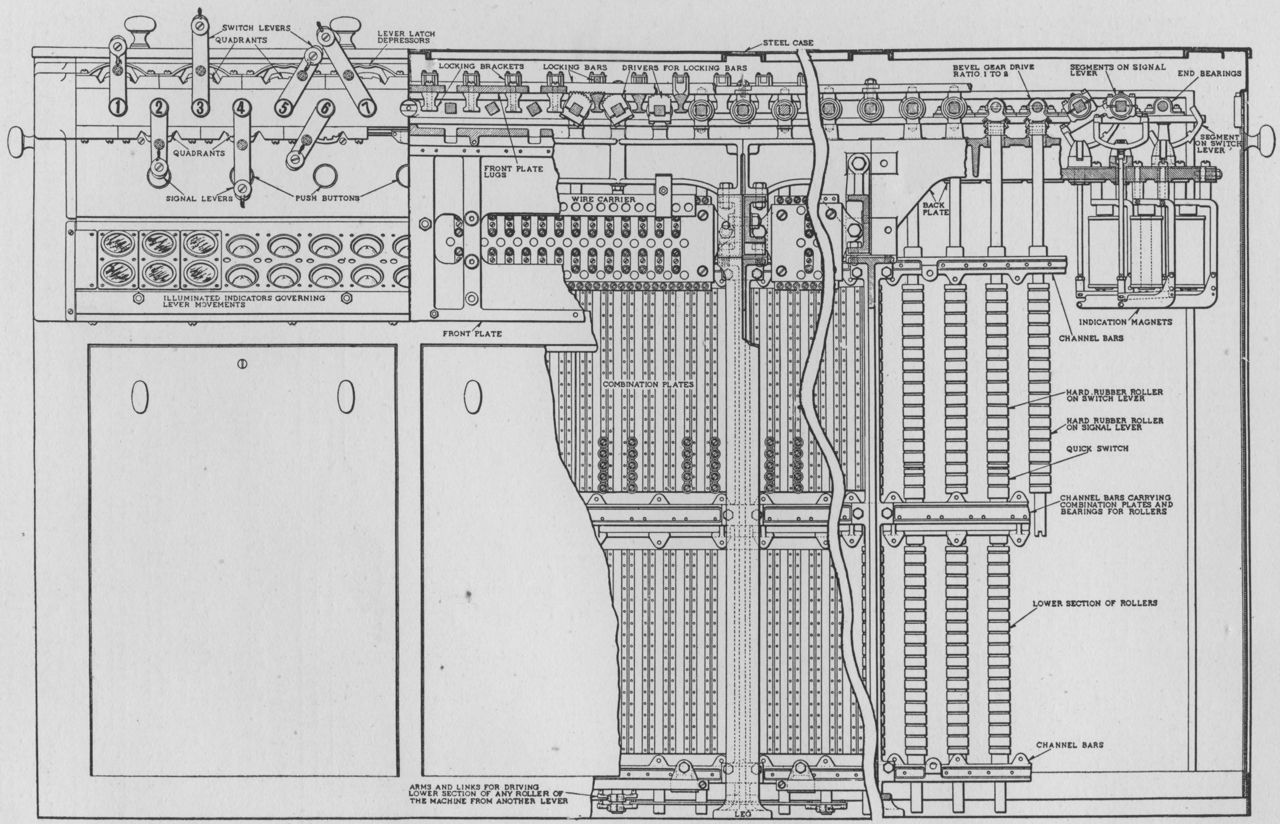


Fig. 5—Model 14 Power Interlocking Machine, front view

both mechanical locking and electric locks. The machine is self-contained and is completely enclosed in an enameled sheet steel case which has removable panels. The panels are equipped with cabinet locks which prevent access to the machine by other than authorized persons.

The design of the Union Model 14 interlocking machine provides for the control of as many switches or as many signals by a single lever as is practical without limiting possible simultaneous traffic movements. For example, both ends of a crossover are controlled by a single lever; also opposing signals, only one of which can be cleared at a time, may be controlled by the same lever. Safety as well as simplicity is secured by a single lever controlling conflicting signals, as the interlocking of these is obtained directly through lever movement and not by means of the dogs and locking which would be required were a lever used for each signal.

Lever Manipulation—The multiple control of either switches or signals from single levers naturally results in a considerable reduction in the size of the machine and consequently the tower space required. The concentration of levers in a small space lends greatly to the facility of the machine's operation, but a further advantage is gained by the form of lever used and its method of manipulation. As will be noted in Figs. 4 and 5, each lever rotates through a 60-degree angle in a plane parallel to the machine. Thus a leverman may operate two widely separated levers at one time, pulling them towards his body or thrusting them away as required.

The complete operation of a track switch from either of its two positions is effected by a partial movement of its lever, the complete movement being impossible until the switch responds to the partial movement. Two circuits are employed before the lever movement can be completed, one for effecting the switch operation, and one for releasing the

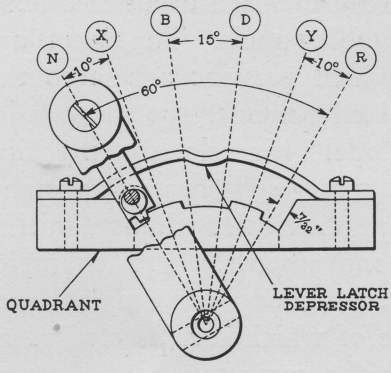


Fig. 6

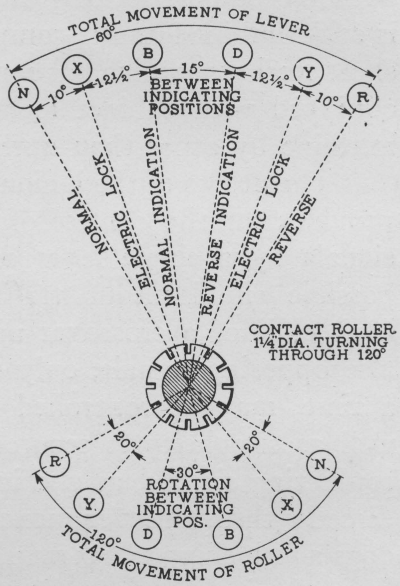


Fig. 8

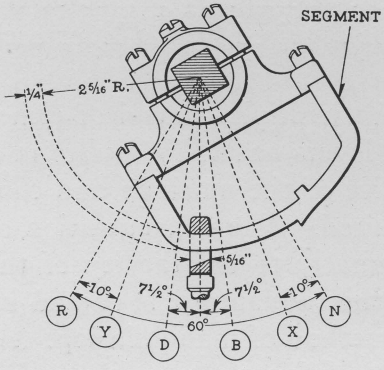


Fig. 7

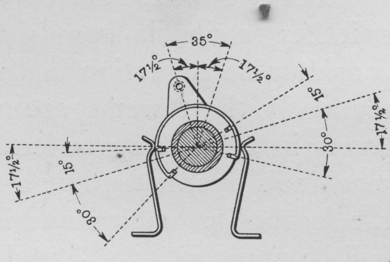


Fig. 9

Diagrams of Switch Lever

lever for its final movement, the latter being the switch indication circuit. The complete operation of a signal from stop to proceed is secured by a continuous, complete lever movement, but its release from proceed to stop necessitates a preliminary lever movement for interrupting the power supply, and a final movement that can be made only after the signal has returned fully to the stop position.

The operation of switches and signals thus involves the opening and closing of contacts in electric circuits during and at definite points of lever movement. The restraint of lever movement by the switches or signals is accomplished by means of electric locks according to the energized or de-energized state of their magnets. The control of these electric locks is not restricted solely to switch and signal operation, train location being at times a factor in it.

SWITCH LEVER—Fig. 6 represents the several positions of a switch lever during the operation of a switch, and shows the formation of the quadrant secured to the front of the machine frame and that of the lever latch carried by the lever. These are involved in restricting lever movements. This figure also illustrates means for forcing the lever latch into engagement with the quadrant at mid-stroke, so that this quadrant and not the segments of the electric locks will receive the impact of the lever's arrested movement, thus insuring entire freedom of action for the latches of the electric locks when these are lifted by the magnet to release the segment for final lever movement after the indication has been received. Incorporated in this figure is the stud or pin which co-acts with the latch to open and to maintain open a set of contacts for certain positions of the latch and lever in order to avoid useless consumption of energy from the battery. Fig. 7 shows one of the two segments and latches of a switch lever that are employed jointly for switch indication and section circuit locking. Fig. 8 shows diagrammatically the several positions occupied by a switch lever, as previously mentioned, and the angle of rotation that the lever movement imparts to the contact roller of the machine. The rollers move through double the angle through which the levers turn. Fig. 9 shows a section of the roller that is not continuously movable with the shaft, being restrained from following it during preliminary lever movement by a spring actuated

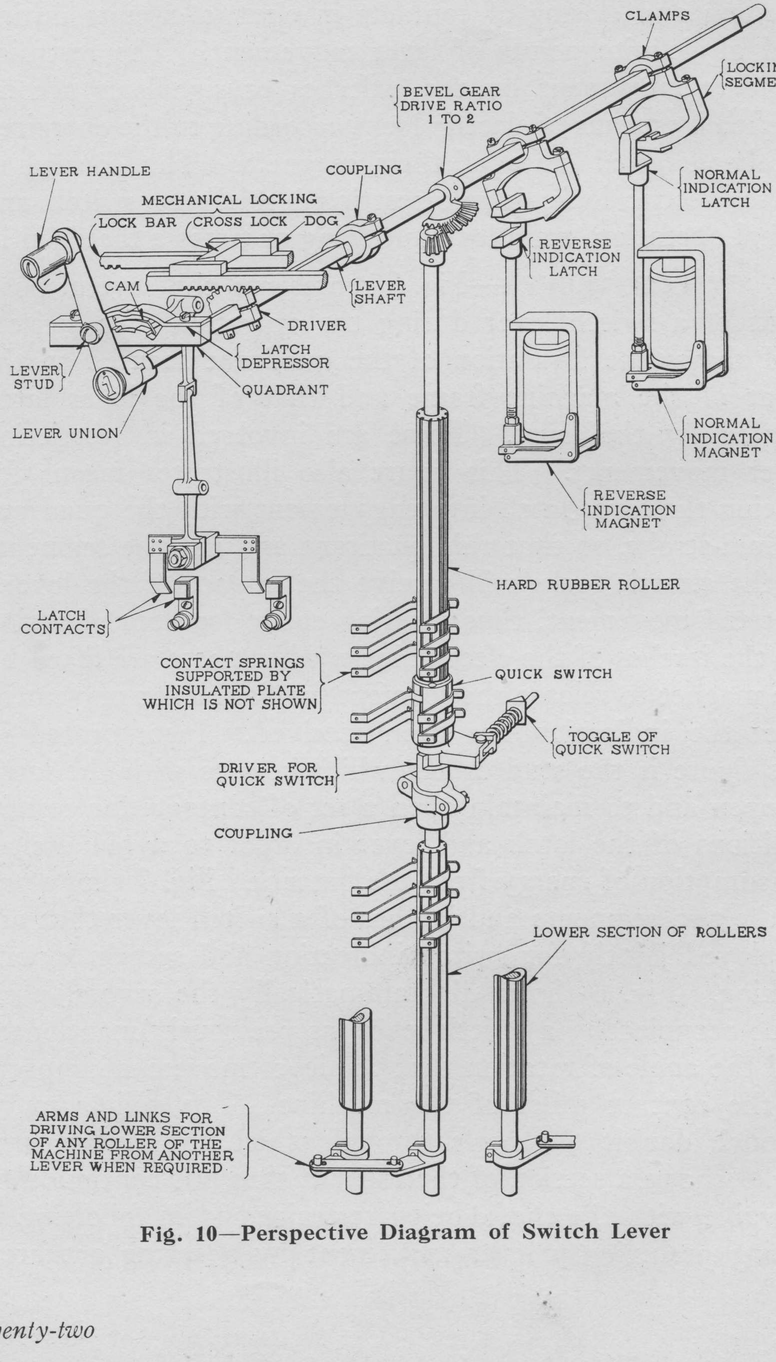
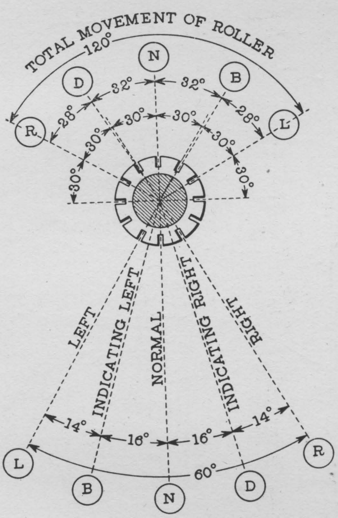
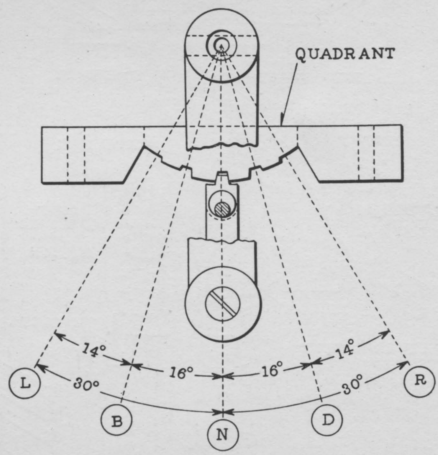


Fig. 10—Perspective Diagram of Switch Lever

toggle and until the final movement of the lever occurs after the indication has been received. This device functions as a part of the indicating system and is known as the "quick switch." Fig. 10 shows in perspective the complete switch lever unit and its relative parts.





SIGNAL LEVER—The signal levers of the Model 14 machine occupy five distinct positions, as shown in Fig. 11, when used to their full capacity. By full capacity is meant the use of a lever movement to the right for the operation of one signal or set of signals and to the left for another signal or set of signals, the two sets necessarily conflicting with

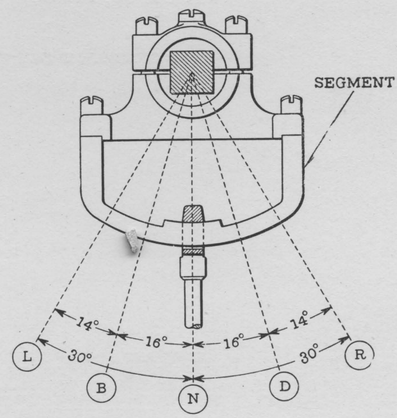


Fig. 11—Diagrams of Signal Lever

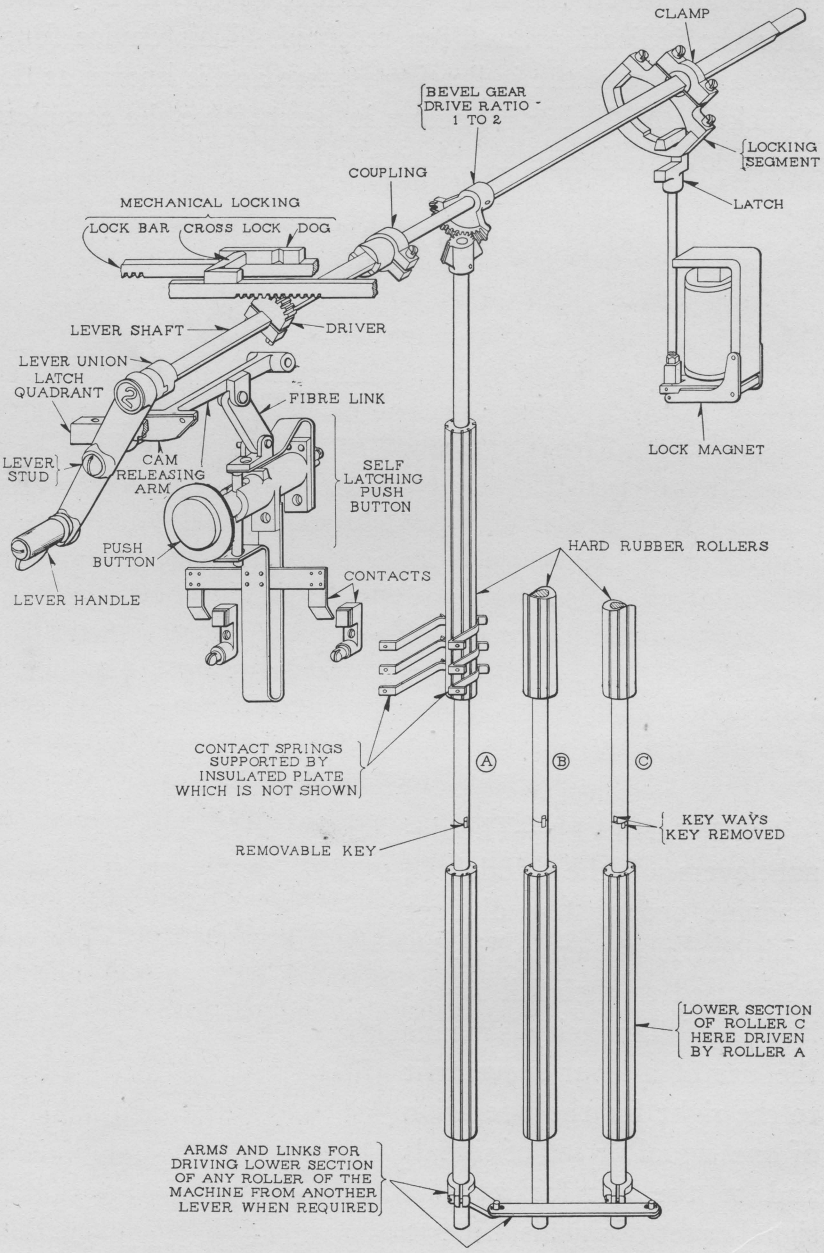


Fig. 12—Perspective Diagram of Signal Lever

each other in respect to the route or routes governed. This feature of the Model 14 interlocking machine gives each signal lever at least double capacity and is an important factor in securing the concentration of the levers, simplicity of locking, and ease of manipulation which provide for the safest and most economical handling of an interlocking plant.

The signal levers normally occupy a central or vertical position. When thrown to the extreme right the signal cleared allows traffic movement over a given track in one direction, and when thrown to the left another signal will clear, allowing traffic over the same track, but in an opposite direction. The signal lever cannot be returned to its central position from either extreme until all signals affected by its movement in either direction are in their most restrictive positions. A partial movement of the signal lever from either of its extreme positions causes a break in the signal holding circuit previously supplied with current, thus allowing the signal blade to assume a restrictive position. Positions B and D of Fig. 11 represent those assumed by the signal lever when moved from either extreme position, represented by lines L and R, to restore the signal to its stop position, and beyond which the lever cannot be moved towards its central, normal, position until the signal has assumed its restrictive aspect.

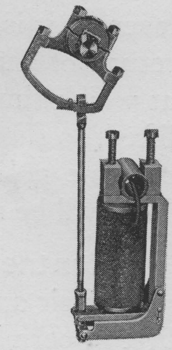
Fig. 12 shows in perspective the design and relations of the various parts of a complete signal lever unit. The push button shown immediately under the lever handle provides for the operation of "calling on" signals.

Checks on Lever Movement

MECHANICAL LOCKING—In order that a signal may not be cleared until every switch, derail, and movable point frog over which it governs is in the proper position and locked, it is necessary that the movement of the levers in the interlocking machine be made in proper sequence. This is the function of the mechanical locking, and it is accomplished by: First, the release of one lever for operation only after another has been fully operated; and, second, by the locking of one lever against operation by movement of another before this movement has advanced sufficiently to cause any change in the position of the switch or signal which it controls. The locking used in the Model 14 interlocking machine is of the well-known Saxby and Farmer type, but in miniature.

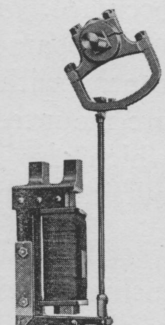
In the method of driving the bars of this locking from the levers, as illustrated in Figs. 10 and 12, a departure from the practice employed in mechanical interlocking machines is made, embracing not only a much more direct and simpler driving mechanism than that used before, but also involving the operation of the locking during lever movement and not preliminary to such movement, as in mechanical machines. This method is employed because of its greater simplicity and because in power interlocking practice, unlike mechanical interlocking, levers are necessarily moved through a considerable part of their stroke before such movement brings about switch or signal action. This provision completely removes from power interlocking machines the need for a preliminary operation of the mechanical locking that arises in mechanical interlocking through the simultaneous action of switch or signal with lever.

ELECTRIC LOCKS—It will be discerned from Fig. 10 that the movement of each switch lever is governed by two magnets together with their latches and segments. These serve not only as indication locks for restraining final movement of the lever until the switch has responded, but also as detector or track circuit locks, preventing the preliminary movement of the lever in case the track is occupied. Prior to the movement of the lever to change the position of the switch from normal to reverse, the normal indication magnet must be energized, and this is possible only when the track section in which the switch is located is unoccupied. Correspondingly, before the lever can be moved from its reverse position, the reverse indication magnet must be energized, this also being possible only when the track section is unoccupied. Assuming that the lever has been moved from its normal position to the reverse indication position (D, Fig. 8), the reverse indication magnet must become energized before the lever stroke can be completed. This energization is possible only when the switch has assumed its reverse position and allowed current to flow to the corresponding indication relay. Before the lever can be returned to its normal position the normal indication magnet must be energized, this showing that the switch has again completed an operation in coördination with the lever movement.



D.C. Indication Magnet

While one magnet thus permits the start of the lever to effect switch operation, the other insures that before the lever stroke can be completed the switch shall have responded to the lever movement and have been locked in its corresponding position. The final movement of the lever transfers the magnet which permitted such movement to the duty of locking the lever in its new position automatically when the track is occupied. Simultaneously with this action the other magnet is withdrawn from its section locking service and transferred to the indicating function required for the next operation of the switch. This transfer of the magnets from one field of usefulness to another occurs



A.C. Indication Magnet

only at the completion of each full lever operation, and is performed jointly by what is termed the "quick switch" and by what are designated as X and Y springs of the contacting system. The Signal Section symbols for the springs last mentioned are NX and RY.

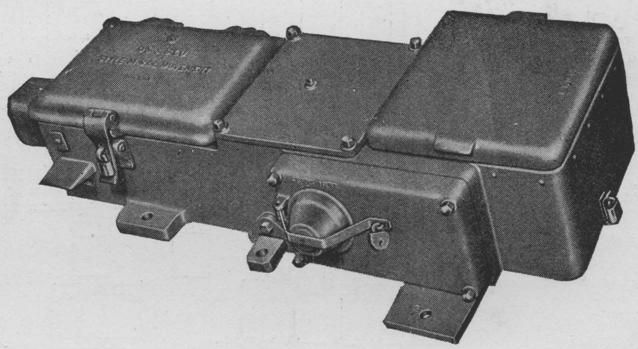
But one electric lock magnet is required for the signal lever, as it is necessary in case of signals to indicate only the return of the signal blade to its most restrictive position, at which time the lock will become energized and the latch lifted, so that the lever stroke may be continued from either extreme position to the normal position which is central. This will be noted by reference to Fig. 11.

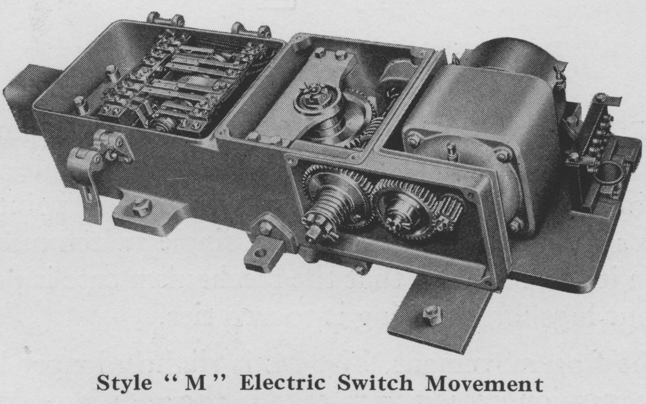
Contact System—The contact rollers are mounted with their axes vertical, which has two distinct advantages, first in permitting their operation at an angle of 120 degrees (double the angular throw of the levers) and second, a concentration of machine parts in the interest of floor space occupied. The 120 degree operation of rollers provides a wide separation of contacts and a close definition of contact control with respect to lever position. The contact springs are mounted upon a panel or plate of moulded insulation which also supports the terminal binding posts to which outside connections are made.

Lever Lights—The front plate of the Model 14 interlocking machine is constructed with a recess under the levers so that lever lights or push buttons may be installed where required. The former may be made to repeat the positions of either switches or signals or to show the track occupancy which may affect the movement of any switch. On many roads the stop position of a signal is repeated by a red lever light indication, released when the lever is put normal. The push buttons are used for "calling on" arms and may be applied in connection with either electrical or mechanical stick control.

Switch Movements

The operation of switches, derails, and movable point frogs is one of the most important functions as well as constituting the greatest load, of an interlocking plant. Safety demands that the switch shall be finally locked in position when a train is passing; economy in handling traffic demands that there shall be no unnecessary loss of time in effecting the change of a switch from one position to the other. The mechanism which meets these conditions must do its work in the following sequence: Unlock, throw, lock switch points; indicate.





Style "M" Electric Switch Movement

Operating Mechanism—The Union Style "M" electric switch and lock movement is compact and efficient. The improvements in manufacturing processes, together with up-to-date machine tools and heat treating equipment, have made it possible to produce in the Style "M" movement a mechanism comparatively small in size but with exceptional mechanical strength. It is universal in application.

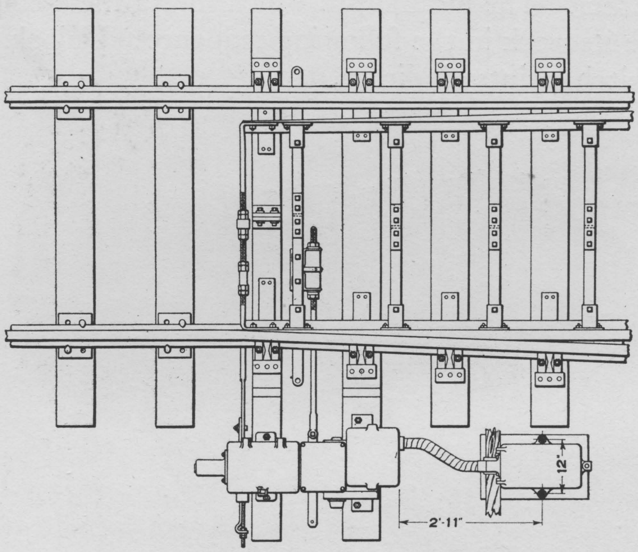


Fig. 13—Style "M" Single Switch Layout

MECHANICAL APPLICATIONS—This movement is made in two forms, one for operating a single switch, derail or slip, another for operating movable point frogs. Fig. 13 shows an application of the single switch movement wherein it will be noted that the mechanism case is provided with four lugs for fastening it to two ties.

The frog movement, Fig. 14, is slightly longer because of the extension necessary to take in the additional lock rod, and is arranged with six lugs for mounting on three ties.

One pair of the frog points is operated directly from the movement, motion being transmitted to the other set of points through a combination of two crank arms. A pair of short arm cranks are recommended, rather than a single straight arm crank.

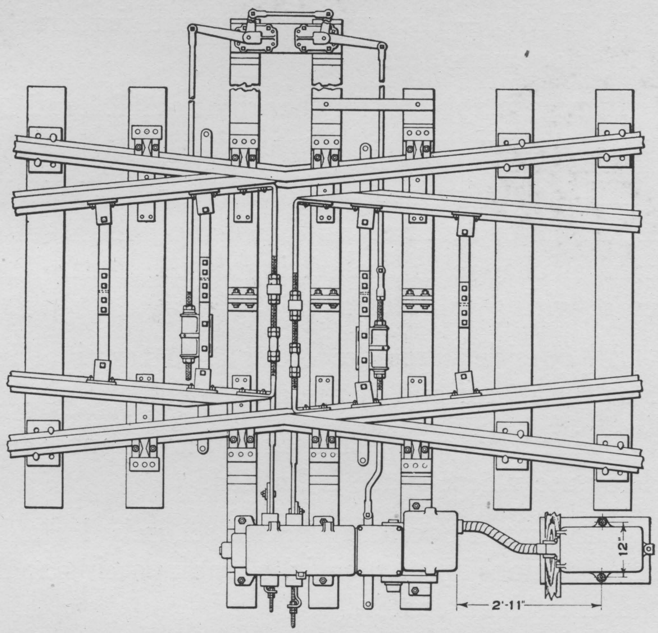


Fig. 14—Style "M" Frog Layout

A notable feature of the Style "M" electric switch and lock movement is its adaptability to limited space. In order to provide for maximum stability of mounting, the fastening lugs are machined on the bottom faces for tie plate application, and also on the sides to allow the use of thrust blocks which may be riveted to the tie plate to prevent side motion under the heaviest load conditions. Ordinarily the movement is sufficiently stable when mounted on framed ties without the use of tie plates.

ELECTRICAL APPLICATIONS—This movement is applicable wherever it is desired to operate track switches by means of electrical energy. Standardization has led to the use of direct current voltages of either 20 or 110, or single-phase alternating current at 110-volts and either 60 or 25 cycles.

ADVANTAGES—The more important features of the Style "M" movement are:

1. It may be applied to either right or left hand layouts without variation in the parts used.

2. All internal wiring is in place and is independent of the normal or reverse position of the switch. A simple mechanical change in the setting of the controller cams makes re-wiring unnecessary.

3. All outside wires are brought to terminal binding posts at the motor end of the movement.

4. Owing to its compactness this movement is specially fitted for use where space is limited.

5. The switch operating bar is securely locked in its extreme positions by virtue of the crank passing 20 degrees beyond the "dead center."

6. The worm gear drive, combined with a driving crank passing dead center when closing the points, constitutes a most powerful means of transmitting motion.

7. The worm drive is mechanically efficient, durable and reliable under the most exacting requirements. In conjunction with the friction clutch it prevents any rebound of the movement.

8. The clutch is simple and capable of taking care of a wide variation in load. The friction discs are of material which maintains a practically constant coefficient of friction, and has long life.

9. The motor cut-out provides a quick break with a large opening.

10. Parts subjected to severe strains are made of such materials as insure against breakage and provide the requisite wearing properties.

11. Due to the small number of operating parts and their rugged construction, maintenance is minimized.

12. The main parts of the driving mechanism are lubricated in such a way that frequent applications of oil are unnecessary.

A detail description of the mechanism explaining just how the switches are unlocked, thrown and locked, and indication provided will be found in Bulletin 93.

Switch Control—The switch control circuit between the interlocking machine bus and the Type "F" controller located adjacent to the switch movement is shown in Fig. 15.

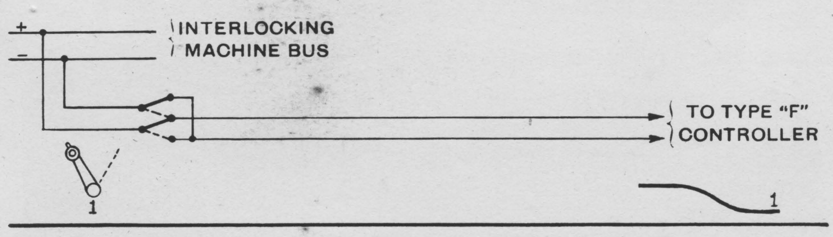


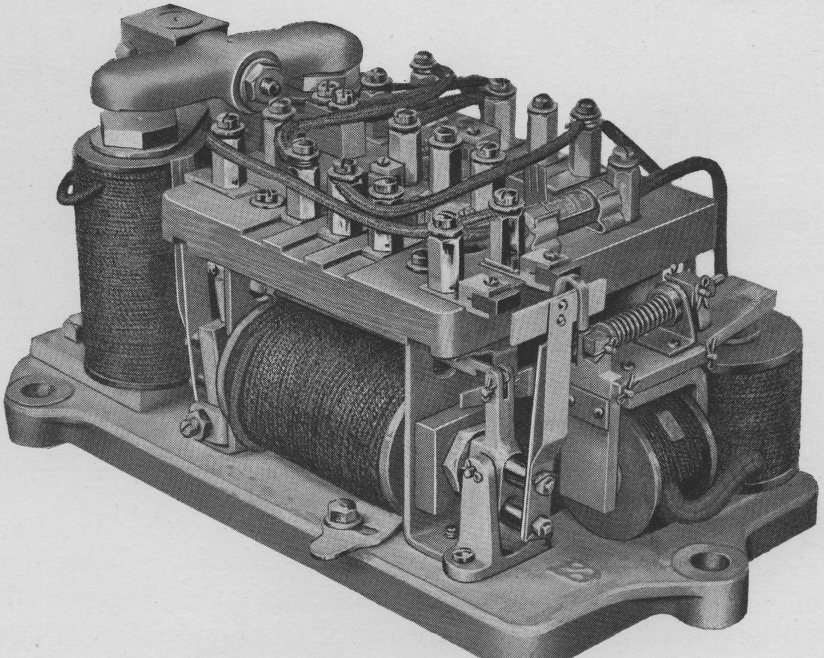
Fig. 15—Switch Control Circuit

The contacts of lever 1, through which this circuit is broken, function as a pole changer as indicated in the diagram. It will be noted that the switch control circuit consists of two wires only, these running without interruption from the interlocking machine contacts to the terminal board on the Type "F" controller at the switch. These wires are used for no purpose other than for the control of the switch movement. The advantages of this control circuit are:

1. The controller is operated by a polarized circuit with a resultant advantage of being practically immune

to crosses. Other safeguards inherent with the Type "F" System prohibit dangerous train movements, as will be explained later.

2. The coils of the Type "F" controller which are supplied with current through the circuit shown are of high resistance, and therefore require but very little current for their energization; the smallest gauge control wire which has requisite mechanical strength will prove satisfactory from a standpoint of conductivity.



Type "F" D.C. Switch Circuit Controller

3. The Type "F" controller makes it unnecessary to transmit current over individual *operating* wires from the tower. It also relieves all combination contacts of the interlocking machine, as well as relay contacts, from carrying currents of such magnitude as might be injurious.

The fuses which protect the storage battery are purposely made of sufficient current capacity not to blow out because of the overloading of any individual switch motor, the Type "F" controller being designed to provide such individual protection.

Type "F" Controller—The Type "F" controller is housed in a cast-iron box mounted on a concrete foundation adjacent to the switch and lock movement, but independent of the track. Therefore, it is not integral with the switch and lock mechanism which, of necessity, is directly connected to the rails and ties. The Type "F" controller for direct current interlocking is normally de-energized; that is, it requires current only when changing from one position to the other, and this is accomplished in less than a second.

In Fig. 16, the various parts of the Type "F" controller are shown in diagrammatic form. N represents a neutral magnet operating front contacts directly and a contact, closed when the magnet is de-energized, by means of a link connection S. Magnet N also actuates a lock on the armature of polarized magnet P. This armature determines the position of three sets of contacts used in circuit selection of neutral magnet N and the switch motor. R represents an automatic motor circuit breaker. The switch motor armature and field are shown by means of standard symbols.

Pole changing contacts actuated by a lever in the interlocking machine are shown as L. Negative battery is connected through a closed contact on pole changer L to wire 1RW and thence through magnet N to negative CH. Both terminals of the coils are therefore connected to the same side of battery, that is, there is no drop in potential across the magnet normally and the armature is not attracted.

The operation of the controller will be more clearly understood by following through a description of what happens when the interlocking switch lever is thrown from normal to reverse, and, after the switch movement has operated and indicated, returned to its normal position. When lever L is reversed, positive battery from the machine bus will be connected to wire 1RW and current will flow through wire 1RW, contact X, wire W5, to neutral magnet N. Magnet N is permanently connected to negative bus wire CH. The energization of magnet N causes its armature to be attracted, closing contact between wires 1RW and W6; W7 and BH; and opening the connection between wires 1W8 and BH.

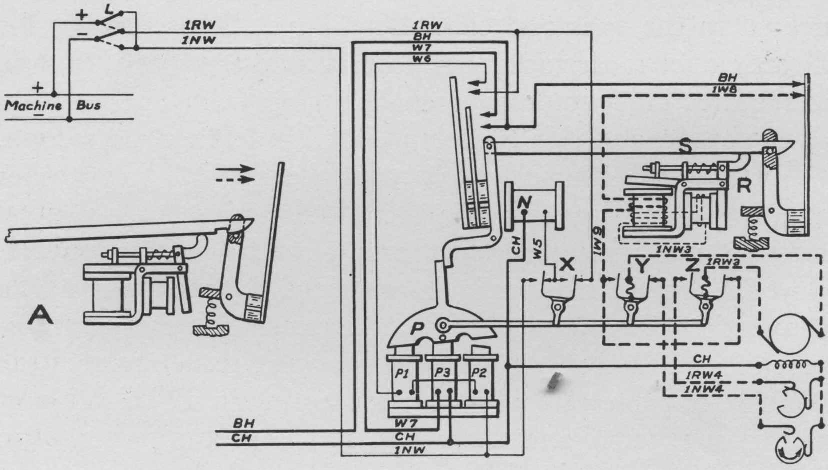
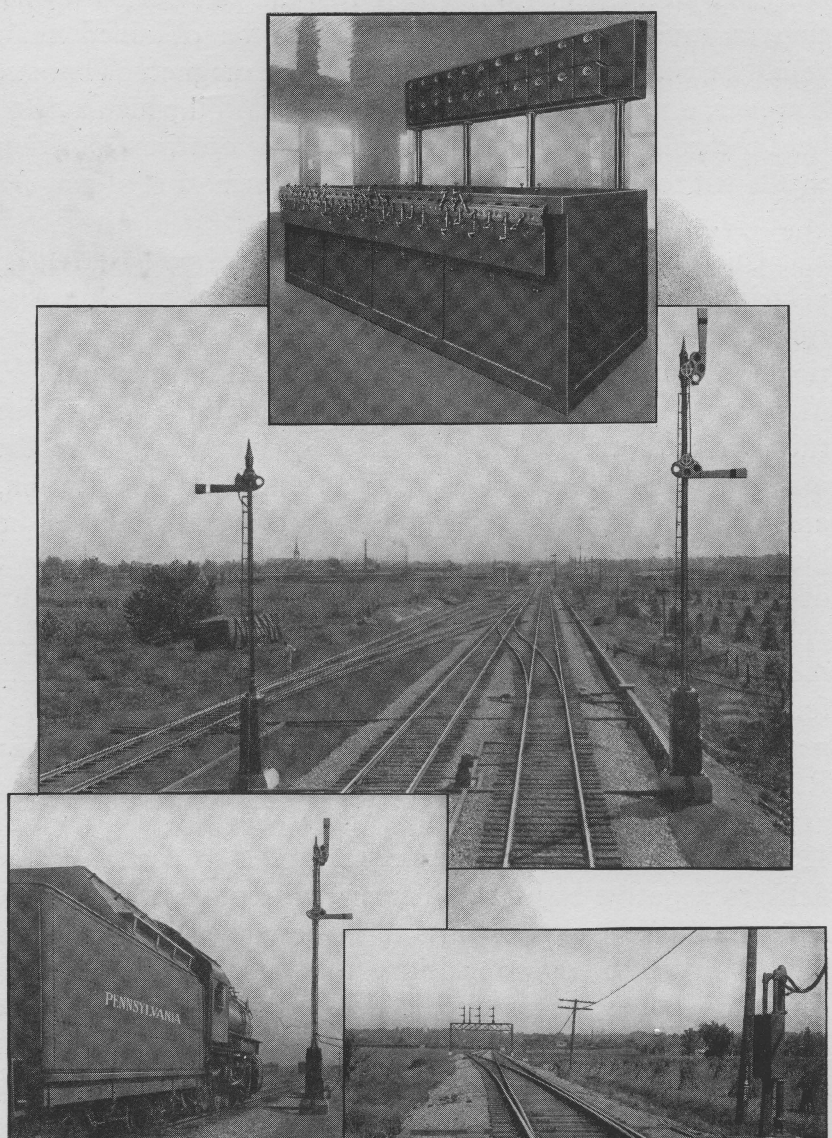


Fig. 16—Complete Control and Operating Circuit for Single Switch

Current will then flow from wire 1RW through front contact operated by magnet N, wire W6, polarized magnet coils P1 and P2, wire 1NW, lever contact L to negative machine bus. It will thus be seen that the operating circuit for the Type "F" controller does not include a common return but is a separate metallic circuit going out over lever contacts to one wire and returning over the lever contacts via another wire. A local circuit through the other front contact operated by magnet N is also closed for the purpose of energizing magnet P3, the function of which is similar to that of the permanent magnet used in a polarized relay. By electrically energizing this magnet during operation, a much higher energization can be obtained than would be possible with a plain permanent magnet. There is, however, a permanent magnet core in this coil which acts to hold the polarized armature in its extreme operated position to allow it to be reliably locked when the armature of magnet N drops.

Current flowing in the direction stated will cause the polarized magnet to be energized and shift polarized armature P, which causes contact X to change over the connection for neutral magnet N from wire 1RW to wire 1NW. Magnet N will then be connected to negative machine bus through lever contact L, and to negative bus CH at the magnet. This will obviously result in its de-energization, and when the armature drops, polarized armature P will be locked mechanically in its reverse position with its magnet de-energized. The other two sets of contacts actuated by polarized armature P will be so connected to the switch motor armature and field, that current will flow through the following path: positive bus BH, back contact of neutral magnet N, wire 1W8, primary coil of motor circuit breaker R, wire 1W9, circuit controller finger Y, wire 1NW3, motor armature, wire 1RW3, circuit controller finger Z, wire 1RW4, motor cut-out circuit controller contact, motor field, to negative bus CH. The switch motor, in revolving, will cause the switch points to be unlocked, thrown and locked in the reverse position, the final movement also resulting in the motor circuit being opened at the motor cut-out circuit controller.

It will be noted that before current can pass through the switch motor and cause reversal of the switch movement, the neutral magnet N must be de-energized, this in turn causing polarized magnet P to be de-energized. Thus the energization of these magnets is momentary and the amount of power consumed is negligible.

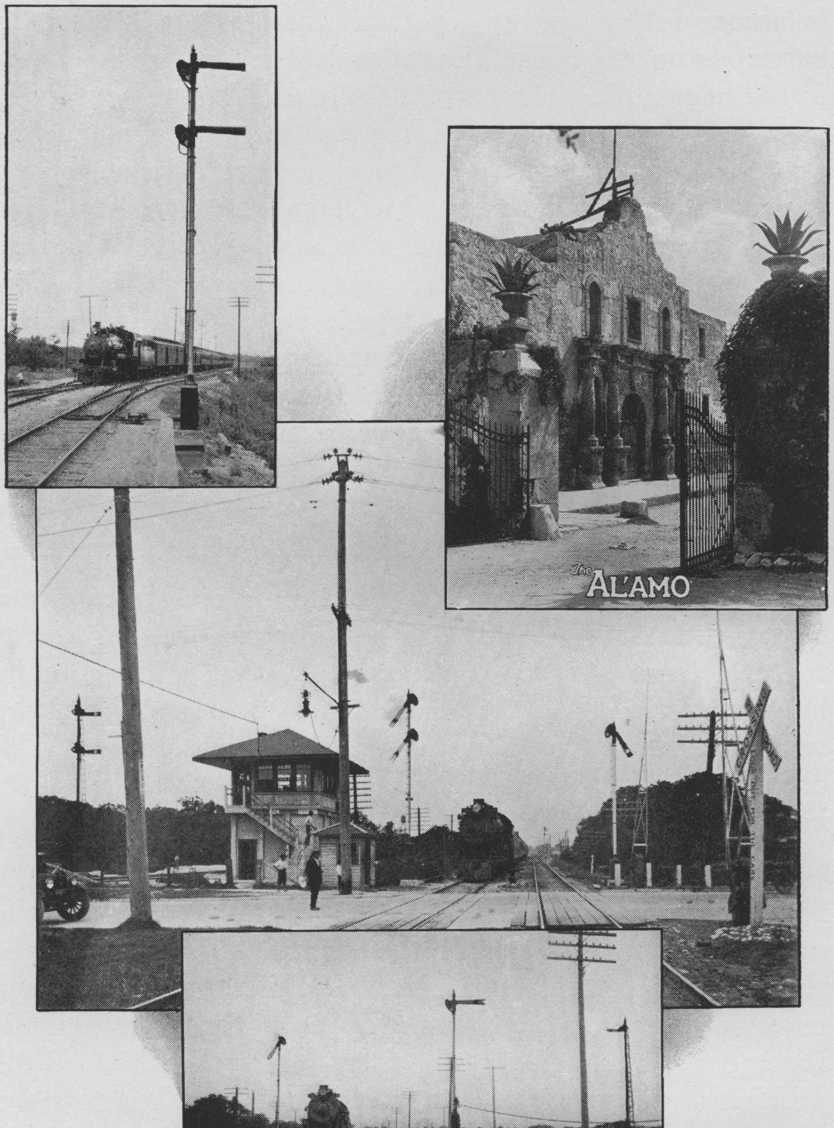


Type "F" Electric Interlocking—P. C. C. & St. L. R. R.

The movement of the switch from reverse to normal is accomplished by the leverman moving the lever to a corresponding position, thus completing the circuit shown in full lines at L. The current will pass through contact L, wire 1NW, circuit controller X, wire W5, neutral magnet N and to negative bus CH. While magnet N is energized the circuit for polar magnet P will again be completed, but in such a way that current will pass through coils P1 and P2 in a reverse direction to that previously described. This will cause the polarized armature to be reversed in position which in turn will actuate circuit controller springs X, causing neutral magnet N to be de-energized, since it will again have both sides connected to negative bus, because wire 1RW is connected to negative at the interlocking machine.

Contacts Y and Z, actuated by polarized armature P, will cause current to flow through the motor armature in a direction opposite to that when the switch movement traveled from normal to reverse. Contact will again be broken at the motor cut-out circuit controller when the switch points have been moved over and locked. The controller springs will then be in the same position as shown in Fig. 16.

As soon as the motor starts to unlock the switch, the motor cut-out circuit controller contacts are shifted to the middle position and remain there until the final locking of the switch reversed, when they are shifted to the extreme reversed position. The reason for the motor cut-out circuit controller maintaining both circuits closed in the middle position during the entire transit of the switch is to allow for reversal of the switch by the lever at any time during transit if desirable, so as to repeatedly attempt to crush snow or ice which might prevent the switch point being forced against the stock rail and locked in that position.



Type " F " Electric Interlocking—M. K. & T. and S. P. Rys.

The automatic overload circuit breaker R is worked on very much the same principle as the overload circuit breakers on power switchboards, except that it is made slow releasing to prevent the possibility of the heavy starting current causing the circuit to be opened at each operation. This circuit breaker consists of two magnets with armatures which are pivoted separately, but are jointly connected to a detent or tripping arm which, when raised, releases the hook, connected to the neutral magnet armature, from the back contact member of that magnet, allowing this contact to be forced open by a coil spring. When the motor circuit is first closed, there is a heavy surge of current through it, due to the low resistance of the motor and the fact that the counter e. m. f. has not had an opportunity to build up, but as soon as the motor speeds up the counter e. m. f. approaches the value of the impressed e. m. f. and therefore the current is reduced to what is usually known as the motor operating current.

If an ordinary circuit breaker were employed, adjusted to open for a heavy current, the momentary current above mentioned would trip the breaker every time the motor started. To prevent this the circuit breaker magnet to the left, which is called the "primary" magnet, has a double winding and functions like a transformer. When the first strong surge of current passes through this coil, there is induced in the other winding on the same core an e. m. f. generally proportionate to the rapidity of the rise of the current in the motor circuit. This e. m. f. is impressed on the magnet coil to the right, called the "secondary," sending a current through it which assists in holding the armature against the pole face. As soon as the current ceases to change in value, there will be no more current induced in the secondary coil of the primary magnet, and hence no magnetic attraction of the armature by the secondary magnet, so that if the current in the primary coil continues at too great a magnitude the primary magnet is then unopposed by the secondary magnet and the armature lifts the detent which releases the back contact of the neutral magnet N as indicated in Fig. 16A. However, if the surge is reduced to normal within a reasonable time, the attraction of the armature by the primary magnet will not be sufficient to overcome the spring and the motor circuit will not be opened.

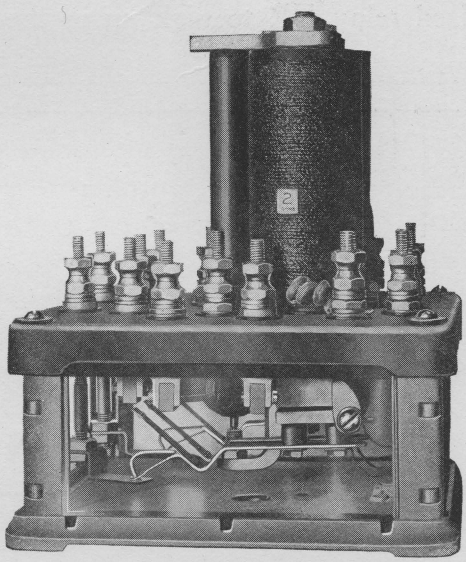
If this breaker opens up due to high current for an excessive length of time, it can be restored by throwing the interlocking machine lever to its opposite indication position. In doing this, the neutral armature is again attracted, the hook engages the back contact member and upon subsequent de-energization of the neutral magnet the circuit breaker will be reset for another movement of the switch.

There are several advantages in the automatic overload circuit breaker and automatic reset. It dispenses entirely with the use of individual motor fuses. A circuit breaker is also more reliable and can be more closely adjusted than fuses, which vary as much as 100 per cent. By the use of this circuit breaker, it is often possible to crush such objects as snow or a piece of coal lodged between the stock rail and the switch points, even though this may require a dozen operations of the switch. Each time the switch fails to complete its stroke the breaker will go out and will then be reset by moving the lever to the other indication position, avoiding the necessity of going to the back of the machine to renew fuses.

The heavy current during overloading of the motor is broken at the back contact member of neutral magnet N, as indicated in Fig. 16A. This contact is specially designed for the service required. By virtue of its being opened and closed once for each operation of the switch movement it is self cleaning, thus insuring low contact resistance.

Fig. 16 shows the motor control wiring for a single switch including all the parts and functions described in detail above. A crossover is wired simply as two single switch layouts connected in multiple, a Type "F" controller being required for each switch movement.

Switch Indication—The functioning of the switch indication circuit will be seen by referring to Fig. 17. Contacts of the switch circuit controller operate only after the switch operating mechanism has completed the stroke of the points and locked them in place. These contacts are connected so as to act as a pole changer. Two wires lead from this pole changer to a polarized relay (KR) in the station. A 9000-ohm resistor is connected in series with this relay when the voltage is 110. It is obvious that a low voltage polarized direct current relay or a 110-volt three-position alternating current relay may be substituted for the relay shown in Fig. 17. The KR relay functions not only in connection with the switch indication, but also in the SS selection of signal control circuits described later.



Model 12 Polarized D.C. Relay

Two magnets are ordinarily applied to the interlocking machine for the joint indication and detector control of lever movements. These magnets are marked NM for the normal position and RM for the reverse position of the lever and switch. The B and D lever contacts are mounted on the "quick switch," previously mentioned, which is so actuated by means of a toggle joint that it snaps over to the position indicated at the last part of the lever movement to the preceding normal or reverse position; that is, the D contact is closed just as the lever is thrown to its full normal position and the B contact just as it is thrown to its full reverse position. This provides a check of the coincidence in position of the lever and the switch movement.

Should the switch lever be reversed and the switch and lock mechanism function properly throwing over the points and locking the switch, the pole changer at the right of Fig. 17 will assume its alternate position, causing the polarized relay KR to pick up in the reverse direction; that is,

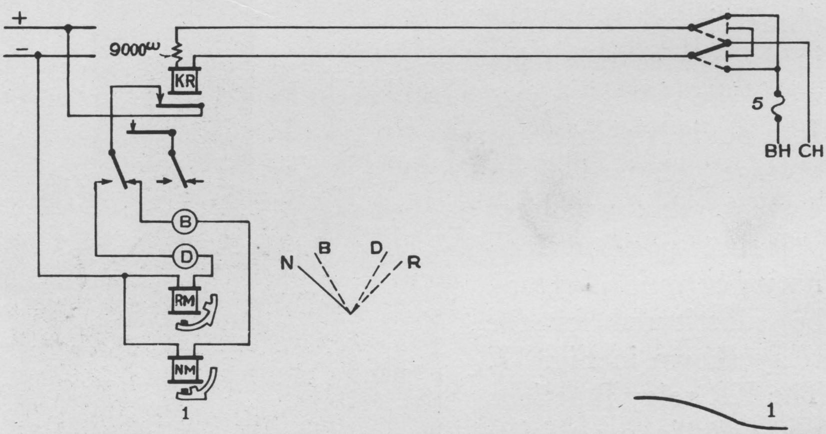
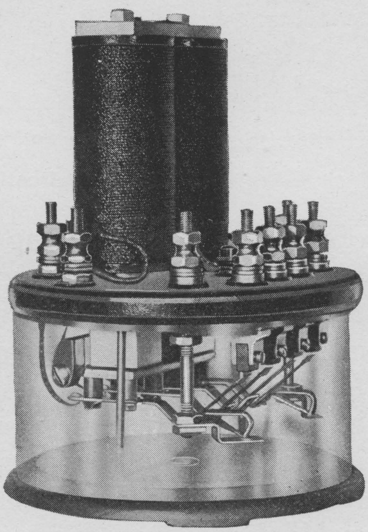


Fig. 17—Switch Indication Circuit

the neutral contact will be closed as shown in Fig. 17, but the polar contacts will assume their opposite position. Since the lever has been thrown over to the position marked D, indication magnet RM will be energized, this picking up the dog from engagement with its segment and allowing the lever movement to be continued to the reverse position, which will release the mechanical locking so that a signal may be cleared. Provision is made in the circuit controller actuated by the switch and lock movement for the contacts shown closed in Fig. 17 to be opened at the first movement of the locking bar tending to unlock the switch points. A shunt between the two wires leading to the KR relay is established at this time and maintained throughout the unlocking, throwing and locking of the switch points and until the last part of the locking stroke, when the pole changer will complete its movement and pick up the KR relay in the reverse direction as previously described. The movement from reverse to normal can now be easily traced.

It should be noted that the KR relay is at all times under the control of the switch, and that the unlocking of the switch by any means whatsoever will cause the KR relay neutral contacts to open and remain open until the switch points are again fully closed and locked. One might assume that when assurance has been received that the switch points have moved into coincidence with the controlling lever the functioning of the switch indication system may be considered as being complete, but such an assumption is not tenable. Continuous control of signals by the switches over which they govern train movement is absolutely essential to safety in train operation. It is during the vastly longer periods after the switch movement has responded to its lever that protection is needed, for it is then that traffic may move through the interlocking plant. It is of relatively small importance what means is employed to insure coincidence in position of the switch points and the



Model 13 Neutral D.C. Relay

levers immediately after their movement, as compared with the means used for detecting any change that may occur in the position of the switch thereafter, when trains may be approaching the switches concerned.

Naturally, when the indicating and the detecting means are one and the same, as is desirable in the interest of simplicity, the degree of safety existing is common to both functions. Such an indicating system is, and has been for years, one of the conspicuous and important features

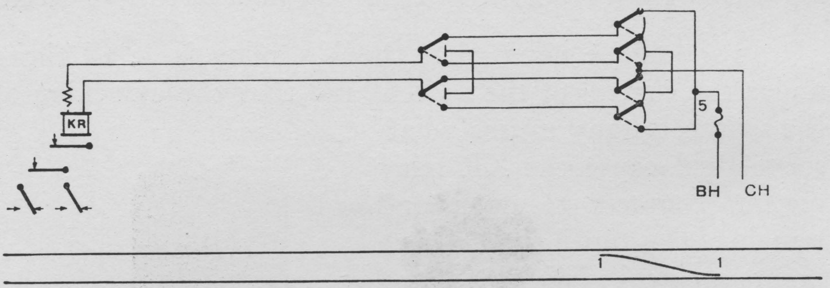


Fig. 18—Indication Circuit for Cross-over

of all power interlocking systems of the Union Switch & Signal Company, and remains characteristically a part of the Type "F" System as now developed. The combination of open circuits and crosses which is necessary to allow a false indication to occur is so remote that this circuit may be classified as being immune to the trouble mentioned. Number 16 copper is again large enough for carrying the current, in this case about 11 milamperes, without appreciable drop. Any number of switches operated by a single lever can be made to indicate their position by means of a single KR relay as shown for a crossover in Fig. 18.

Section Locking—Section, or detector, locking has practically superseded the older form of switch protection—mechanical detector bars—used before track circuits were available for preventing the unlocking and moving of switch points when a car was at the switch. The increased protection gained by the use of section locking, both in the greater extent of track covered and the preliminary locking of the lever against movement, combine with the desirability of eliminating needless load and questionable operation under certain conditions, to remove the detector bar from further consideration.

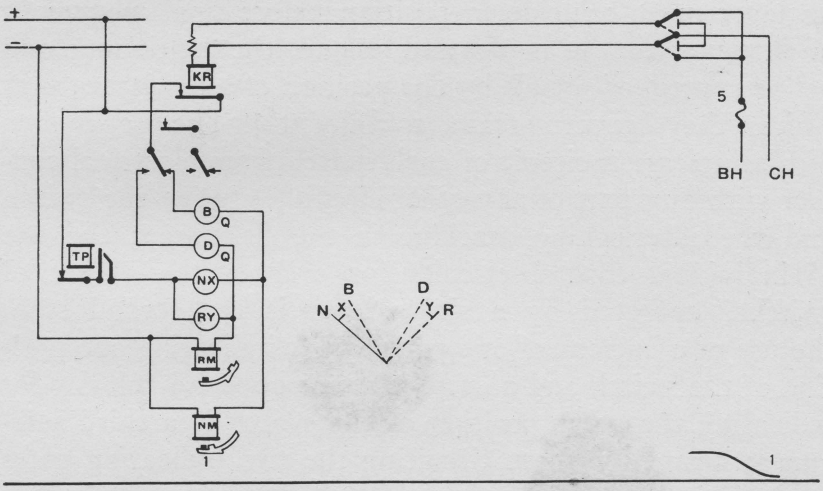


Fig. 19—Switch Indication Circuit with Section Locking

The combination of switch indication and section locking is shown in Fig. 19. The NX and RY contacts, functioning in conjunction with the B and D contacts, provide for the alternate energization of the normal and reverse lever lock or indication magnets in such a way as to secure section or detector locking when moving the lever from either of its extreme positions and indication locking when it is approaching the opposite extreme position, i. e., at the indication point B or D. A latch contact is provided in the section locking circuit for the sake of battery economy. This circuit breaks through either ordinary track relays TR or their repeaters TP or such relays as may be installed for sectional route locking. Approach and route locking may be added with equal facility.

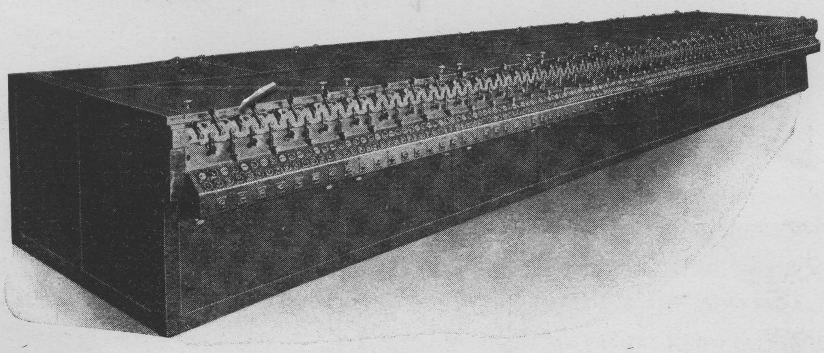
Safety Features

CROSS PROTECTION. The greatest protection against dangerous effects of crosses in power interlocking circuits is secured by the separation of their functioning along the natural lines of control, operation and indication. The Type "F" System provides first, that each switch and its lever must coincide in position before final movement of the lever can be made, and second, the continuous and active control of signals by the position of all switches over which they govern train movement. The separation of the indication circuit of each switch from electrical contact with any part of any other circuit between the switch and the interlocking machine is the first step; the use of individual control circuits for each switch or set of switches operated by a single lever is the second step; the use of a current of one polarity for indicating one position of the switch and a current of the opposite polarity for indicating the other position of the switch is a third safeguard; means for short circuiting the two indicating wires at the switch until it is properly locked in one or the other of its extreme positions constitutes the fourth protection; the fifth step embraces the use of a polarized indicating relay at the interlocking machine adapted so as to control jointly the current supply to both the indicating magnets of a switch lever and all signals governing traffic over the switch or switches operated by that lever. Thus the Type "F" interlocking circuits provide maximum protection against the effect of crosses and grounds without varying from the simplicity which is characteristic of the approach, route and section locking circuits ordinarily used in conjunction with all power interlocking. It should be borne in mind that the circuits last mentioned form a vital part of the general scheme of protection and that they function in all power interlocking without the use of any special cross protective device.

The most direct benefit of the simplified scheme of protection provided in Type "F" interlocking is the avoidance of cross protective devices which would be necessary if the control and indication wires were not separated. The usual cross protective device depends for its action upon the presence of current and may fail electrically or mechanically.

"SS" CONTROL OF SIGNALS—The continuous control of each signal by the switches, both facing and trailing point, over which it governs train movement, through the agency of the KR switch indication relays constitutes the greatest modern advancement in the interlocking field. Not only the switches directly concerned, but also all switches and derails providing protection against side-wiping, continuously control the position of every signal concerned. This "SS" scheme of control will be described in detail later.

ELECTRIC LOCKING—Electric locking is the second modern development in protection of traffic at power interlockings. It includes approach, route or sectional-route and section locking, the functioning of which will be described under "Automatic Electric Control."



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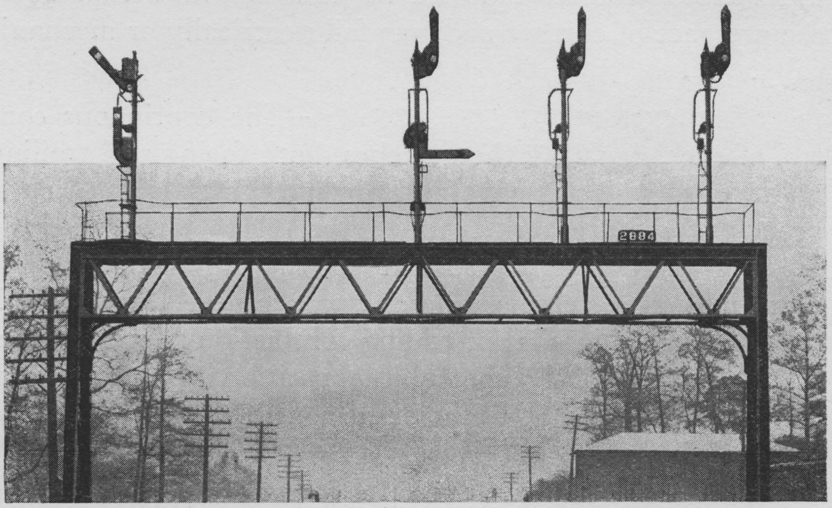
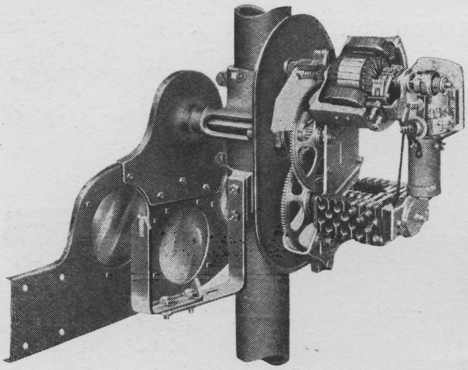
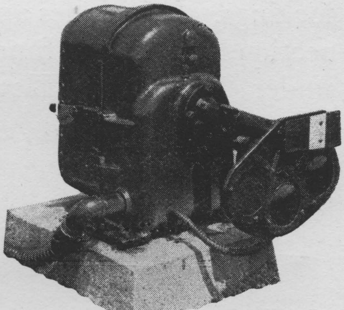






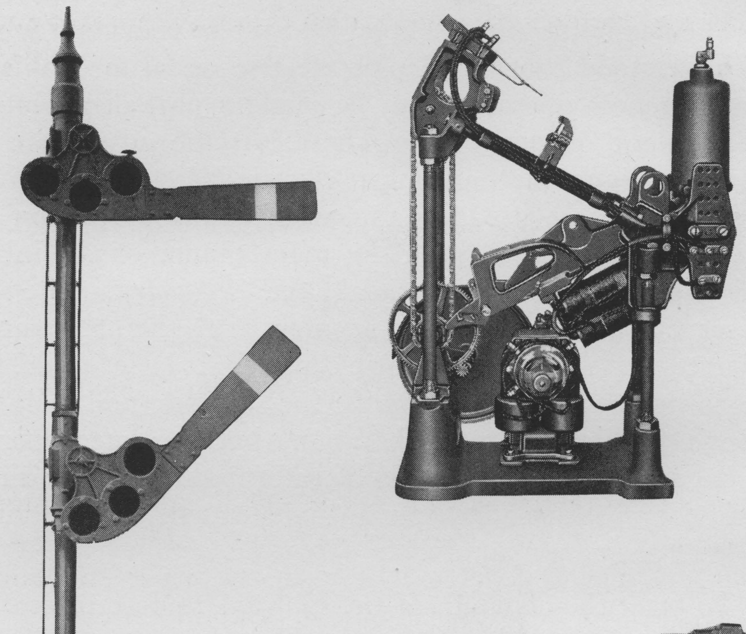
Style "T-2" Electric Signals

Signals

The flexibility of the Type "F" System is evident when it is understood that any Union electric signal mechanism, no matter how operated, can be made a part of an interlocking plant of this type. There is some advantage in having the signal mechanisms at electric interlocking plants the same as those used for automatic signal protection on the railroad concerned with the maintenance of the interlocking, and this is possible at a Type "F" plant. The signals serve as satisfactorily and as safely as do their thousands of counterparts under automatic control. It is desirable, for reasons of economy, to equip the motors and holding devices for high voltage operation, but the mechanisms proper, as well as the factors of safety which insure their satisfactory performance, remain independent of the source and kind of energy supply.

To meet the demands of the railways as determined by varying service requirements, the Union Switch & Signal Company offers signals with mechanisms at either the base or the top of the mast, the signal in each case being designed for the particular application. These signals may be controlled and operated by either high or low voltage direct current or alternating current. Dwarf signals are operated by either motors or solenoid magnets.

Requisites—The interlocking signal is the specific means of conveying information from the person at the interlocking machine directing train movement to the man directly controlling the train. It must therefore be capable of giving such indications as may be required by track and traffic conditions. The number of aspects and their meaning is ordinarily determined by the Signal Engineers of the railways concerned. The very considerable factor of safety in Union signal mechanisms insures reliability of signal



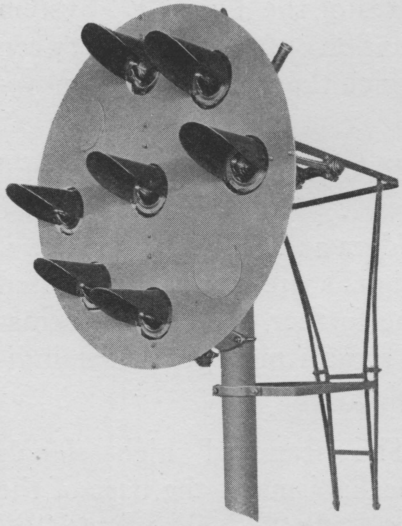
Style "B" and "S" Electric Signals

operation and the basic principles of the Type "F" System guarantee the necessary coordination of functioning between signals and the switches over which they govern train movement.

Types—Signals may be divided first into the general classifications of high and dwarf. High signals may be located on the ground or on bridges and may have one, two, or three arms each. Dwarf signals are ordinarily located on the ground. Signals may be further divided into semaphore and light types. Light signals may give their indications by either position or color.

SEMAPHORE SIGNALS—The standard high signals of the semaphore type, with mechanisms at the base of the mast, are the Style "B" and the Style "S." The Style "B" signal is the original slot arm type signal and was designed particularly for two-position operation. The Style "S" signal is a logical development from the Style "B" and is also of the slot arm type, but is primarily intended for three-position operation. Either may give its indications in the right or left hand, upper or lower quadrant. A complete description of the Style "S" signal is contained in Bulletin 42. The Style "T-2" signal is distinctly of the top of the mast type, having its mechanism located closely adjacent to the semaphore spectacle and blade. This signal may be arranged for either two or three-position operation, giving indications in either the right or the left hand, upper or lower quadrant. A complete description of this signal is contained in Bulletin 67.

COLOR LIGHT SIGNALS—The application of color light signals has been mostly confined to the automatic protection of traffic where electric propulsion is used, but they may also be applied to interlocking, particularly where automatic signals of similar type are used for adjoining sections of track.



POSITION LIGHT SIGNALS—Position light signals have been used for both automatic and interlocking signal protection. These signals give their indications by means of rows of lights reproducing positions which might be assumed by signal blades, but visible throughout the twenty-four hours of each day.

Signal Control—The control circuit for a single arm signal R2 is shown in Fig. 20. This consists of simply two wires extending from the signal to the interlocking machine, where both are broken through R contacts on the signal lever and the proper contacts on the switch lever or levers

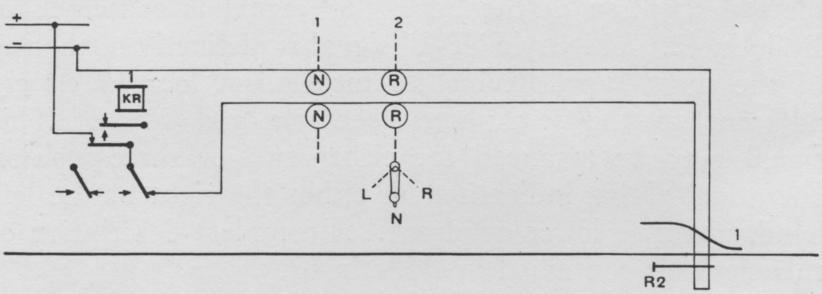


Fig. 20—Signal Control Circuit

concerned. This circuit is also carried through both neutral and polar contacts of KR switch indication relays for all switches, movement over which is governed by the signal in question. Current for the signal motor is supplied from the bus-mains through contacts of a control relay or signal hold clear device.

In Fig. 21 will be seen an enlargement of the circuit shown in Fig. 20 to take care of signal RB2. Since only one of the two signals shown can be cleared at a time there is no necessity in the Type "F" System for a separate lever to be used for each blade. It will be noted that both sides of

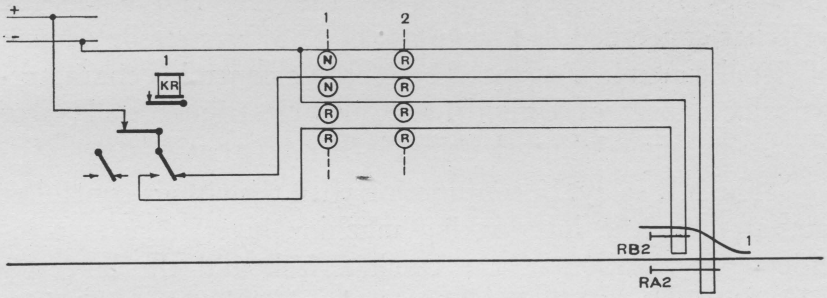


Fig. 21—Signal Control Circuit for Converging Routes

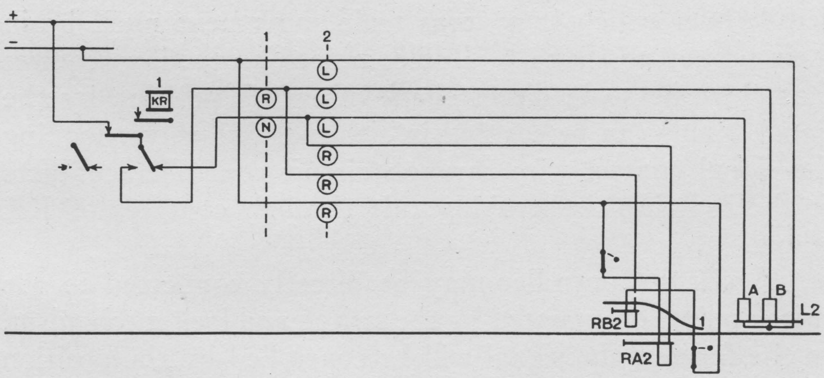


Fig. 22—Signal Control Circuit for Converging and Diverging Routes

the circuit for both blades are broken through the signal lever contacts and selected through No. 1 switch lever contacts. A further enlargement of the signal control scheme is shown in Fig. 22. It is practicable to control all four blades by one lever No. 2. A slight variation is made in the circuits from those previously described to indicate that by the inter-control of two blades through circuit breaker contacts closed only when the signals indicate stop, one wire between the signal and the tower can be eliminated. This is shown for signals RA2 and RB2 in Fig. 22.

"SS" Scheme of Control—The continuous check of the position of each and every switch over which a signal governs train movement, by carrying the control circuit of that signal through contacts on the KR relays for the switches concerned, is known as the "SS" system or scheme of signal control. As stated before, this control is characteristically a part of Union Type "F" electric as well as of electro-pneumatic interlocking.

The KR relay, in conjunction with the circuit controller actuated by the interlocking machine lever, insures coincidence in position of the track switch and the lever by which it is controlled. The mechanical locking provides that before a signal lever can be thrown all switches and derails over which it governs train movement must be in their proper positions. But complete protection requires that there be some direct check of switch position by the signal. This can be secured in either of two ways: looping the signal control wire through circuit controller contacts at the switches or breaking this through contacts of KR relays.

A circuit controller may be directly connected to the switch points or actuated by the switch and lock mechanism. In the former, the signal will be controlled by the position of the switch points and not by their locking in place; in the latter it can be controlled by both the throwing and the locking of the points. Either of these methods is of questionable value where the signal control wire is looped through switch circuit controllers because the opportunities for grounds and crosses are multiplied and maintenance is complicated by introducing a maze of control wires extending from one end of the plant to the other.

The breaking of signal control wires through KR relay contacts provides maximum protection because each control wire will extend unbroken from the tower to the signal. A ground or a cross is then but a remote possibility, and even if one did occur there would be slight chance of its being detrimental. Any possible circuit trouble can be quickly located and corrected. The amount of wire required is reduced to a minimum. Number 16 copper wire will suffice as the current carried over the wire is only that required for the control relay or signal hold clear device. The "SS" scheme allows a concentration of parts vital to the safe control of signals in the tower where they are protected from the weather and other possible damage, and where good maintenance is encouraged by facilitated inspection.

The "SS" scheme assures:

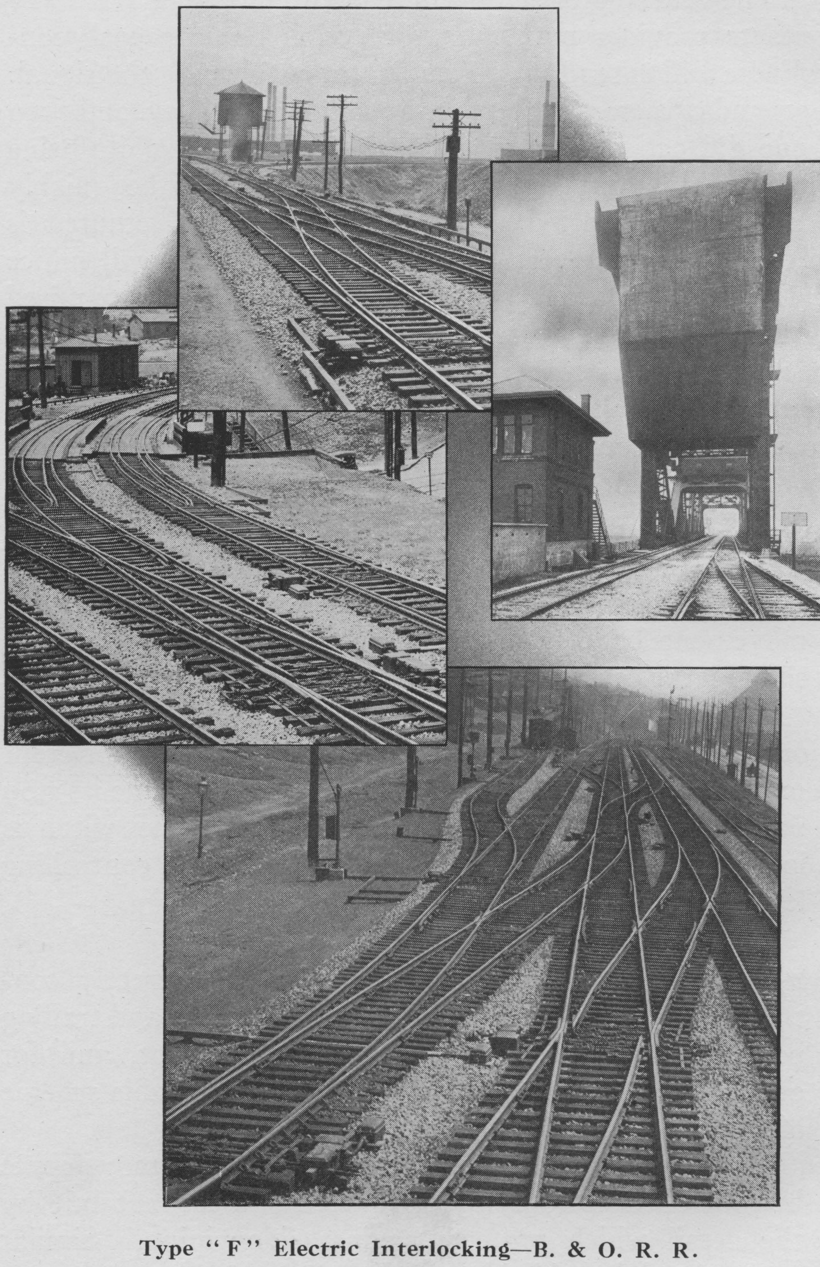
First, that should a switch not respond to a lever movement and through some fault or series of faults the lever movement be completed, subsequent operation of any signal lever cannot cause a signal to clear.

Second, that should a switch be accidentally or maliciously changed in position, any signal cleared for train movement over the switch will immediately assume its stop position, nor can any signal be cleared until the switch is locked in a position coinciding with that of its controlling lever.

The "SS" control of signals provides:

That *every* signal, high and dwarf, be directly controlled by *every* switch and derail, both facing and trailing point, over which it governs train movement, and for every minute of the time. In other words, this scheme of control is *complete.*

That the signals governing the main track movements be controlled not only by the switch of a turnout but by the derail which protects against side-wiping. Similar protection is provided at crossovers.



Type "F" Electric Interlocking—B. & O. R. R.

That even though the mechanical locking be removed from the interlocking machine, and the indication magnets relieved of their duty, no signal can be cleared without its route being set up properly with every switch in position and locked. This scheme is then, self-sufficiently safe.

Signal Indication—The indication circuits for signals in the Type "F" electric interlocking system embody the same simplicity which is characteristic of the signal control circuits, as will be noted by reference to Figs. 23 and 24.

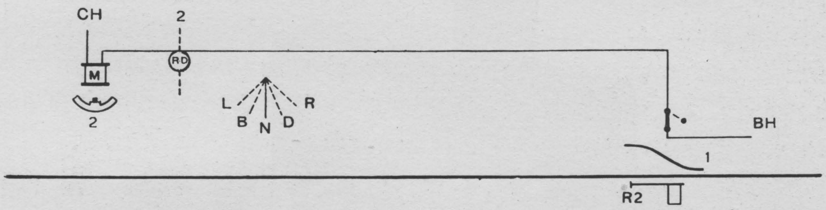


Fig. 23—Signal Indication Circuit

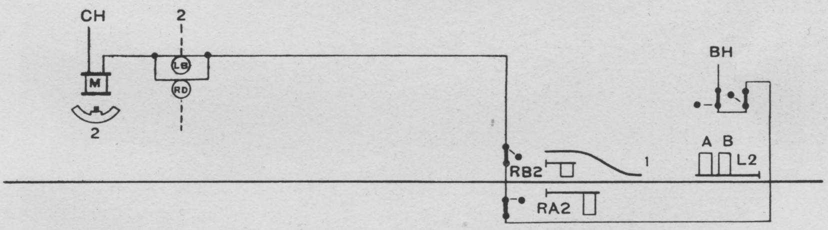
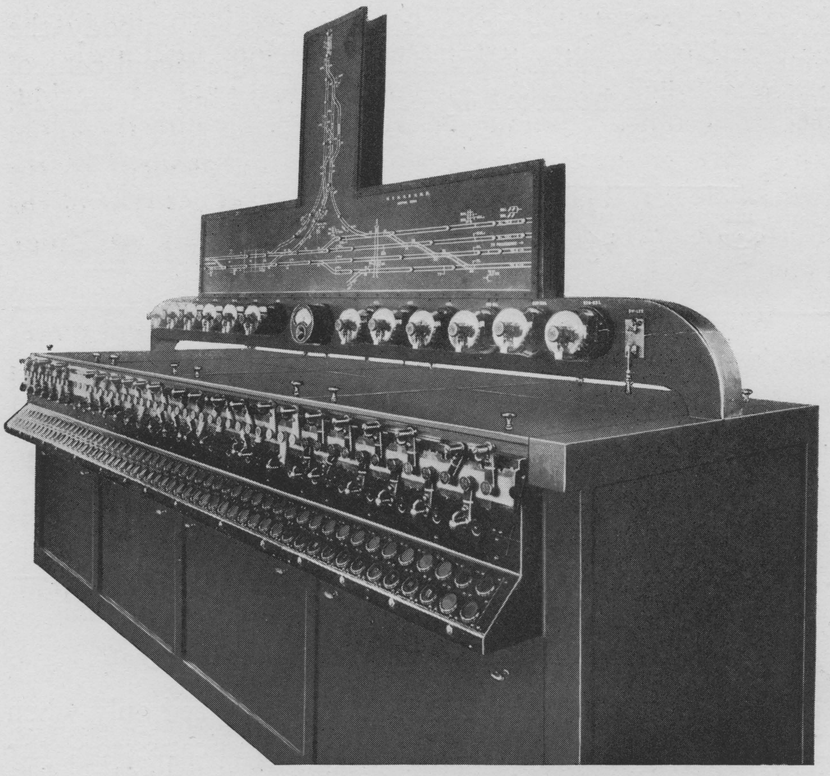


Fig. 24—Signal Indication Circuit for Opposing Signals

Since the indication magnet should be energized only when all blades controlled by a signal lever indicate stop, the circuit controller contacts actuated by these blades are connected in series. The circuit is also broken through LB and RD contacts on the signal lever, connected in multiple.



Model 14 Power Interlocking Machine, with Track Model and Clock Work Time Releases

Type "F" Alternating Current Electric Interlocking

While alternating current electric interlocking is of more recent development than is direct current, yet the Type "F" alternating current system has been in successful use since 1914, and its practicability has been thoroughly demonstrated. The first installation and practically all plants installed since that time are Union Type "F." This system occupies a unique position in being directly applicable with no basic change whatever, independent of the form of electrical energy available. Over 90 per cent of the alternating current interlockings in service today are Union Type "F."

Wherever a reliable source of alternating current power is available, a Type "F" alternating current interlocking has the following advantages over one using direct current:

1. The power equipment is greatly simplified.

2. Power losses between source of supply and interlocking units operated are reduced to a minimum.

3. Alternating current track circuits insure maximum safety and economy.

Power Supply

The general scheme of the Type "F" System of electric interlocking is the same whether electricity is utilized in the form of direct or of alternating current, as previously stated. Either form of current or a combination of the two may be the means of transmitting energy throughout a Type "F" interlocking. On account of the similarity of the two systems, but little exposition of the parts peculiar to the alternating current application is necessary.

An electric interlocking of ordinary size has a very limited power requirement when compared with other loads of a central station, but it is of first importance that there be no interruption of traffic so that either the source of power supply must be infallible or some arrangement must be made to take care of emergency requirements.

Generation—Ordinarily alternating current interlockings are supplied with energy generated at some distance from the plant. This will be evident when it is borne in mind that the main reason for the use of alternating current is the facility with which it can be transmitted over long distances. Alternating current interlockings are, therefore, found more generally where there are alternating current power lines, and have particular application to railroads utilizing electricity for propulsion purposes.

Transformation—The only appliance which must be interposed between the transmission line and the distributing and operating switchboard at an alternating current interlocking is the transformer. The potential is ordinarily reduced to 110-volts for distribution throughout the plant and to take care of the load in the tower.

Switch Boards—The alternating current interlocking switch board is greatly simplified, so much so, in fact, that the power and operating boards can be combined. The resulting switch board has only parts which have been standardized in other electric power plant practice. No special appliances are required, the simplicity of the entire scheme being immediately apparent. A diagram showing the entire power supply, transformation, and utilization is shown as Fig. 25. This may be varied to meet with local requirements, but in general represents the layout installed. A comparison of this diagram with that shown as Fig. 3 will indicate the similarity of Type "F" direct current and alternating current interlocking power supply and the comparative simplicity of the latter.

Power Distribution

Bus-Mains—As in direct current Type "F" interlocking, the greater part of the energy for the alternating current system is distributed by means of bus-mains extending throughout the plant. These may be run in duplicate where desired and, in any case, are of heavy wire of low resistance, with a resultant provision of practically normal voltage for the operation of each unit, no matter how remotely located. This provides a wide margin of safety to take care of possible poor regulation of the alternating current

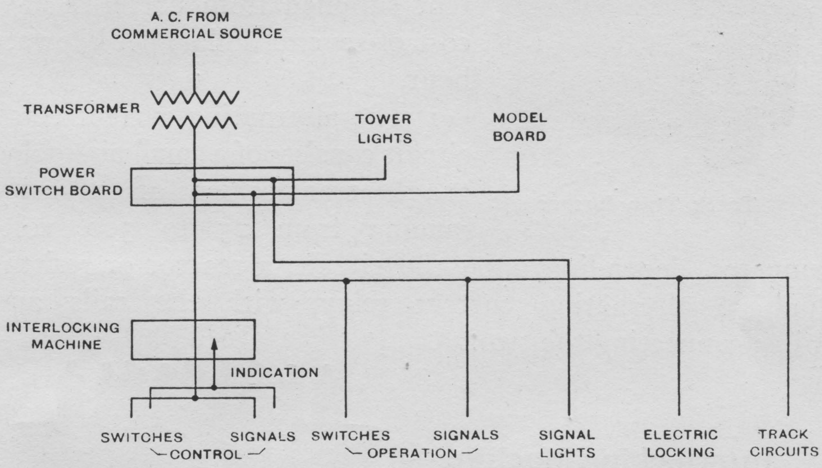
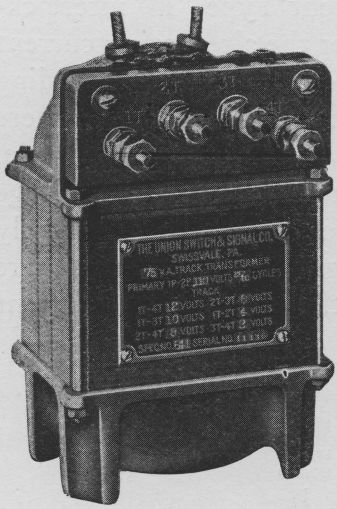


Fig. 25—Diagram of Power Supply; A.C. Interlocking

supply line. There is also a very considerable saving in copper in the complete plant because the heavy load is segregated and supplied over the bus-mains.

The supply of energy for switch and signal operation and electric locking is entirely similar to that in direct current Type "F" interlocking. Track circuits may in alternating current interlocking be supplied from the same mains that supply the units just mentioned. Signal lights may in either case be controlled over a separate wire in order that this circuit can be opened during the daytime if desired.

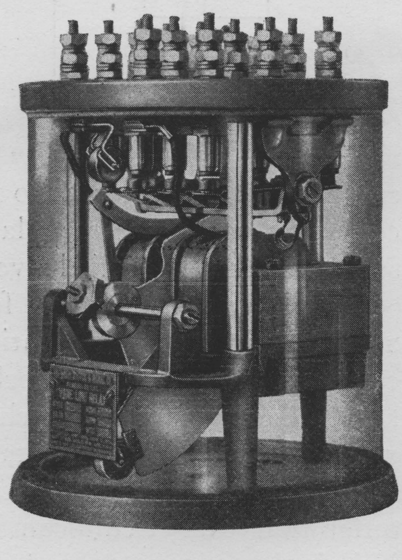


Track Transformer

Track Circuits—Alternating current track circuits have a distinct advantage over those utilizing direct current because the former may be made immune to the effects of foreign current. Alternating current track circuits are also more economical, as they use alternating current at a few cents per kilowatt hour instead of current supplied from batteries at a cost of several dollars per kilowatt hour.

The alternating current track circuit consists of a small air-cooled track transformer of capacity ranging from 25 to 500 volt-amperes, depending upon the circuit, a reactor or resistor and an alternating current relay, with the rails and wires connecting the two.

Interlocking Machine—Energy is taken through the switch board and interlocking machine to supply control circuits for switches and signals. Alternating current is also received at the machine to indicate the position of the units outside.



Style SLV-13 Vane Type Relay

Interlocking Machine

The Model 14 interlocking machine, as illustrated in Figs. 4 and 5, and described in the section on direct current interlocking, functions in exactly the same way and possesses the same safeguards for traffic on alternating as on direct current. The only difference in this machine is in the detail construction of the indication and lock magnets. It is obviously necessary that these be constructed for the form of current they use. The alternating current magnet must have a laminated steel core and be wound to suit the frequency as well as the voltage, while the direct current magnet may have a solid iron core and attention need be paid only to the voltage impressed upon its winding.

Switch Movements

Operating Mechanism—The alternating current Style "M" switch movement is mechanically the same as the direct current movement, even including the reduction gearing between the motor pinion and the worm, and differs only in the use of an alternating current motor, which is interchangeable with the direct current motor both in mounting and mechanical connection.

Switch Control and Indication Circuits—The complete control, operating and indication circuits for a single switch operated as a part of a Type "F" alternating current plant are shown in Fig. 26. The similarity of these circuits to those used in direct current Type "F" interlocking will be immediately apparent, the only difference being in the operation of the Type "F" controller, which will be described later, and in the indication circuit.

The Type "F" alternating current indication circuit is supplied with energy by means of a small 1:1 transformer, located at the switch, through pole changing contacts actuated by the switch and lock movement, and extends to a three-position KR alternating current relay located

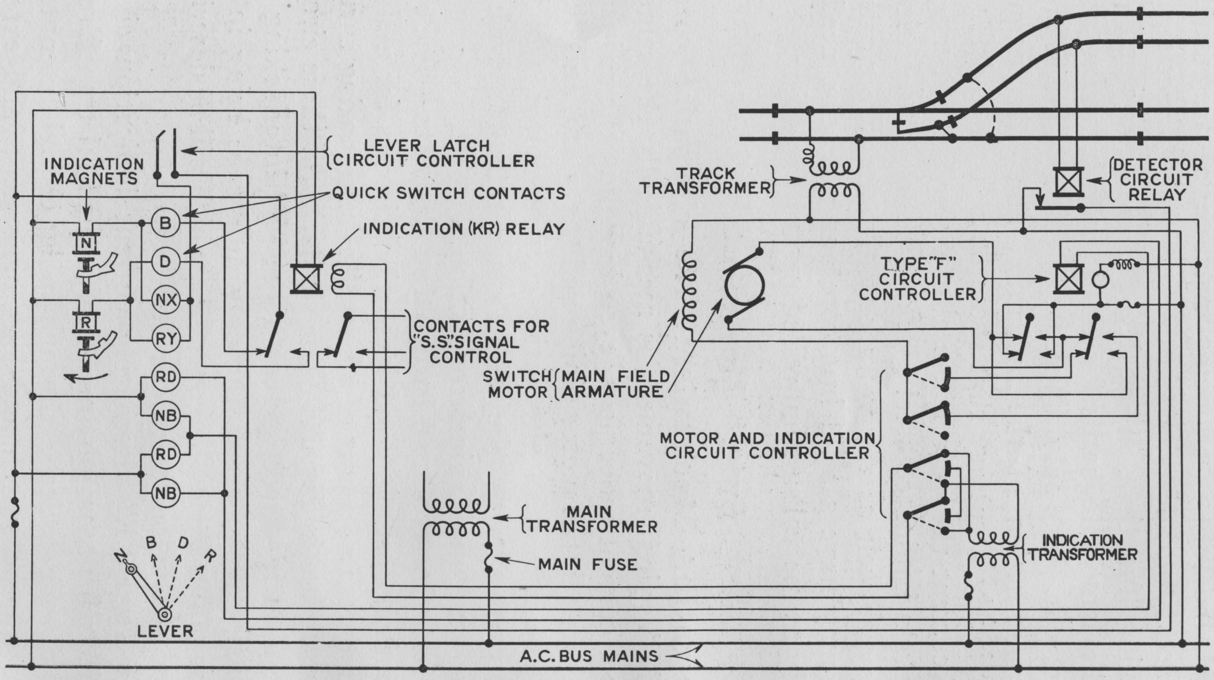
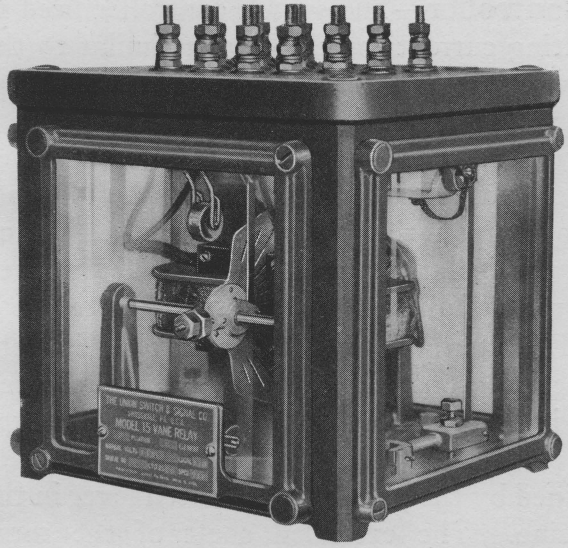


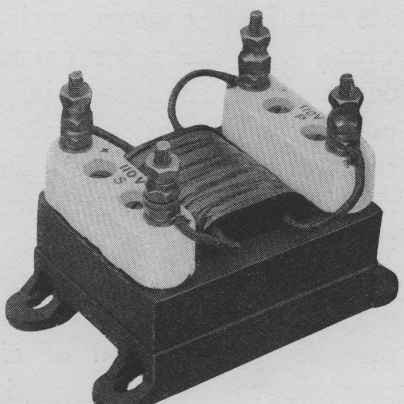
Fig. 26—Complete Control, Operating and Indication Circuits for Single Switch. Alternating Current Interlocking

in the tower. This relay has a local coil supplied with energy continuously from the alternating current mains and a control coil which receives current of a certain polarity relative to the current supplied the local winding, as determined by the position of the pole changer at the switch.



Model 15 Vane Type Relay

Thus the indication circuit is similar to the polarized indication circuit used in direct current interlocking. The use of a 1:1 transformer at the switch allows for the complete isolation of each indication circuit. The secondary winding of this transformer is made of resistance wire, so that the phase relation of the currents in the relay windings will be such as to provide maximum torque. By virtue of this



Indication Transformer

provision, the relay is immune to the effects of current coming through crosses with wires from other sources. The high resistance transformer secondary also makes fuse protection unnecessary, and prevents a single transformer from supplying pick-up energy to two relays.

Type "F" Controller—The switch controller used in Type "F" alternating current interlocking is similar to the corresponding device used in direct current interlocking, except that it is not arranged for normal de-energization, nor does it incorporate an automatic circuit breaker for opening up the motor circuit should the switch be blocked. Any dangerous load upon the alternating current switch motor, which is a particularly rugged device, will be taken care of by the blowing of a fuse in the motor circuit.

The Type "F" alternating current controller is very simple in construction, consisting of a bi-polar laminated field magnet carrying a coil, and a wire wound shuttle type rotor, the relative polarity of the currents in these two windings being determined by the position of a switch lever in the interlocking machine. The extended shaft of the rotor carries circuit controller contacts. The controller bracket supports terminal boards of moulded insulation to which are attached contact springs and their terminals. The winding of the rotor or moving element is permanently connected to the bus-mains, and is, therefore, of a constant polarity with relation to the source of power supply. When the switch lever in the tower is reversed, this changes the relative polarity of the two windings, causing the rotor to turn and the contacts it carries to reverse the switch motor connections. The rotor torque is made of considerable magnitude to insure good contact pressure. Toggle springs provide quick action of circuit controller and sufficient pressure to maintain good contact independent of controller energization. Both elements of the Type "F" alternating current controller are continuously energized, but the actual power taken in watts is very low due to the highly inductive character of the windings. In other words, the device operates at an extremely low power factor and since the cost of alternating current is not great, the continuous energization is of little consequence.

Safety Features—The same protection against effects of crosses and grounds as is afforded in the Type "F" direct current interlocking is provided in the alternating current plants as well.

Signals

Alternating current signals of the semaphore type can be provided in the same styles as for direct current interlocking. Semaphore signals with their mechanisms at the base of the mast, Styles "B" and "S," and that with its mechanism at the top of the mast, Style "T-2," have been supplied for alternating current operation for a number of years. While necessarily differing electrically, these signals all agree in mechanical construction in general with their direct current prototypes, and any one or all of them can be applied to alternating current interlocking, with an assurance of entirely satisfactory service. Light signals of the position or color type can also be applied.

The signal control, operating and indication circuits are the same as for direct current interlocking. The "SS" scheme functions with the same reliability and insurance of continuously safe and satisfactory operation no matter whether supplied with alternating or direct current. It should be remembered when considering alternating current interlocking that the relative safety and reliability of operation of the two systems can be placed at par.

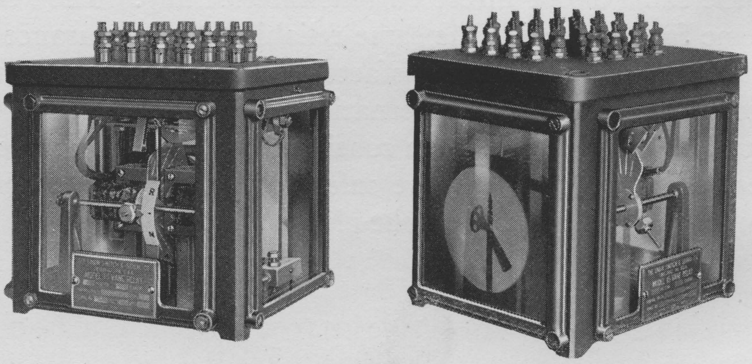
Auxiliary Devices

Tower Indicators

It is desirable from a standpoint of efficient operation that the leverman be informed concerning the location of trains both approaching the interlocking and within home signal limits. One means used to show track occu-

D.C. Tower Indicator

pancy is the lever light described as a part of the interlocking machine. Another means is the tower indicator. The latter are generally similar to standard relays

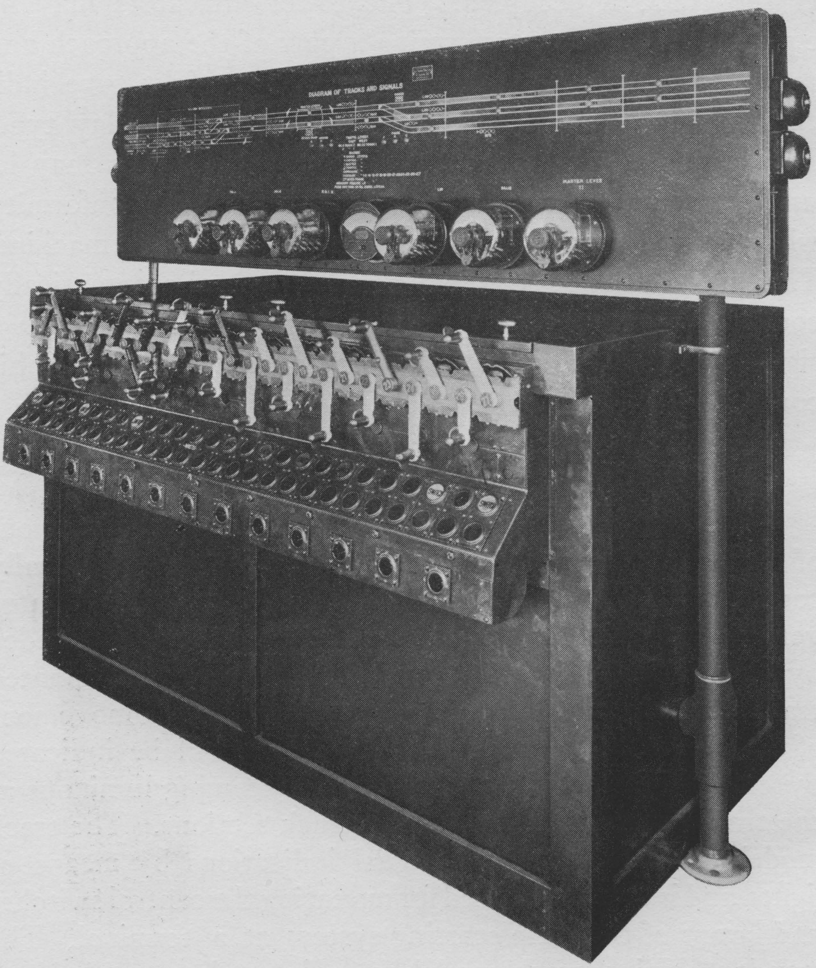


A.C. Tower Indicators

but with indicator blades or discs actuated by the armature. The position of the blade or disc indicates whether the track is occupied. The tower indicators may be equipped with contacts forming a part of the approach and route locking circuits. In some instances light type indicators have been substituted for those of the relay type. In addition to repeating track sections, indicators may be used to show whether a signal has cleared in conformity with the movement of the lever in the interlocking machine. This may be desirable where signals are semi-automatically controlled, in order that the towerman may know when a signal has failed to clear due to some condition beyond his control.

Track Model

The older form of track diagram which comprised a layout of tracks and signals with metal strip switches mechanically connected to the interlocking machine levers, all mounted vertically back of or over the machine, has been superseded by what is termed a track model. This is an illuminated track diagram with lamps so arranged that the movement of a train through an interlocking plant will be indicated by either lights going out or lamps becoming luminous as the train passes over the various track sections. The track model may also repeat the signal indications by means of lights, and is sometimes used for mounting the control switches and lamps of the train starting system at a terminal. The standard Union track model has a front plate and back of sheet steel mounted on a channel shaped pressed steel frame, thus providing a fire-proof structure, which is considered essential. The clear distinctive indication of light colored tracks, switches, and signals on a black background is shown in accompanying illustrations of track models in service. Experience has shown that this combination of colors is



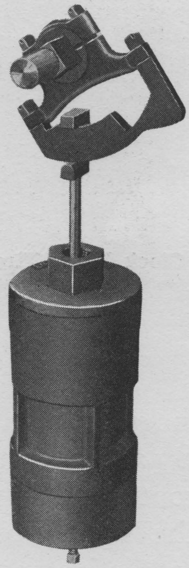
Model 14 Power Interlocking Machine, with Track Model

best. The track model has proven an almost indispensable convenience at the larger interlocking plants. Tower indicators will ordinarily serve the purpose very well at the smaller plants.

Time Releases

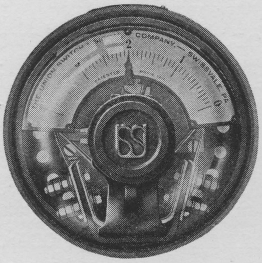
If all trains passing through an interlocking plant were to continue on the route first lined up for them by the leverman, and if there were no failures of track or other circuits affecting the automatic locking of the plant, there would be no necessity for time releases, but since it is at times necessary to change a lineup, due either to a misunderstanding on the part of the leverman, or to a change in other conditions which has made such action desirable, a device which will allow this to be done safely is necessary. A time release is a mechanical device for securing this result.

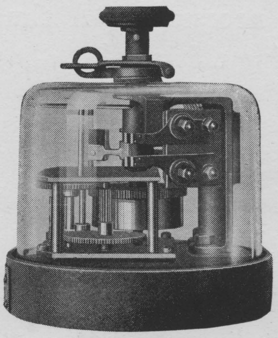
Two types of time releases are in ordinary use. The mercury time release is intended for direct connection to the lever in the interlocking machine and functions coincidently with lever movement. It is carried on the plate which supports the usual indication or lock magnets and is operated from the lever shaft. It consists of an iron case containing mercury which is arranged to flow through an orifice of certain size, in this way providing a time interval which is the determining factor in the lever movement, or the circuit controlled. The time interval can be varied by adjusting a needle valve.



Mercury Time Release

The clock work time release is usually operated by hand. It has a graduated dial and clock hand which indicates at all times the amount of time elapsed after it has been released. This release may be set so as to provide any time interval up to four minutes.





Clock Work Time Release

The mercury time release is generally used for interlocking machine lever applications. It may be made to delay lever movement mechanically, or to close a circuit after a given time interval. By applying time releases to signal levers approach locking can be accomplished independently of approach track sections. A dwarf signal can be located safely within five feet of the switch or derail it protects, and considerable track space saved. This type of approach locking is installed quite generally for slow speed train movements, with a considerable saving in cost. No time interval need be introduced in returning a signal lever normal after a train has accepted and passed a "Proceed" signal, so that no delay necessarily results in normal operation.

The clock work time release is used more commonly in connection with electric approach and stick locking. By actuating this release a leverman will be able to change a route while a train is occupying the approach section, after the signals concerned have been returned to their more restrictive positions and a time interval has elapsed. A less frequent application is to release section or sectional route locking.

Automatic Electric Control

Automatic electric control forms as essential a part of the protection for moving trains at an interlocking plant as do the control, operation and indication of the interlocking devices. In early days there was no such a thing as automatic electric control, but with power interlocking, higher speed, and heavier trains, this has come to be absolutely necessary. It is not sufficient that the leverman be kept informed concerning the location of trains approaching a plant and within home signal limits, but his hands must be tied so that he cannot take any action which might create a hazard in connection with train movement. This is what automatic electric control does.

Semi-Automatic Control of Signals

But slight additional expense is required to include semi-automatic control of home signals in a Type "F" electric interlocking plant. Nor is the expense of making distant signals semi-automatic disproportionate to the betterment secured thereby, as an interlocking plant is ordinarily installed at a point where traffic would naturally tend to become congested, and, therefore, where automatic protection is desirable. This control means merely that the signal control circuits be carried over track relay contacts so that the signals will, in addition to responding to lever movement, function otherwise as though they were automatic signals. No hazard is introduced by the combined control, as a signal will in any case assume the indication which is most restrictive as determined by the two means.

Section Locking

Section or detector locking consists of the control of switches by track sections which may form a part or all of a route and of which the switches protected are a part. Section locking provides that whenever a train is immediately adjacent to a switch the relay of the track circuit protecting this switch will become de-energized, thus opening a circuit which will prevent the release of a lock which prohibits manipulation of the interlocking machine lever controlling the switch in question. The track relay may be located in the tower, if this is not too far distant from the switch, or it may be repeated by a line relay or indicator located in the tower. A simple section locking circuit is illustrated in Fig. 27, in this case a repeater relay being used. The wiring for complete switch indication and section locking is illustrated in Fig. 19.

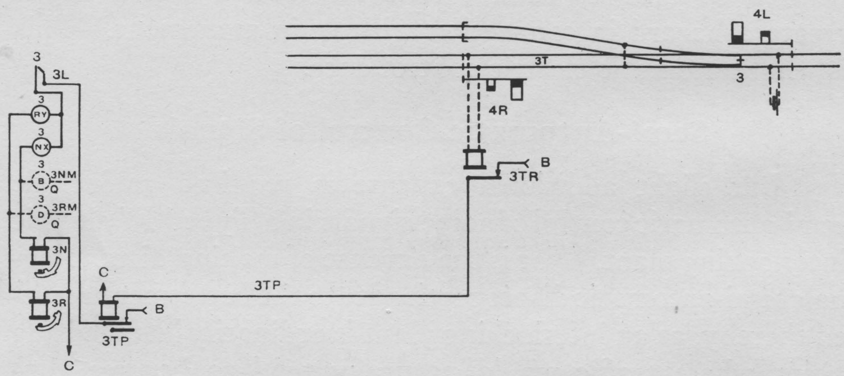


Fig. 27—Section Locking Circuit

Sectional-Route Locking

It is desirable to prevent the manipulation of any switch after a train has passed a signal governing movement over that switch, no matter how remotely the signal may be located from the switch in question. This leads to the control of a switch by more than one track section, or route locking. Where traffic is heavy it is also desirable that the switches be released as quickly as practicable after a train has passed over them. That is, the switches in one section may be released while those in another section of the same route are still electrically locked, for traffic in a certain direction. This is a question of expeditious handling of traffic and not of safety, and is called sectional-route locking. How it is accomplished is indicated by the circuit shown as Fig. 28. A stick relay remains energized or becomes de-energized when a train is on track section 6T as determined by which

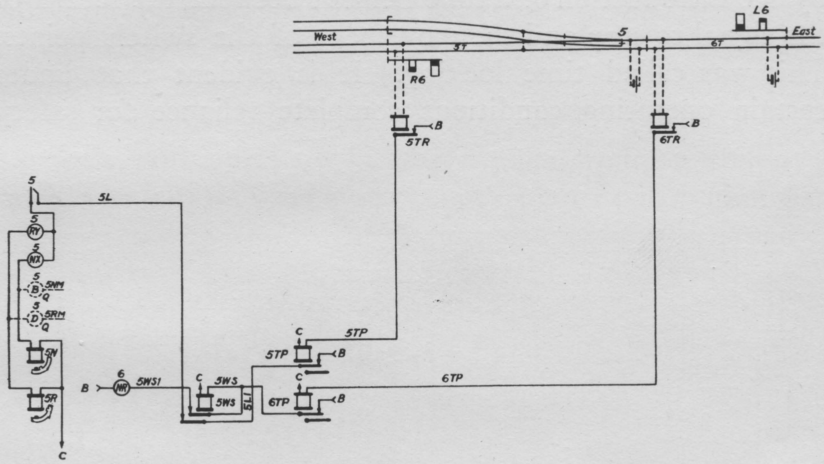


Fig. 28—Sectional Route Locking Circuit

of the signals, R6 or L6, has been cleared, i. e., by the direction of train movement. In Fig. 29 will be noted an enlargement of this control so as to take care of the early release of the route for traffic movement on either direction.

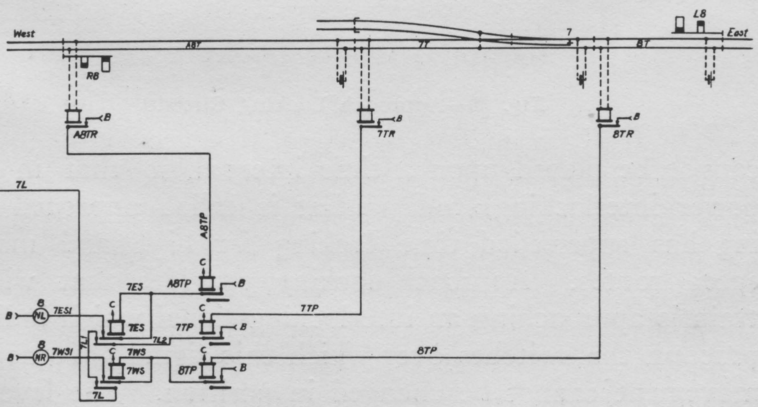


Fig. 29—Sectional Route Locking Circuit

Approach Locking

In the early days of interlocking, some assurance of protection against a switch being changed in position, after a train had accepted and passed a clear signal, was provided by the introduction of a time element between the return of the signal to stop and the movement of the switch points. This was called time locking. It is evident that under certain operating conditions complete reliance for safety

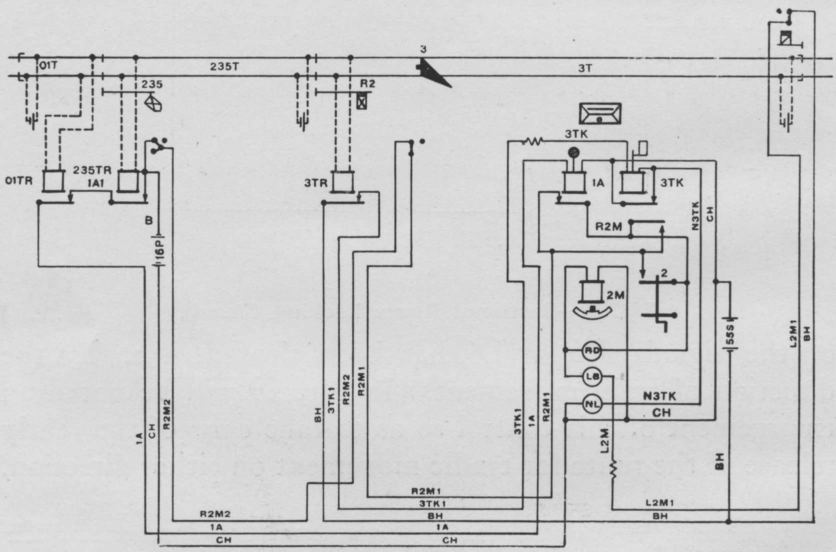
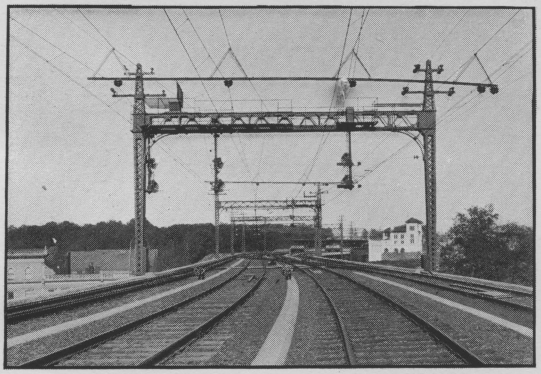


Fig. 30—Approach Locking Circuit

cannot be placed upon a time interval, so that in most power interlockings today what is called approach locking has superseded time locking for high and medium speed routes. Approach locking provides that while a train is approaching an interlocking signal which indicates proceed, the switches over which this signal governs train movement cannot be changed in position. The leverman always has the ability to cause signals to assume their most restrictive positions, as it may become necessary for him to stop a train after he has once cleared the signal for it to proceed. Approach locking provides that he cannot, even after restoring the home signal to a stop position, change the position of any switch or derail which might affect the route for train movement. A provision to take care of an emergency requirement is made by the use of a clockwork time release not mechanically connected to the lever, previously described.

Ordinarily approach locking circuits are made effective as soon as a train enters the track circuit approaching the distant signal, so that if the distant signal indicates proceed the train is protected long before reaching the home signal near the derails and switches. A circuit illustrating how approach locking is ordinarily effected is shown as Fig. 30. The electric locks which function in approach locking control are generally applied to signal levers.



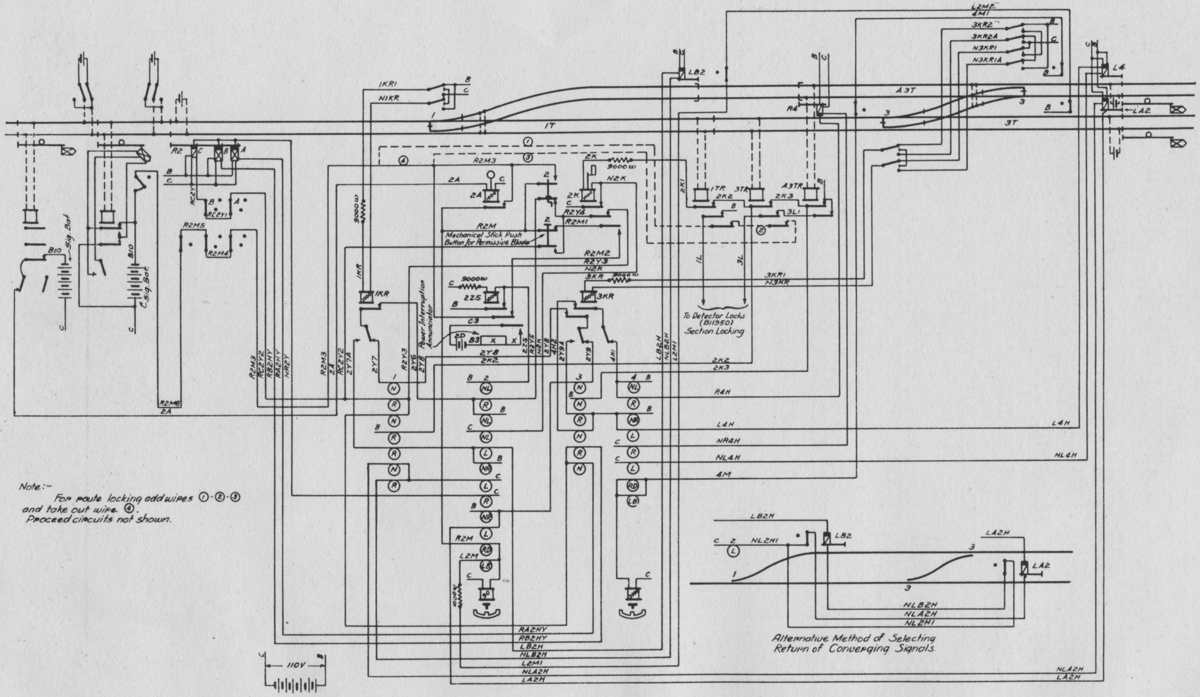


Fig. 31—Circuits for Type "F" D.C. Electric Interlocking, with Approach, Route and Section Locking

Check Locking

Check locking consists of the intercontrol between levers in separate interlocking machines. This is ordinarily required when provision must be made for reversing the normal direction of traffic between two interlocking plants. It is accomplished electrically by means of lever locks which are similar to those used in connection with approach, route, and section locking. There must be coöperation between levermen before a signal can be cleared for train movement onto the track protected. A typical check locking circuit is shown as Fig. 32.

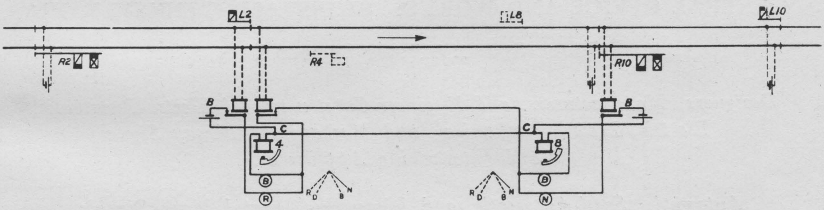


Fig. 32—Check Locking Circuit

A combination of circuits previously described is shown as Fig. 31. The simplicity of these circuits will be evident to anyone who has followed through the description of the various elements which go to make up the complete Type "F" plant.