American Railway Signaling Principles and Practices

CHAPTER XIX

Electric Interlocking

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ELECTRIC INTERLOCKING

General.

Electric interlocking is a type of power interlocking, and as the name implies, electricity is the operating agency. The first machine was installed in America in 1888. The essential elements for a complete electric interlocking system are a source of electrical energy, a machine with its levers and auxiliary apparatus for controlling switch and signal mechanisms, and apparatus for preventing unauthorized movement of an operated unit.

In power interlocking, means are provided to check the correspondence of position of switch, signal or other unit controlled with the lever, and for preventing the unauthorized movement of the operated unit. The former is known as indication locking and the latter as cross-protection.

Two systems of electric interlocking are in general use, one in which the electrical energy for operating the unit is carried through contacts on the lever and over wires to the unit; the same wires being generally used for the return of the indication current for operating the indication locking. This system, known as the electric dynamic indication system, employs what is commonly known as the dynamic indication principle in which the energy for indication purposes is furnished by a current generated by the momentum of the motor of the operated unit. In the other system, known as the Type "F" electric interlocking system, the electrical energy for operating the unit is carried direct to the various units throughout the system by a pair of bus mains or feeders, and a separate alternating or direct current source is used for indication purposes. Each unit is controlled by a local relay or its equivalent constituting a part of the switch or signal, this relay being governed in position by two separate and independent wires leading direct from the control lever in the machine. Two separate wires carry the indication current from the unit to the lever.

The Type 341 electric interlocking described in this chapter is similar to the electric dynamic indication system.

Principles of interlocking systems using machines with mechanical locking.

The design of the machines and the controlling circuits is such that the following features essential to safe operation are afforded:

1. No lever can be moved from a given position if another lever mechanically interlocked therewith is in such a position that its controlled unit will conflict with the unit to be operated. Furthermore, due to the mechanical locking being of the preliminary type, before a given lever can be moved from its position, all conflicting levers will be locked to prevent their movement until such time as conditions are proper for them to be released.

2. The movement of a switch lever cannot be completed either to the normal or reverse position until its controlled unit has moved to, and is locked in, the position corresponding with that of the lever. In the case of a signal lever, this correspondence of position is required only when restoring lever to the normal position, which can be completed only after the signal has assumed its most restrictive position.
3. Each unit, when in a position of rest, is protected against unauthorized operation which might otherwise be accomplished through current being wrongfully applied to its controlling circuits.

Power supply.

When the switch and signal units are operated by direct current, the supply is usually obtained from a storage battery of 110 volts, which may be charged by electric energy obtained from a commercial source, or by electric current generated at the interlocking plant. An additional low-voltage storage battery of 10 or 12 volts is generally used for the control of relays, etc. The details for charging storage batteries are described in Chapter IX—Rectifiers. When the units are operated by alternating current the supply is transformed to the voltage required.

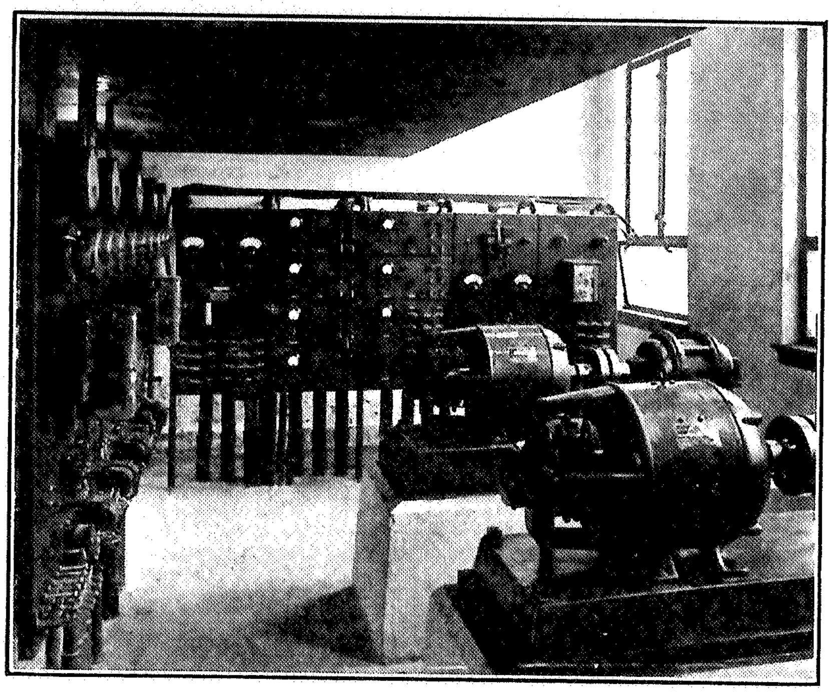


Fig. 1.
Power Switchboards and Motor-Generator Sets at Interlocking Station.

The storage battery with its charging apparatus together with the switchboard in connection therewith are usually located in the interlocking station and are shown in Figs. 1 and 2.

Electric interlocking machine.

The Signal Section, American Railway Association, defines Electric Inter-

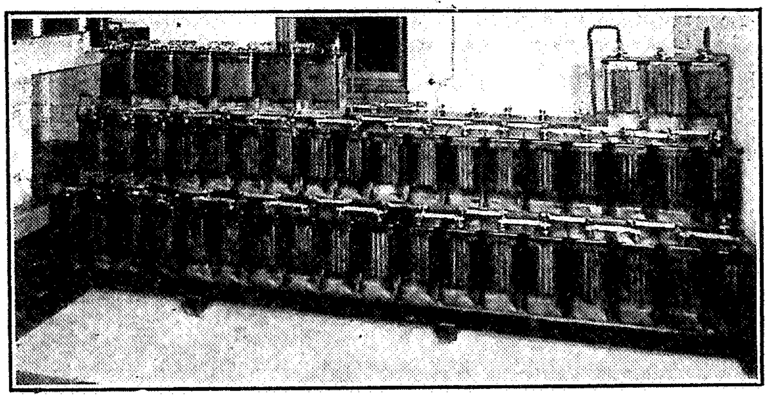


Fig. 2.
Storage Battery and Racks.

locking Machine as: An interlocking machine designed for operating and controlling the units electrically.

Electric Dynamic Indication System

Machine.

One type of interlocking machine used in the electric dynamic system is shown in Fig. 3 and is known as the Model 2 unit lever type. Table interlocking machines are sometimes used to control units operated by this system and are described in another portion of this chapter.

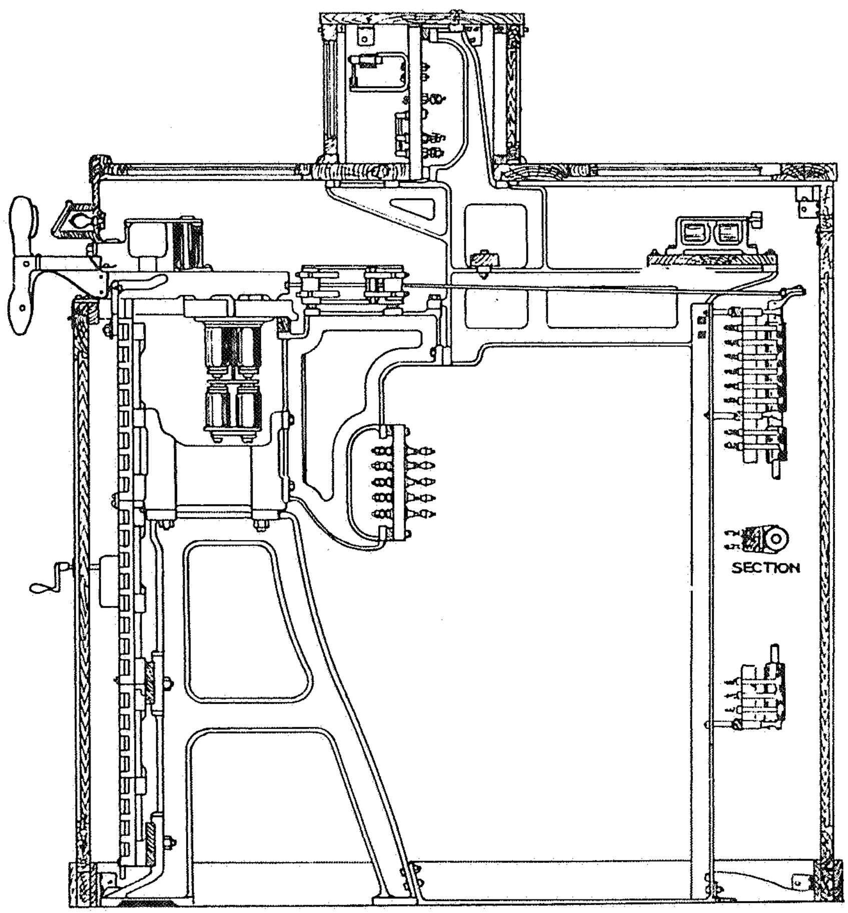


Fig. 3.
Cross-Section of Model 2 Unit Lever Type Machine.

The interlocked levers with their guides, indication magnets and circuit controllers are mounted in a common frame spaced 2-inch centers, the general practice being to furnish an individual lever for each signal and switch unit. Where two switches are operated together, such as a crossover, the levers are rigidly connected and operated as a single unit.

Locking.

The locking is described in Chapter XVI—Interlocking.

Lever.

Each lever with its guide, indication magnet, controller, etc., comprises a complete unit in the interlocking machine, the design being such that the unit may be removed from the machine without moving the lever tappet from the normal position or disturbing adjacent levers.

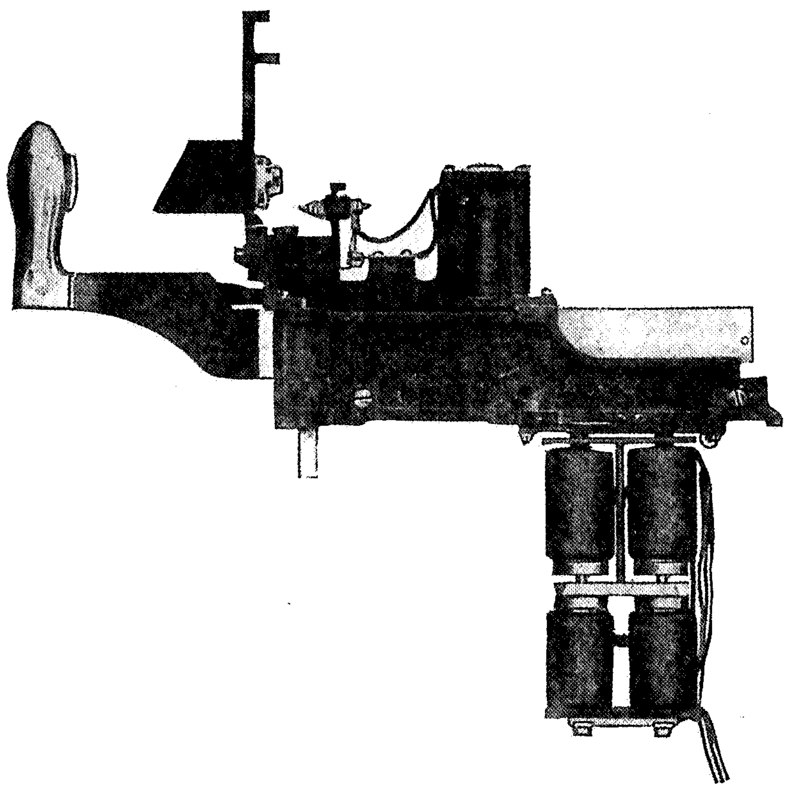


Fig. 4.
Switch Lever Equipped with Lever Lock and Lamp Case.

The circuit controller with which each lever is equipped can be provided with a maximum of five tiers of contacts, controlling five normal and five reverse independent circuits. Additional contacts are available on the auxiliary controller at the back of the machine as shown in Fig. 3.

Lamp case and number plate.

The combined lamp case and number plate is mounted above each lever, as shown in Fig. 4. The number plate is designed to set at an angle which renders it readily visible to the operator when manipulating the levers. Lamps and sockets are furnished only for levers specified. They are generally used in conjunction with some type of electric locking to indicate whether the lever may or may not be moved. If desired, a double lamp case can be furnished to provide two separate indications.

Polar relay.

The polar relay shown in Fig. 5 is provided with a soft iron core which sets lengthwise between the poles of a permanent magnet, the design being such that current passing in one direction through a winding on the soft iron core tends to hold the relay armature normal and the contact closed, while current in the opposite direction tends to reverse the armature and cause the contact to open.

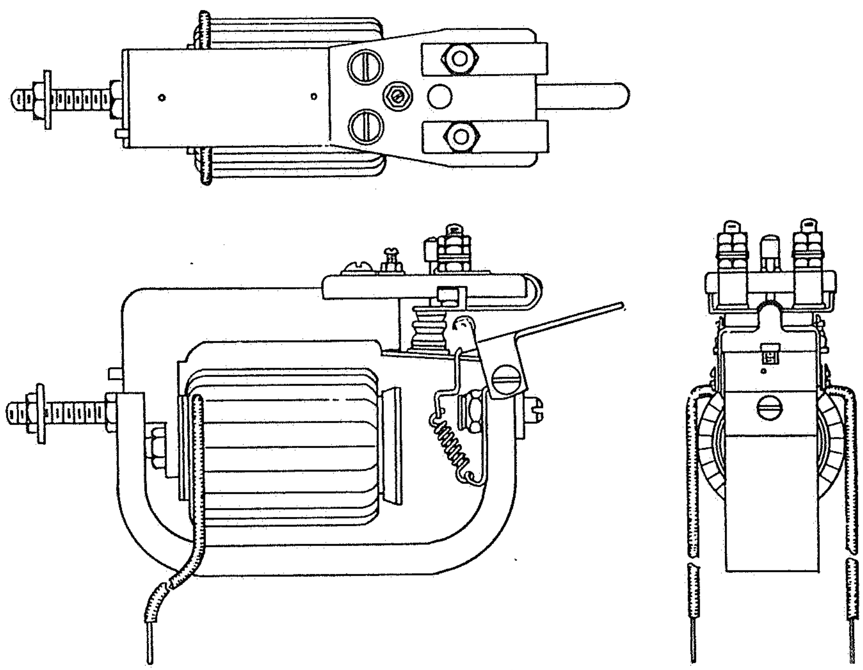


Fig. 5.
Polar Relay.

Indication selector.

The indication selector, one of which is used in connection with each switch lever, consists of two electromagnets and a contacting armature which moves in one direction when the lever is reversed, and in the other direction when the lever is normal.

Lever lock.

The electric lever lock shown in Fig. 4 may be applied to any lever in the machine and may be provided for operation by direct or alternating current.

The lock is designed to be mounted on top of the lever guide, locking the lever in any required position by means of a solenoid plunger, which, when the magnet is de-energized, is forced into a notch cut in the top of the lever. To conserve battery the circuit for the lock is broken through a contact actuated by the lever latch.

Operation of lever.

In explaining the operation of the lever its movement may be considered as divided into three parts: preliminary, intermediate and final.

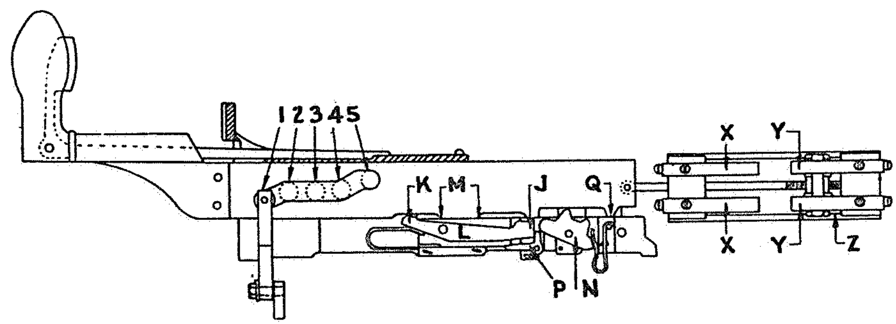


Fig. 6.
Switch Lever.

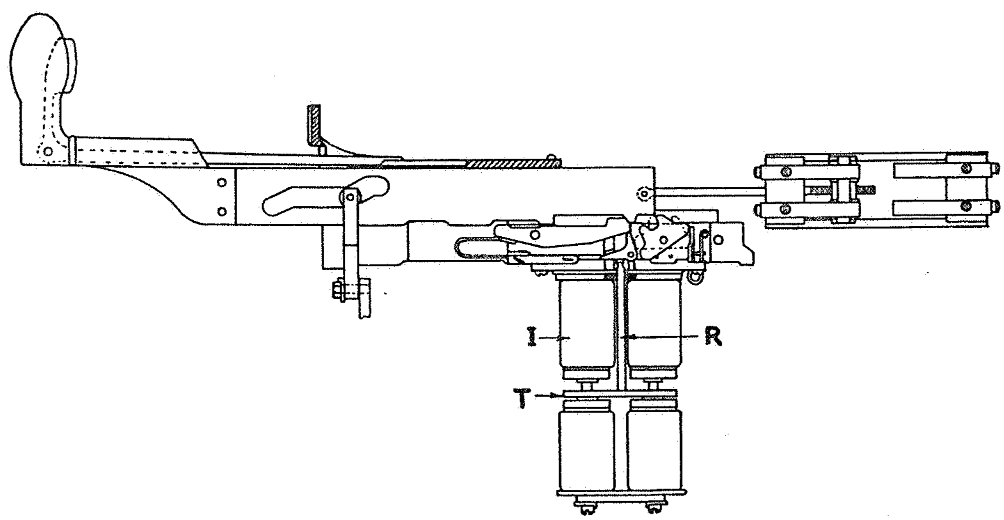


Fig. 7.
Switch Lever.

The operation of a switch lever is as follows: Each switch lever is provided with a cam slot, by means of which intermittent motion is transmitted to its tappet bar and thence to the cross-locking. In Fig. 6 the dotted circles 1 to 5 in the cam slot indicate the position of the locking tappet roller which corresponds with the like-numbered position of contact block *Z*. In the preliminary movement of a lever from position 1 to 2, the locking tappet is moved through one-half of its stroke which locks all levers which conflict with the new position of the lever in question; in this movement no change is made in the switch operating circuits. During the intermediate part of the travel from position 2 to 4, the tappet bar remains stationary and contact block Z is moved out of contact with springs YY and into contact with springs XX as shown in Fig. 7, thus setting up the circuits for the operation of the switch. The lever is held at this point, through the mechanical design of the lever until such time as the switch, having moved to a corresponding position, makes it possible for the motor to generate the electric dynamic indication current which effects the release of the lever and permits its movement to position 5. During this final movement from position 4 to 5, the stroke of the locking tappet is completed, unlocking all levers which do not conflict with the position of the lever operated.

The method by which the lever is prevented from completing its stroke until the switch has moved to a corresponding position and has sent in its indication, is as follows: In moving from position 1 to 2, Fig. 6, projection M on the lever coming against projection K on latch L causes the latch to assume the position shown in Fig. 7. This brings projection J on latch L into the path of tooth Q on the lever. In moving from position 2 to 4, tooth Q engages with cam N, rotating it to the position shown in Fig. 7. As it passes the central position it comes in contact with dog P which is forced under latch L, thereby locking latch L in the position assumed. The lever is stopped at position 4 by tooth Q coming against projection J on latch L as previously explained. The indication current, flowing through magnet I, Fig. 7, lifts armature T which causes plunger R to strike dog P, Fig. 6, and trip it out from under latch L. Latch L then drops to the position shown in Fig. 6, thereby releasing the lever and permitting its final movement. The movement of the lever from reverse to normal is performed in a similar manner. When the lever has been moved to, or beyond, position 3, it can neither be moved forward beyond position 4 nor backward beyond position 2 without the receipt of an indication.

The movement of the signal lever is identical with that of the switch lever except that no electrical indication is required during the reverse movement, the lever not being checked at position 4 because of a change in the design of dog P, which is mechanically tripped at this point from under latch L by cam N. The mechanical locking insures that before a signal lever can be reversed all levers controlling switches and derails in that route are in the proper position.

Cross-protection.

The various signal and interlocking units are protected against unauthorized energy by means of the cross-protection system, the principal element of which is the polar relay. All lever contacts which form a part of this cross-protection system are used in the operation of the unit and hence are checked, as to their integrity, with every complete operation.

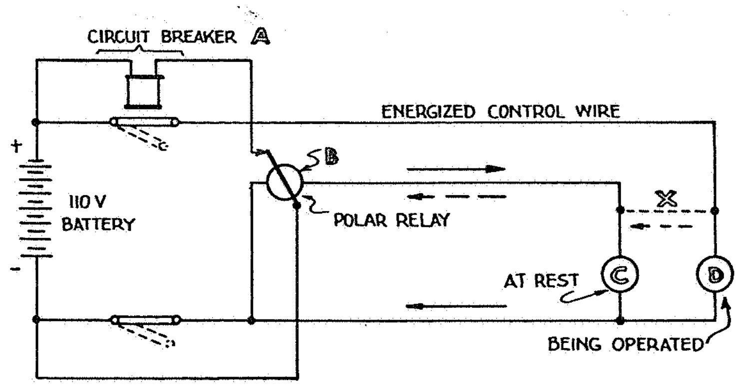


Fig. 8.
Simplified Circuit Showing the Principles of the Cross-Protection System.

All units when at rest are in closed circuits as shown by unit C, Fig. 8. All normal currents will flow through polar relay B in the direction indicated by the heavy arrows; but all currents, because of a cross, will flow in the opposite direction as indicated by the dotted arrows. Hence current supplied through a cross X will de-energize polar relay B which will cause circuit breaker A to open, cutting off the current from the entire interlocking sytem.

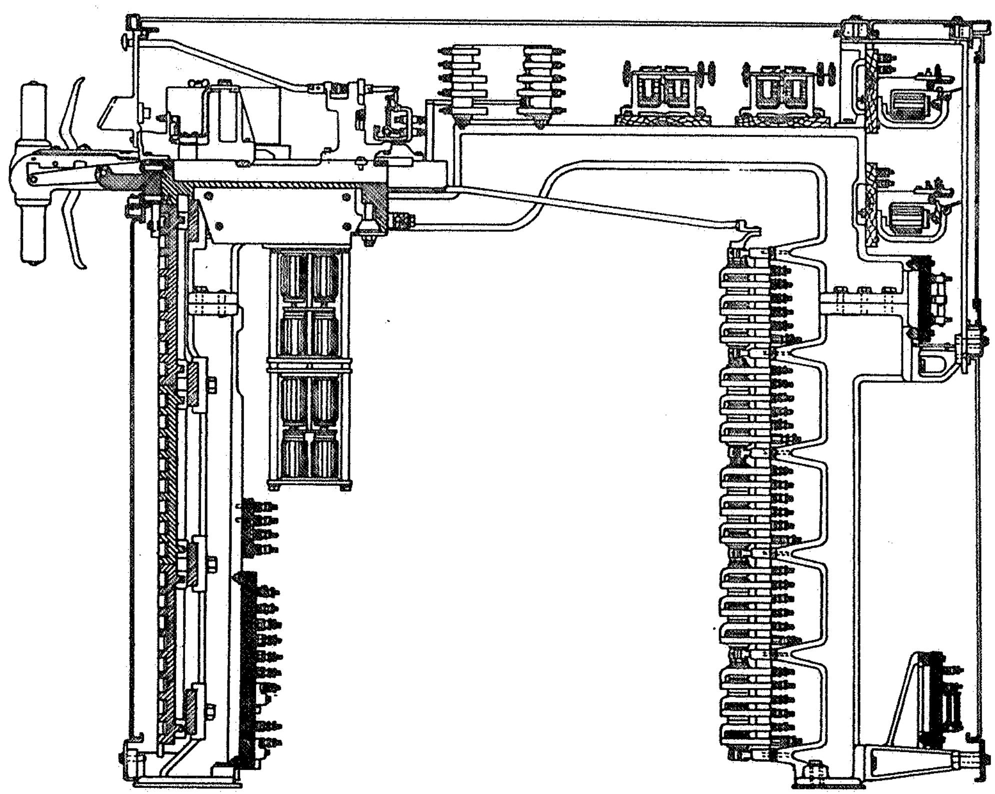


Fig. 9.
Model 5 Type Machine.

Another design of interlocking machine using the electric dynamic indication system embodies latch type locking (as shown in Fig. 9), two indication magnets mounted one over the other so that two switch machines may be operated from one lever; terminal boards, polar relays, circuit controllers, etc., arranged differently; and the frame so designed as to permit ease of inspection by means of a pit underneath the machine.

Switch machine control.

Switch and derail units in this system are operated by switch machines driven by electric motors.

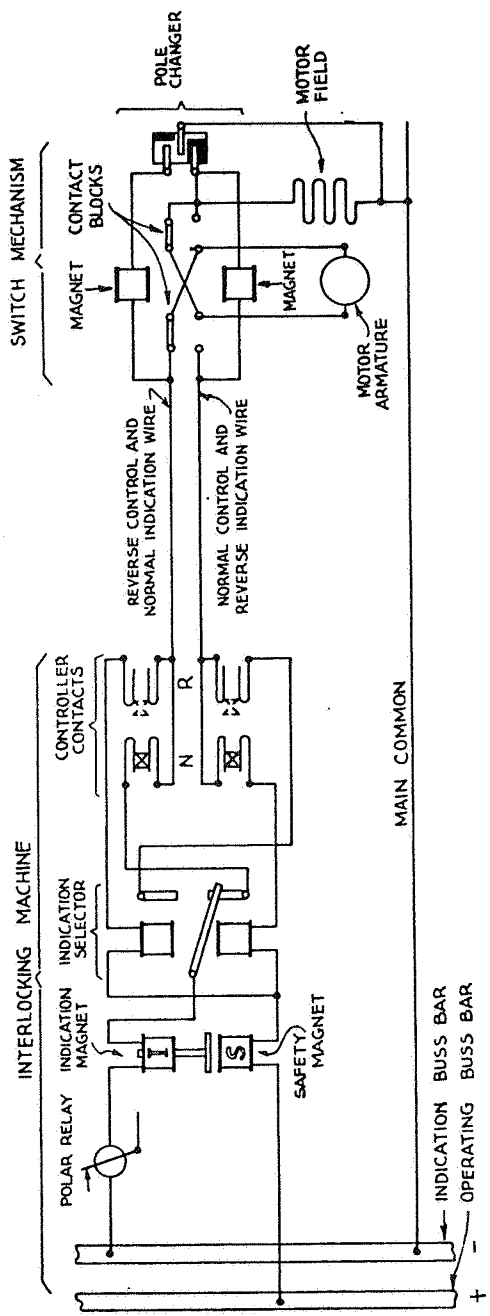


Fig. 10.
Circuits for Switch Machine Using Electric Dynamic Indication.

These switch machines require two operating and one common return wire for their operation, one of the operating wires being used for the normal and the other for reverse operation. These wires are also used for indication purposes, the normal control wire being used for the reverse indication and the reverse control wire for the normal indication. The circuit is connected to the common return wire at the switch location, or to an individual return wire.

When the lever is moved to a position to cause the operation of the switch machine (see dotted position of lever contacts in Fig. 10), current is taken from the positive bus bar through the safety magnet, indication selector, lever contacts and the control wire, through the switch motor, to common return wire. This causes the desired movement of the switch machine, which performs the following functions in the order given:

1. Switch is unlocked.
2. Switch points thrown.
3. Switch points locked.
4. Current is cut off the motor, and the connections to the motor armature reversed for indication purposes, thus leaving the motor properly connected for the next movement.

The motor is now on a closed circuit which includes the indication magnet. Because of the momentum acquired during the switch operation, the motor armature continues for several revolutions thus providing means for the generation of the current which energizes the indication magnet and permits the final movement of the lever to be completed. The operation of the switch machine in the opposite direction is accomplished in the same manner.

Changing of the motor operating connections at the end of the switch operation is effected by the mechanical shifting of the contact block in the pole changer. In addition to being mechanically operated, this contact block is under the control of two sets of solenoid magnets, so that should the switch not complete its movement the controlling lever may be shifted and, through the energizing of one set of the magnets, cause the pole changer to set up the circuit for the operation of the switch in the opposite direction. This places the machine under the control of the leverman so that should the switch points be blocked with snow, ice, etc., the points may be moved back and forth, frequently dislodging the obstruction, thereby permitting the desired movement of the switch to be completed.

The switch machine is, at all times, safeguarded from improper operation and its lever from improperly indicating as follows: With the switch lever in either its normal or reverse position and the switch machine at rest, the unauthorized movement of such switch machine, because of currents wrongfully applied to its circuit, is prevented by the cross-protection system as previously described. While the lever is being moved to a position to cause operation of the switch it is guarded against premature indication by the mechanical design of the lever.

During the time current is flowing through the lever contacts for the operation of the switch machine, the safety magnet insures against the possible receipt of an improper indication because of an accidental cross between the control wires. The safety magnet is mounted beneath the indication magnet and arranged so that the same armature is actuated by both the safety and indication magnets in opposite directions. The safety magnet coils are connected into the operating circuit in such manner that the operating current flows through them, hence any current flowing through the indication magnet because of a cross between the control wires of the switch machine cannot exceed the current through the safety magnet. The winding of the safety magnet is proportioned so that in conjunction with the above two features, the indication magnet armature will not be lifted by current resulting from a cross.

From the time the lever is moved to the other operating position until the operation of the switch machine is completed, the indication selector further insures against the possible receipt of an improper indication, being so connected that the operating current will attract its armature and close the contact for the reverse indication only when the lever is moved reverse, and close the contact for the normal indication when the lever is moved normal. It should be noted that both the indication selector and safety magnet coils are connected in series with the control circuit, therefore if the circuit through them is not intact, operation of the switch machine will be prevented.

When the motor operating circuit is opened by the action of the pole changer, after the switch has been locked in position, current ceases to flow through the safety magnet. Therefore, the armature of the indication magnet is no longer held down, thus permitting the indication to be effected upon receipt of the dynamic current generated by the motor. The mechanism is now at rest protected against an unauthorized movement in the same manner as before the controlling lever was reversed.

Because of the design of the operating circuits, the magnetic control of the pole changer prevents the switch from being moved by the use of a hand crank from the position occupied, except by breaking the operating circuits by some such means as lifting the brushes from the motor. If this is done and the switch machine is operated to a position out of correspondence with its controlling lever, upon replacement of the brushes the switch will immediately assume its proper position. Manipulation of the pole changer by hand will not cause movement of the switch out of correspondence with its lever.

Signal control.

Motor-driven signals are operated by mechanisms in which a series-wound motor is directly connected to the semaphore shaft through the medium of low reduction gearing.

The signal mechanisms used are of two types:

1. The non-automatic type, which is entirely under the control of a lever in the interlocking machine. Generally speaking, this type is furnished for dwarf signals and for such high signals that will not require track circuit control.

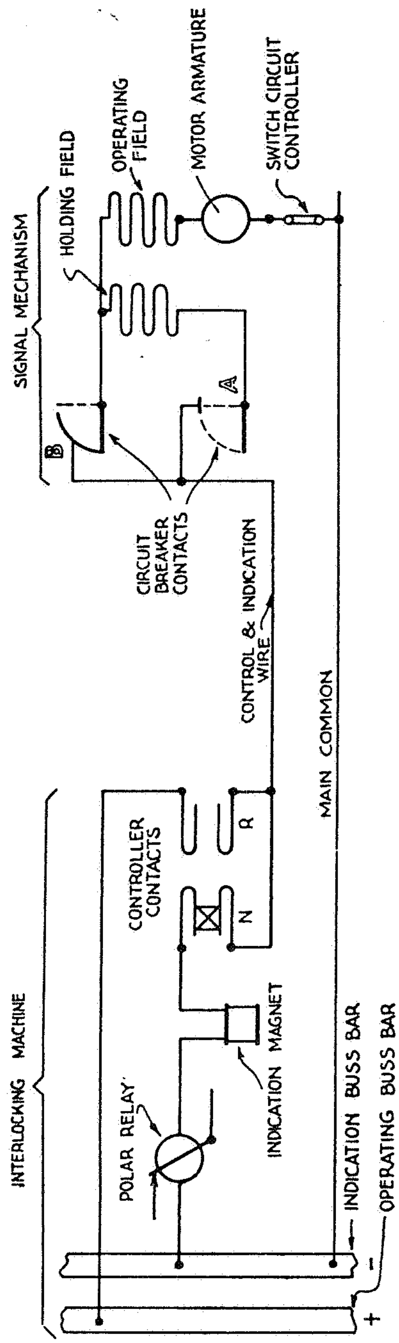


Fig. 11.
Circuits for Control of Non-Automatic Motor-Driven Signal.

2. The semi-automatic type, which is operated under the joint control of a lever in the interlocking machine and the track circuits in such sections of track as are governed by the signal. The semi-automatic mechanism is also furnished for non-automatic high signals when there is a possibility of the signal being controlled by track circuits at some future time, or in case it is desired to have uniformity in the type of mechanisms throughout the installation.

Each two-position non-automatic signal requires only one control wire (and a common return wire) for its operation, this wire being used both for operating and indication purposes. When the signal is to operate in three positions two control wires are required. In the case of semi-automatic control three wires are required.

Non-automatic signal control.

The following description of the operation is based on the circuit shown in Fig. 11 which is for the control of the two-position non-automatic signal mechanism.

Upon reversing the controlling lever, current is taken from the positive bus bar through the lever contacts, the control wire, the operating field and armature of the signal motor, and thence to common return wire through the various switch circuit controllers, as required. This causes the movement of the semaphore arm from the stop to the desired position, upon the completion of which movement circuit breaker contact B opens and A closes, thus connecting the holding field of the motor in series with the operating field and armature. The design of the pole pieces on which the holding field windings are mounted is such that the magnetic flux, thrown across the air gap between the motor armature and the pole pieces, magnetically holds the armature against rotation and thereby retains the signal in the desired position as long as the circuit is intact. Since the holding field windings have a high resistance the current used to hold the signal in this position is reduced to a minimum.

The signal lever is not indicated in the reverse position since no safety features are sacrificed should the signal not assume the proceed position upon reversing the controlling lever.

When the lever is placed in the normal indication position, current is cut off the motor and the signal returns by gravity to the stop position, thus causing the gearing and motor armature to revolve backward to their original position. Contact A opens at the beginning of the movement and contact B closes just before the signal reaches the stop position, thus connecting the motor armature and operating field in their original closed circuit in which is included the indication magnet. Because of the acquired momentum of its armature, the motor (now a generator) produces a dynamic current in this circuit, which effects the release of the controlling lever and permits it to be restored to the normal position. The generation of the indication current effectually checks the speed of the returning mechanism and brings it to rest without shock.

In the case of the three-position signal, operation from the zero to the 45 degree position is the same as for a two-position signal. Operation from this point to the 90 degree position is ordinarily dependent upon the signal in advance. The signal is held in the 90 degree position through the medium of the holding fields in the same manner as in the 45 degree position. When the signal is returning from the 90 degree position and is to be held at the

45 degree position, its movement is arrested at that point by short circuiting a "snubbing" winding on the motor described in Chapter XII—Semaphore Signals, which causes current to flow in this winding, thereby bringing the mechanism to rest. The signal is retained in this position by current flowing through the retaining fields of the motor, as previously explained.

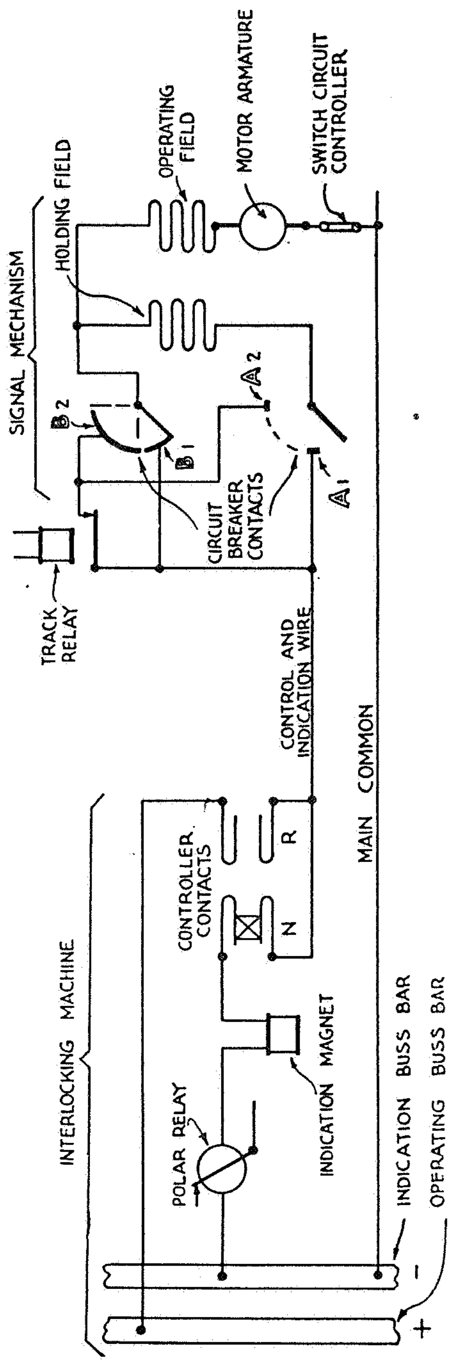


Fig. 12
Circuits for Control of Semi-Automatic Motor-Driven Signal.

Semi-automatic signal control.

When it is desired to have the signal controlled semi-automatically the operation differs from that previously described in that the first 40 degree movement of the mechanism from the normal position does not effect the position of the semaphore arm, but puts under tension a set of coil springs which are strong enough to rotate the motor on the return movement with sufficient speed to generate the current for energizing the indication magnet on the lever. This preliminary movement of the mechanism is always under the control of the operating lever irrespective of whether the track circuit is occupied or not, the receipt of the indication therefore not requiring the restoration of the lever to the normal position simultaneously with the entrance of a train into the controlling track section. Any movement of the mechanism beyond this point, however, is dependent upon the track circuit or circuits being unoccupied.

Referring to the circuit for a two-position semi-automatic signal, shown in Fig. 12, it will be seen that upon reversing the controlling lever current is taken from the positive bus bar through the lever contacts, the control wire, the signal motor operating field and armature, to common return wire. This causes the operation of the mechanism through its preliminary 40 degree movement to the zero degree position at which point the mechanism will be held against the tension of the coil springs in the event of the track circuit being occupied; this is accomplished by circuit breaker contact B_1 opening and A_1 closing which connects the holding fields in series with the operating fields and armature of the signal motor. Should the track circuit be unoccupied, the mechanism will not stop at this point but will continue its movement, current being taken through the track relay contact and circuit breaker contact B_2; the movement of the mechanism from the zero degree position on, carries the semaphore arm with it to the proceed position. Just before reaching the proceed position, circuit breaker contact B_2 opens and A_2 closes, again connecting the holding field in series with the operating field and armature, thereby retaining the signal mechanism and semaphore arm in that position.

Upon the entrance of a train into the track section controlling the signal, the track relay is de-energized, cutting current off the motor which causes the semaphore arm and mechanism to return to the zero degree position. The speed of the returning mechanism is checked at this point by "snubbing" the motor in the same manner as at the 45 degree position of the non-automatic mechanism. Circuit breaker contact A_1 closes, thereby retaining the mechanism in the zero degree position during such time as its lever may be reversed. Sometimes the control is so arranged that a second clearing of the semaphore arm can be secured only after the mechanism has been returned to its minus (—) 40 degree position. When the lever is moved to the normal indication position current is cut off the motor, and the mechanism, because of the tension of the coil springs, is driven to its minus (—) 40 degree position; just before reaching this position circuit breaker contact B_1 closes, thus connecting the motor armature and operating field into a closed circuit in which is included the indication magnet. Because of the momentum of the motor armature acquired during this movement, the motor (now a generator) builds up the dynamic current necessary to energize the indication magnet and release the lever, permitting it to be restored to its normal position.

Should the controlling lever be placed in the normal indication position before the entrance of a train into the controlling track section, the semaphore arm and mechanism return to the zero degree or stop position, and the mechanism continues its rotation to the minus (—) 40 degree position because of the action of the indication springs. When within a few degrees of the end of its travel, the dynamic indication for the release of the controlling lever is generated as previously described.

It will be seen that the operation of the signal mechanism, from the time the semaphore arm begins its movement to the stop position until it returns to that position, is the same as that of the non-automatic signal, the indication springs being in no way depended upon to bring the semaphore arm to the stop position.

Where light type signals are used, the dynamic indication is not required. There are different methods used for indicating the stop position of such signals and they are shown in Chapter XX—Interlocking Circuits.

Type "F" System

Machine.

The interlocking machine used in this system is described in Chapter XVIII —Electro-Pneumatic Interlocking. A cross-section of this type of machine is shown in Fig. 13.

Type "F" switch circuit controller.

As previously stated, the electrical energy for operating the switch machines of this system is carried direct to these units by means of a pair of bus mains which extend throughout the interlocked area. Each switch machine is controlled by a Type "F" controller, sometimes termed a local relay. Switch circuit controllers are operated by current flowing over two wires controlled by suitable circuit controllers operated by an interlocking lever; the wires are used for the exclusive control of switches. A Type "F" direct current switch circuit controller is shown in Fig. 14. It is housed in a cast-iron box mounted on a foundation adjacent to the switch machine, but independent of the track. Therefore, it is not integral with the switch machine 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.

In Fig. 15, the various parts of the direct current 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 polar 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 circuit breaker. The switch motor armature and field are shown by means of standard symbols.

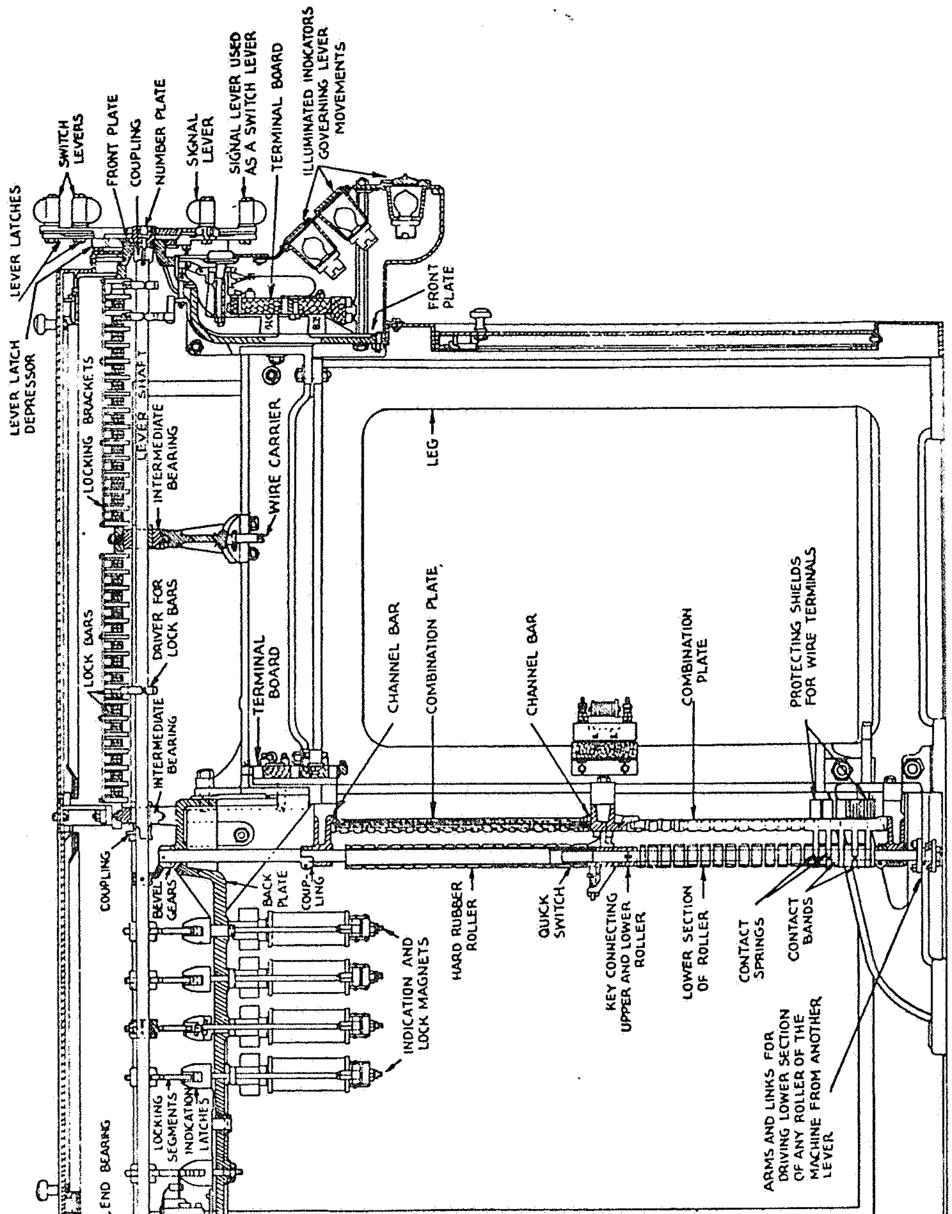


Fig. 13.
Cross-Section of Machine Used in Type "F" System.

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, 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.

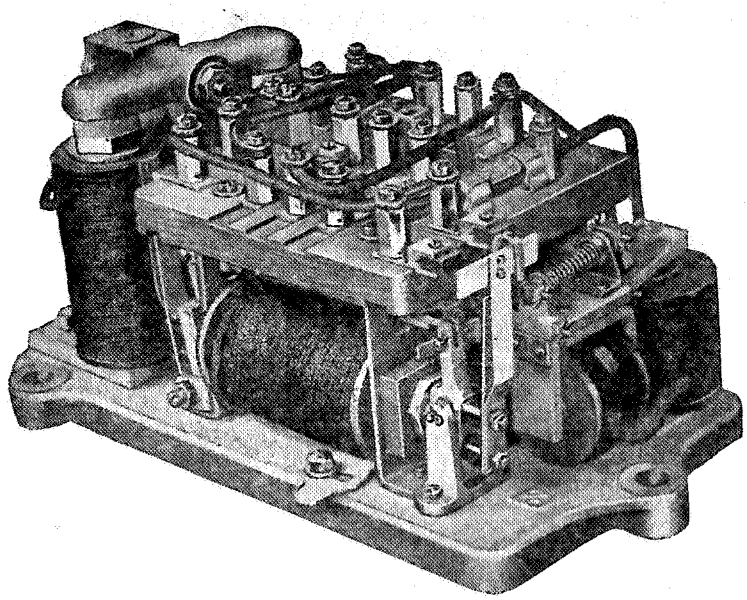


Fig. 14.
Type "F" Direct Current Switch Circuit Controller.

The operation of the controller will be more clearly understood by following a description of what happens when the interlocking switch lever is moved from normal to reverse, and returned to its normal position. When lever L is moved to the reverse indication position, 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.

Current will then flow from wire 1RW through front contact operated by magnet N, wire W6, polar 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 wire but is a separate metallic circuit going out over lever contacts on one wire and returning over the lever contacts over 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 polar 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 polar armature in its extreme operated position to allow it to be locked when the armature of magnet N drops. Current flowing in the direction stated will cause the polar magnet to be energized and shift polar 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 result in its de-energization, and when the armature drops, polar armature P will be locked mechanically in its reverse position with its magnet de-energized. The other two sets of contacts actuated by polar 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 contact Y, wire 1NW3, motor armature, wire 1RW3, circuit controller contact 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 polar magnet P to be de-energized. Thus the energization of these magnets is momentary and the amount of power consumed is negligible. When the switch has completed its movement and is locked mechanically it completes the reverse indication circuit allowing the switch control lever to be moved to the reverse position.

The movement of the switch from reverse to normal is accomplished by moving the lever to the normal indication 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, 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 polar 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 polar 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 moved normal and locked. The controller springs will then be in the same position as shown in Fig. 15.

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 switch is reversed and locked when the contacts are moved to the reverse position. The reason for the motor cut-out circuit controller maintaining both circuits closed in the middle position during the entire movement of the switch is to allow for reversal of the switch by the lever at any time during its movement if desirable, so as to repeatedly attempt to crush snow or ice which might prevent the switch point being moved against the stock rail and locked in that position.

The automatic overload circuit breaker R is worked on very much the same principle as the overload circuit breakers on power switchboards, except that

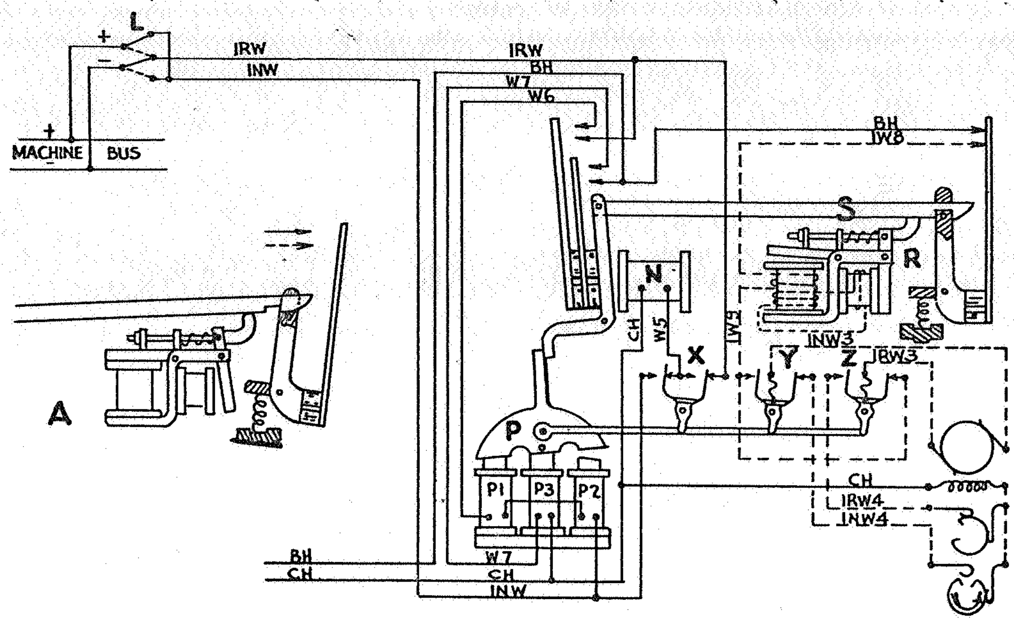


Fig. 15.
Diagram of Circuits for Type "F" Controller for a Single Switch.

it is made with a slow pick-up 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, because of the low resistance of the motor and the fact that the counter electromotive force has not had an opportunity to build up, but as soon as the motor speeds up the counter electromotive force approaches the value of the impressed electromotive force and therefore the current is reduced to what is usually known as the motor operating current.

If an ordinary overload circuit breaker were employed, adjusted to open for a heavy current, the momentary current previously 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 coil an electromotive force generally proportionate to the rapidity of the rise of the current in the motor circuit. This electromotive force 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. 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 the breaker opens 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 is reset for another movement of the switch.

A crossover is wired as two single switch layouts connected in multiple, a Type "F" controller being used for each switch.

SS scheme of control.

The continuous check of the position of all switches over which a signal governs train movements, 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 control. This control is characteristically a part of Type "F" electric interlocking as well as of electro-pneumatic interlocking.

Complete protection requires that in the signal control circuit there shall be some direct check of the position of the switch. This can be secured in either of two ways: looping the signal control wire through circuit controller contacts at the switches or breaking the signal control through contacts on KR relays. The KR relay contacts in conjunction with switch lever contacts insure coincidence in position of the switch and its controlling lever.

Provision may be made by operation of the indication contacts in the switch machines by point detectors so that the switch points must be in proper position and locked when a signal to proceed is displayed.

In the SS scheme of control the signal control wires extend unbroken from the interlocking station to the signal. A ground or cross is then a remote possibility, and even if one should occur there would be but slight chance of its being detrimental. Circuit trouble can be quickly located and corrected. The SS scheme of control allows a concentration of parts vital to this reliable control of signals in the interlocking station where they are protected from the weather and other possible damage and where proper maintenance is encouraged by facilitated inspection.

It will also be noted that, with the SS scheme of control, 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 display a proceed indication.

Also, should a switch be accidentally or maliciously changed in position, any signal cleared for train movement over the switch will display its most restrictive indication.

Switch Indication Circuits

The switch indication circuits are somewhat similar to the polarized switch indication circuits described in Chapter XVIII—Electro-Pneumatic Interlocking. Two types of indication circuits are used, one employing the "quick switch," also explained in Chapter XVIII, and one in which the quick switch is not used. The indication segments used on the switch levers are also the same as those used on the electro-pneumatic machine. Figure 15a shows the indication circuit for a crossover where the quick switch is used. The normal indication starts from battery at the far end of the crossover, through contact 16-17 closed with the switch machine normal, wire 1KR1 to contact 16-17 on near end of crossover, closed with the switch machine normal, wire 1KR2, through coils of KR relay, wire 1KR3, through contact 19-18, closed with switch machine normal, wire 1KR4, through contact 19-18 on far end of crossover closed with switch machine normal, to common return wire. This circuit causes the KR relay to energize and close the right-hand polar contacts, completing the circuit to the normal indication magnet from battery, through a front neutral and normal polarized contact on the KR relay, through contact B on quick switch closed with lever in the normal indication position, through normal indication magnet NM, to common return wire.

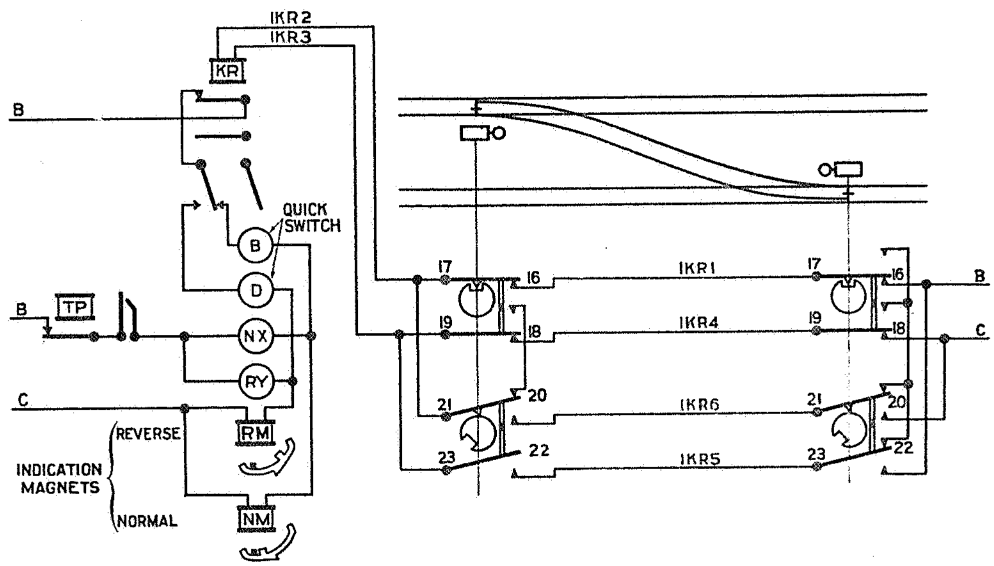


Fig. 15a.
Switch Indication Circuit for Crossover Using Quick Switch.

The reverse indication circuit starts from battery at the far end of crossover through contact 22-23, closed with switch machine reversed, wire 1KR5, through contact 22-23 on near end of crossover closed with switch machine reversed, wire 1KR3, through coils of KR relay, wire 1KR2, through contact 21-20 on near end of switch closed with switch machine reversed, wire 1KR6, through contact 21-20 on far end of switch closed with switch machine reversed, to common return wire. With current flowing through the KR relay in this direction the front neutral contacts and left-hand polar contacts are closed, completing a circuit from battery, through a front neutral and reverse polar contact, through contact D on quick switch closed with lever in reverse indication position, through reverse indication magnet RM, to common return wire.

It will be noted there are two additional contacts in the indication circuit controller on each end of the crossover. The purpose of these is to provide a shunt on the coils of the KR relay while the switch is moving from normal to reverse, or vice versa, to further insure that the KR relay is de-energized while the switch is moving. With switch machine operating from normal to reverse position, contact 19-18 on near end of crossover will close the contact now shown open as soon as the switch is unlocked. This applies the shunt on the KR relay from wire 1KR3, contact 19-18, contact 20-21 which is still closed, to wire 1KR2.

When the switch machine has operated to the opposite position and is locked, contact 20-21 will operate, opening the shunt contact and closing the reverse indication contact so that the KR relay will become energized in the reverse position, allowing the reverse indication magnet to be energized and the lever stroke completed.

The shunt is also applied on the far end of the crossover in about the same manner as previously described.

A turnout or single switch is wired the same as the near end of the crossover, battery being applied in place of wires 1KR1 and 1KR5, and common being applied in place of wires 1KR4 and 1KR6. The remainder of the circuit is the same as shown for the crossover.

Figure 15b illustrates the circuit arrangement for a crossover where the quick switch is not used. It will be noted that the main change in the circuit

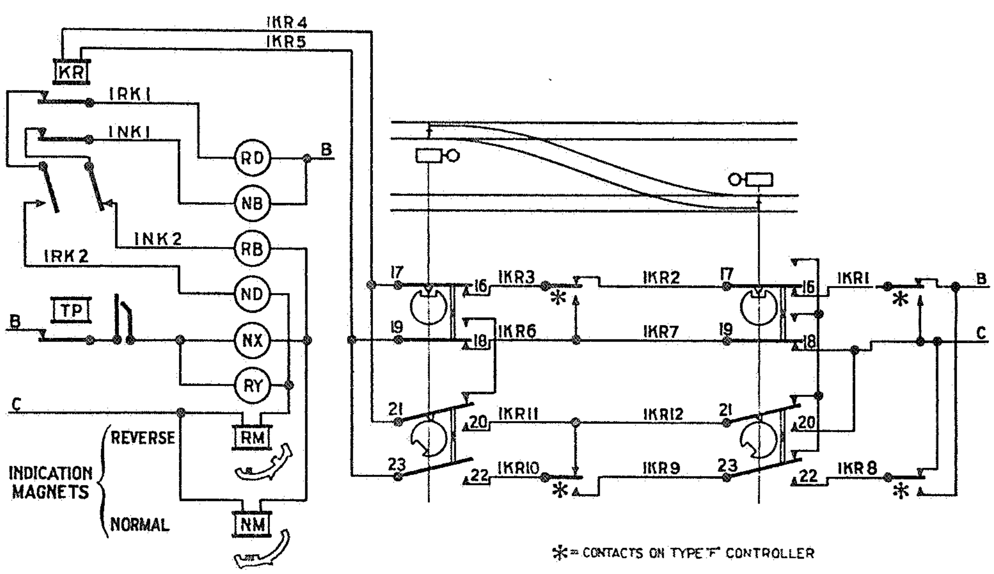


Fig. 15b.
Switch Indication Circuit for Crossover without Quick Switch.

outside the interlocking station is the inclusion of a checking contact in the Type "F" controller, which insures that the controlling device and the switch machine are in corresponding position before the indication can be received.

The circuit as illustrated in Fig. 15b shows the Type "F" controller contact closed in normal position. The contact shown open is closed when the controller is in the reverse position.

The indication circuit in the interlocking station is somewhat different from that using the quick switch. The normal indication takes battery through an NB contact on the switch lever, wire 1NK1, through a front neutral and normal polar contact on KR relay, wire 1NK2 to an RB contact on lever to normal indication magnet NM, to common return wire. The reverse indication takes battery through an RD contact on the switch lever, wire 1RK1, through a front neutral and reverse polar contact on KR relay, wire 1RK2, to an ND contact on lever to the reverse indication magnet RM, to common return wire.

A single switch is wired the same as the near end of the crossover, battery being applied to the terminals as shown in place of wires 1KR2 and 1KR9, common being applied in place of wires 1KR7 and 1KR12, the remainder of the circuit being the same as for the crossover.

By eliminating the quick switch and installing the checking contacts in the Type "F" controller, it is not necessary to complete the stroke of the lever to normal or reverse position before returning it to its original position. In other words, if the lever is moved from normal to reverse indication position and the switch does not indicate, the lever can be returned to the normal indication position and if the switch locks in the normal position the lever can be returned to normal position, whereas with a quick switch it would be necessary to place the lever in reverse position so that the quick switch could operate and close the normal indication circuit ready for the next operation of the lever, as explained in Chapter XVIII—Electro-Pneumatic Interlocking.

Cross-protection.

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 in providing cross-protection; the use of individual polarized 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 indication 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 indication relay at the interlocking machine adapted so as to control jointly the current supply to both the indication magnets of a switch lever and all signals governing traffic over the switch or switches operated by the lever. Cross-protection is inherent in the circuits employed and does not require the use of cross-protection devices.

A Type "F" alternating current switch circuit controller is shown in Fig. 16. It is similar to the direct current type except that it is normally energized

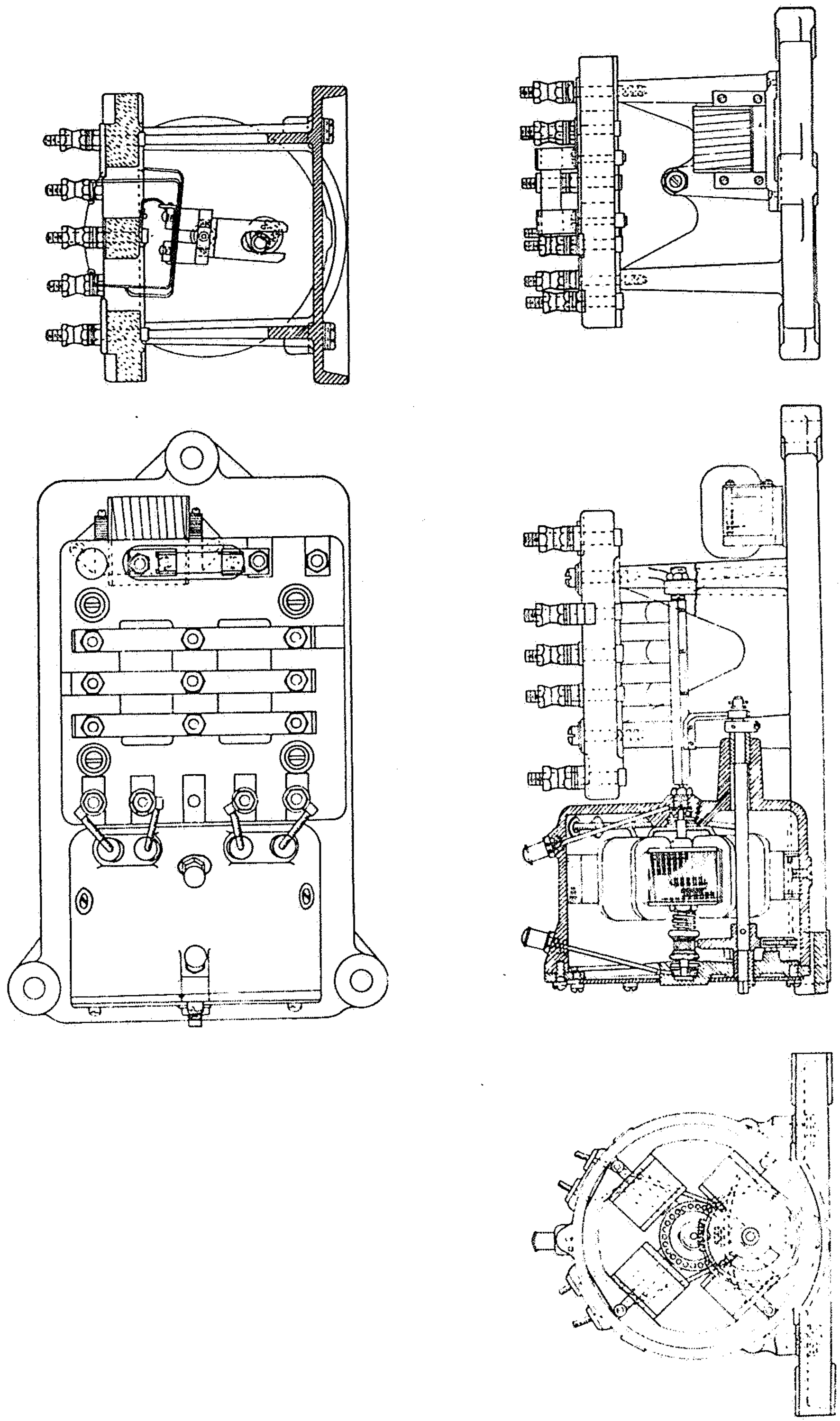


Fig. 16.
Type "F" Alternating Current Switch Circuit Controller.

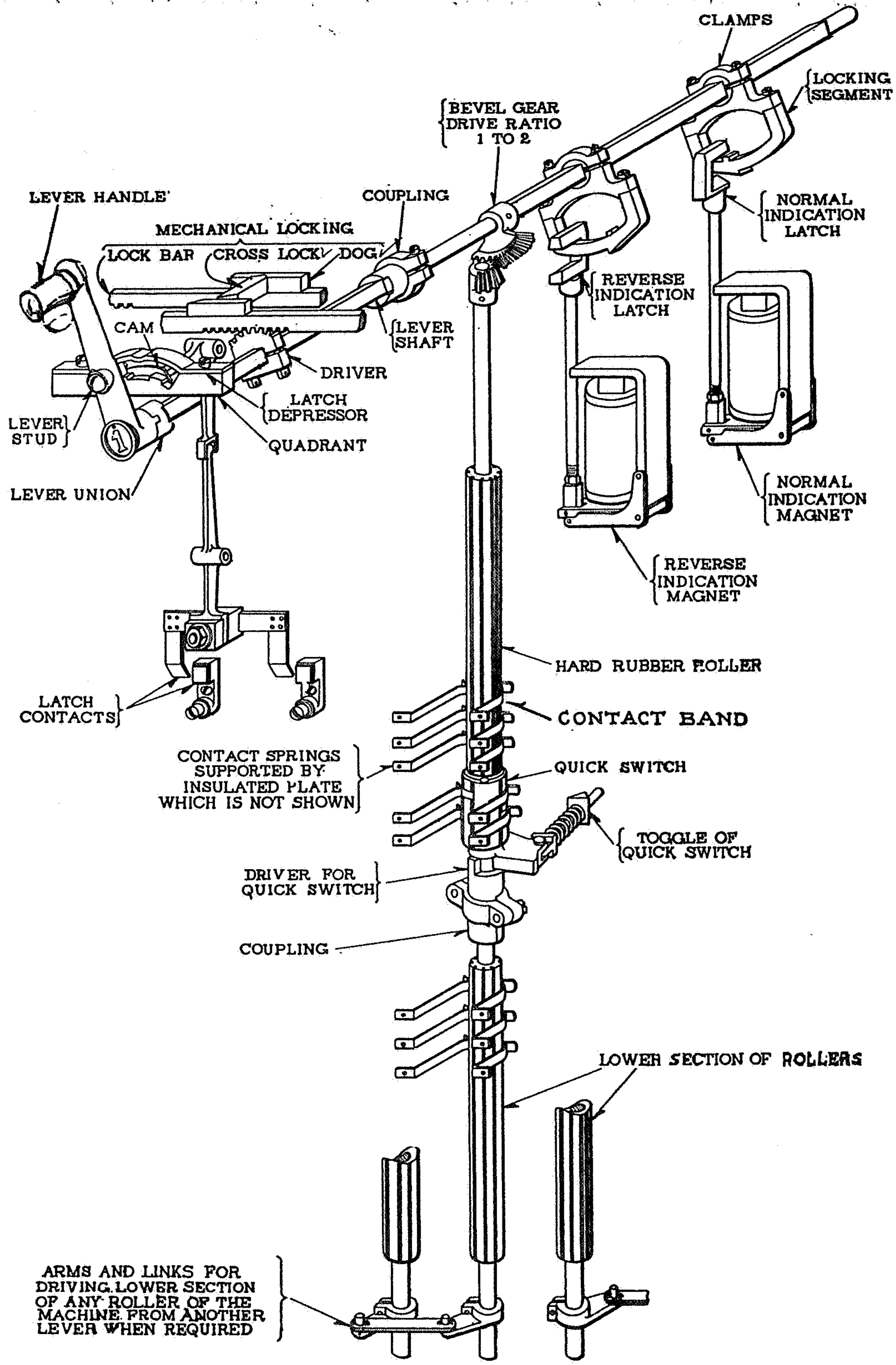


Fig. 17.
Perspective Diagram of Switch Lever, Complete.

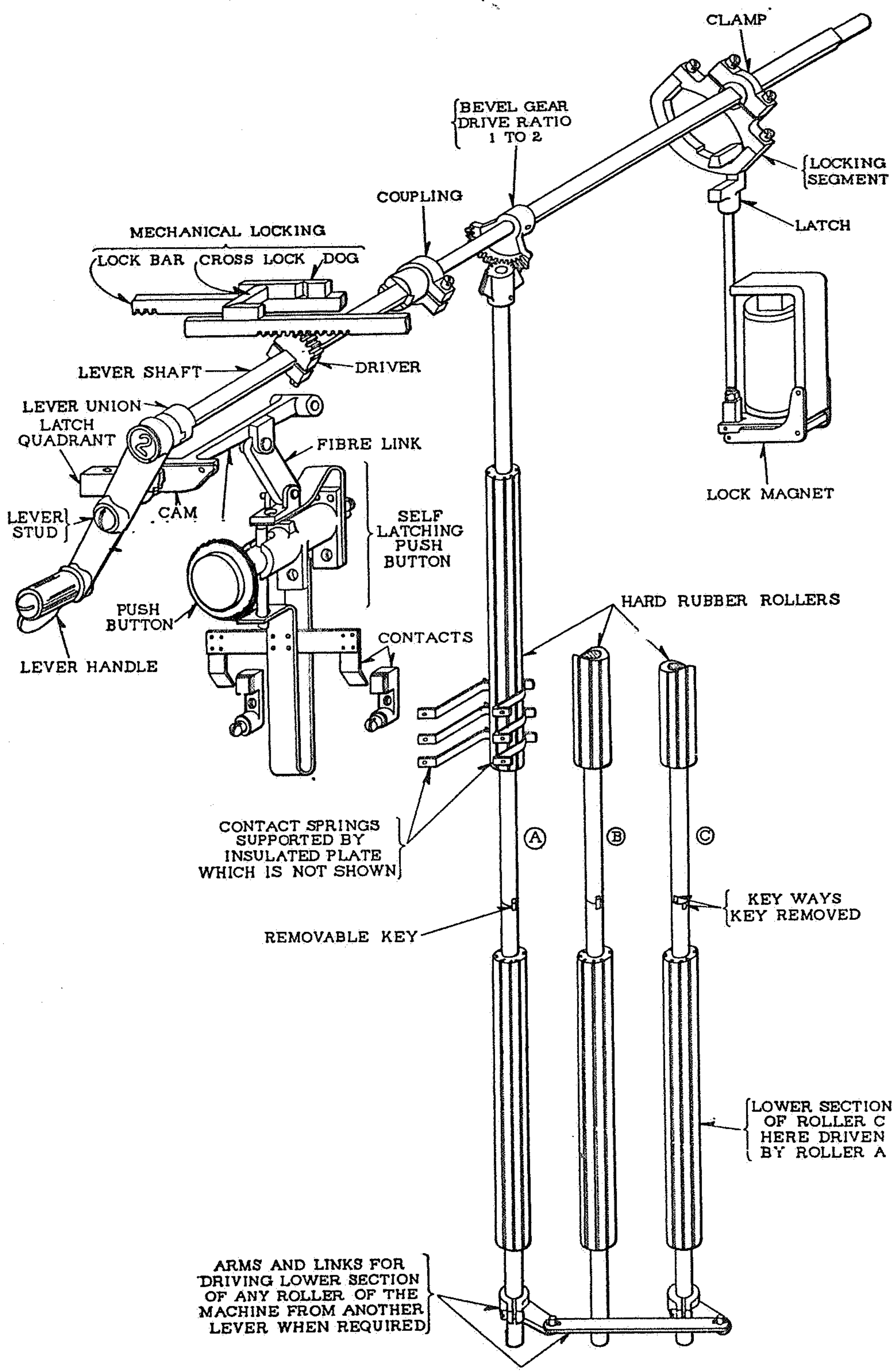


Fig. 18.
Perspective Diagram of Signal Lever, Complete.

and does not have an automatic circuit breaker. Any overload on the switch machine is taken care of by a fusible link cut out in the motor circuit. The contacts of this controller are operated by a salient pole induction motor, the stator of which has four coils, each pair of opposite coils being connected in series. One pair of coils constitutes the local element and is connected to local alternating current energy at the switch through a series reactor. The other pair of coils constitute the control element and are energized from the pole changing contacts on the switch lever in the interlocking machine through a series reactor. When the switch lever in the interlocking machine is moved to the opposite position, it causes a change in the relative polarity of the two windings on the stator and causes the rotor to rotate and thereby moves the contacts of the controller to the opposite position and operates the motor of the switch machine. The torque of the rotor is great enough to insure sufficient contact pressure on the controller contacts. The controller is so designed that once it has been moved to either energized position, a toggle action in conjunction with the contact spring pressure will hold the contacts closed without depending on the energization of the controller windings. In this way a switch restoring circuit is maintained even though the control circuit or the local circuit of the controller should become open.

An earlier type of this alternating current switch circuit controller, known as the shuttle type, was operated by a motor consisting of a bi-polar laminated field magnet with a coil and wire wound shuttle type rotor. The winding

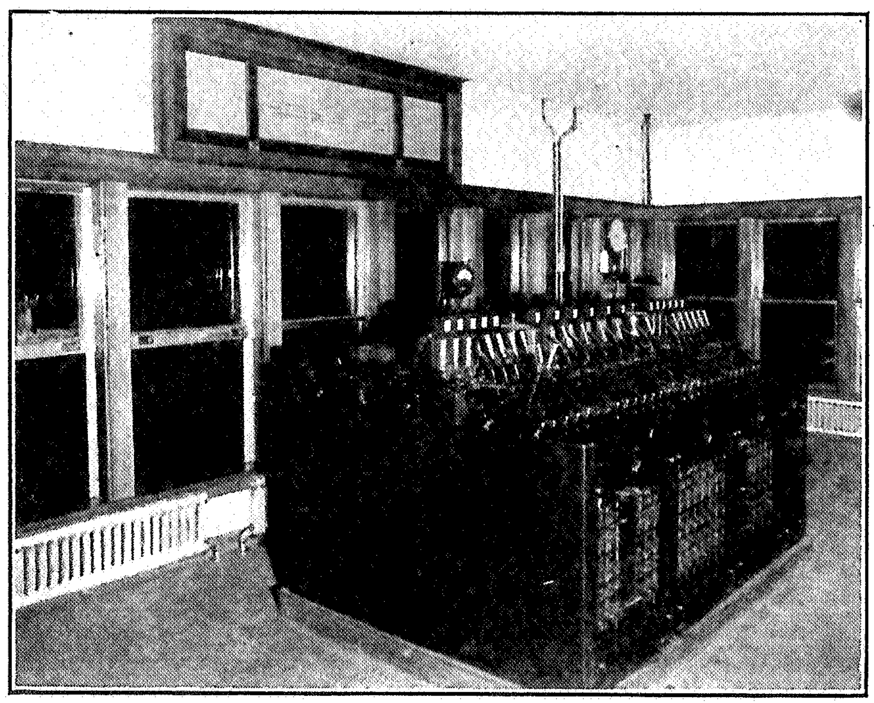


Fig. 19.
Type 341 Machine.

of the rotor was permanently connected to the alternating current mains and the coil on the field was connected to the pole changing contacts of the switch lever.

Switch and signal levers.

Figure 17 shows a perspective diagram of a complete switch lever, and Fig. 18 shows a signal lever. Both of these, as well as their operation, are described in detail in Chapter XVIII—Electro-Pneumatic Interlocking.

Type 341 System

Type 341 electric interlocking is similar to the electric dynamic indication system, the dynamic indication being augmented by a battery indication. The machine used in this type of interlocking is shown in Fig. 19.

Machine.

A cross-section of this type of interlocking machine is shown in Fig. 20.

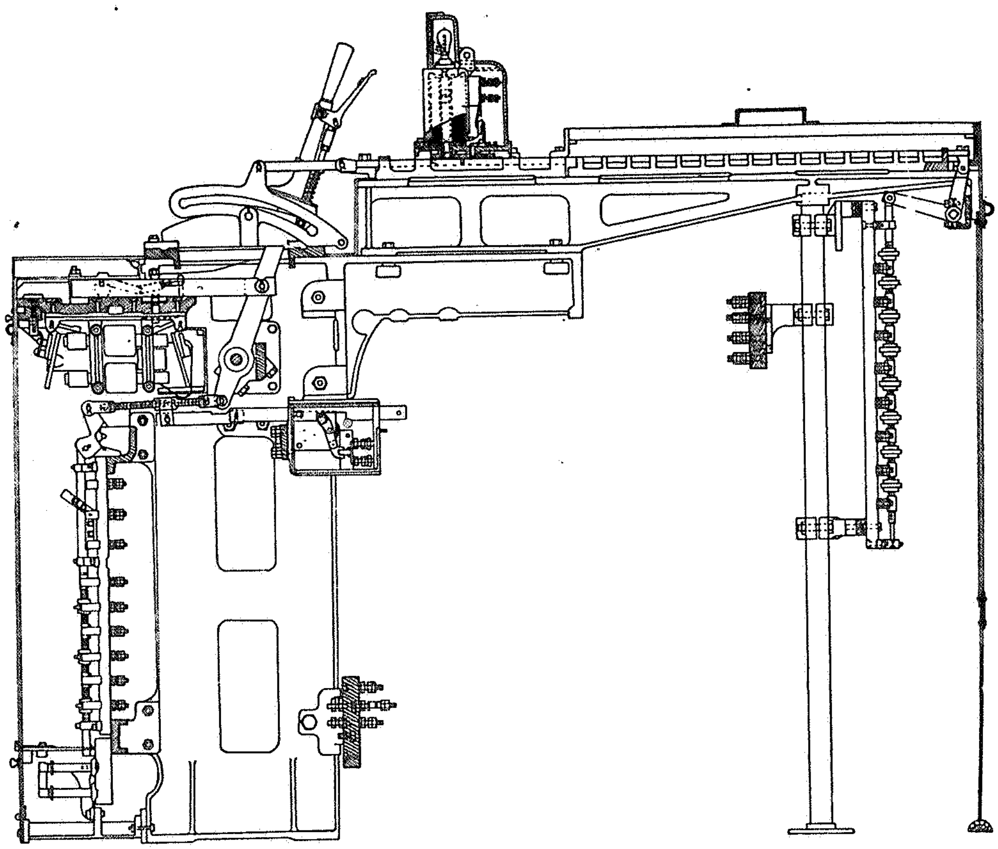


Fig. 20.
Cross-Section of Type 341 Machine.

It will be noted that the levers are miniature improved Saxby and Farmer, and that the rocker link is connected directly to the locking tappet in the locking bed, which is mounted in the top of the machine back of the levers. Between the lever and the locking bed are the electric locks which engage the locking tappet, preventing the lever latch being raised unless the electric lock is energized. The low-voltage circuit controllers are mounted at the back of the machine and operated by a crank from an extension of the locking tappet. The high-voltage circuit controllers are mounted in the front of the machine and operated from a crank connected to an extension of the machine lever. Immediately over the high-voltage circuit controllers and in front of the levers are the indication and safety magnets and the indication slide directly attached to the lever. The indication slide or magnet may be removed from the machine without disturbing adjacent units.

Operation of switch and signal levers.

Figure 21 shows the wiring between the levers and outside units for a single switch, a two-position non-automatic signal, and a three-position semi-automatic signal.

In the switch lever shown in Fig. 21, magnets D, N and I are all assembled to the same frame or structure. The armature at the right-hand end is employed to release the indication dog, while armature XPA, when attracted, opens the safety circuit which holds the main circuit breaker on the operating switchboard in the closed position. This main circuit breaker, when open, cuts off both positive and negative battery from the entire plant. Magnet N is a low-resistance magnet of 0.06 ohm and connected permanently in series with common return wire WC; the other terminal of magnet N is connected to negative bus WCH. Magnet D is also connected on one side to negative bus WCH and its other terminal to terminals 1 and 4 of the double pole knife switch which is operated by the lever. Magnet D has considerably more turns than magnet N but is substantially a magnet of low resistance, the ohmic value of which is approximately 0.37 ohm. Magnet I has a resistance of approximately 360 ohms and is connected to contact 5 of the lever, which contact is closed only when the lever is in the operating position and open when lever is in the normal or reverse position.

The condition for the attraction of the indication armature is for current to flow through magnet I from contact 9 controlled by the locking plunger of the switch movement simultaneously with a snubbing current, through magnet D generated by the armature of the switch machine coming from the next or idle control wire just as the switch has completed its operation. When such snubbing current flows through magnet D from the next control wire it will return to the switch motor armature, through magnet N and over wire WC. Such a flow of current through D and N simultaneously will not move armature XPA. If, however, indication wire WM has been energized at such a time both magnets D and I will be energized, with the result that the indication armature will be attracted, thereby releasing the lever.

Referring to the switch machine, the two windings, marked 300 ohms, are magnets connected respectively to the normal and reverse wires so that the

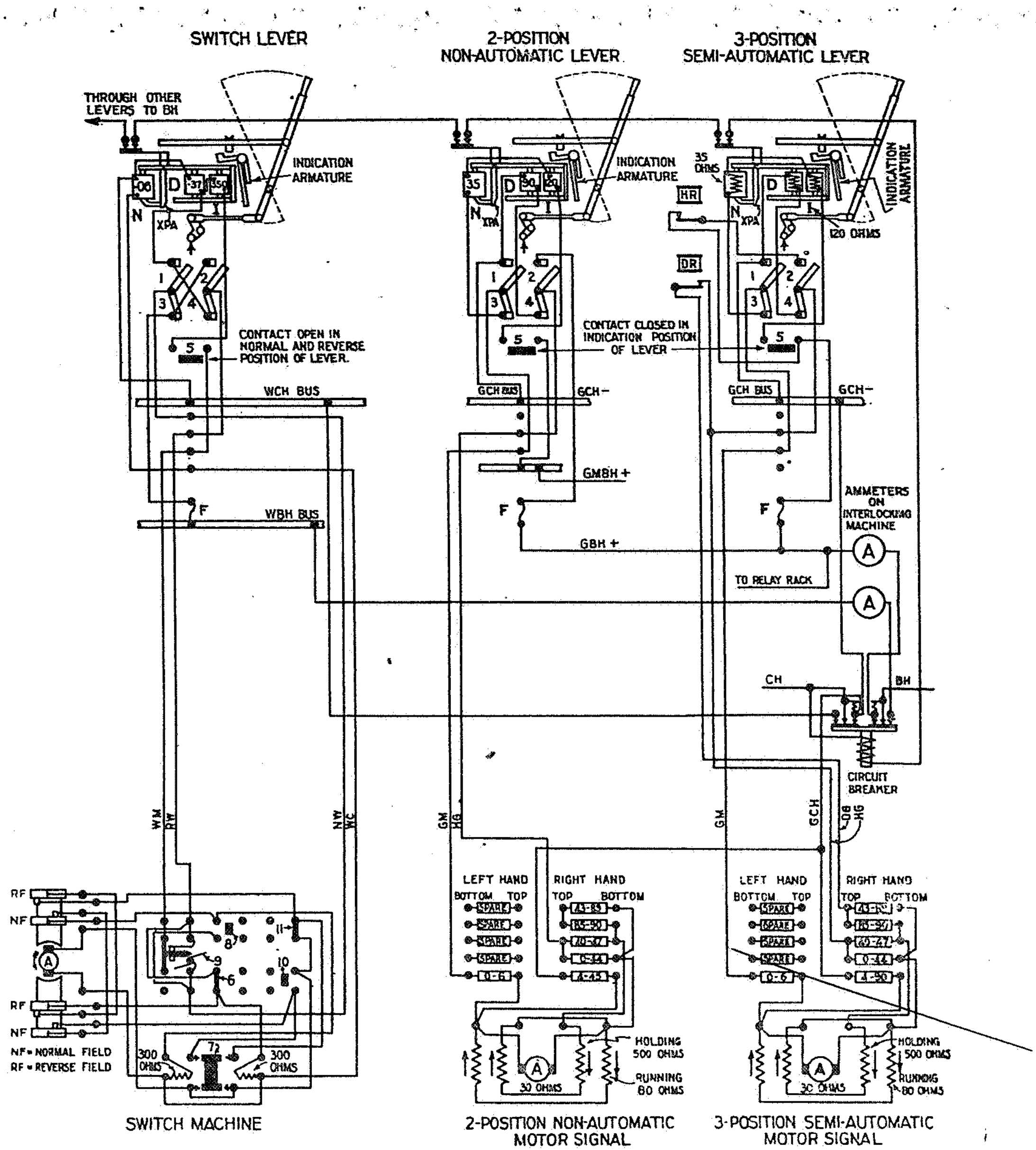


Fig. 21.
Diagram of Circuits for Type 341 System.

position of switch 7 may be controlled in accordance with the reversal of the lever in the intermediate positions of the switch machine.

This system of switch control requires an individual common return wire, WC, two control wires, NW and RW, and an indication wire, WM, for each switch.

Switch cross-protection.

When the lever has been placed in either the normal or reverse position, it will be observed that a cross between the positive bus or any wire connected to WBH, to the NW or the RW wire, will find a low-resistance path to negative bus WCH, over wire RW (or NW, depending on the position of the lever), to switch blade 4, through magnet D, to bus WCH. This current will not energize the indication armature but will attract armature XPA and cause the main circuit breaker to open, disconnecting all energy from the interlocking machine.

Switch operation.

The complete operation of a switch is as follows: assume that the switch lever, Fig. 21, is moved toward the reverse position indicated by the dotted line when contacts 1 and 2 of the double pole knife switch will close and contacts 3 and 4 will open. Indication contact 5 will close, thus connecting wire WM to magnet I. Current will now flow from positive bus WBH, through fuse F, to contact 2 of knife switch, over wire RW, to the reverse field coil RF of switch motor, through operating contact 6, to magnet controlled contact 7, to armature A, to wire WC, to magnet N, to negative bus WCH. At the same time current will flow through right-hand magnet at the switch machine, marked 300 ohms, to negative WCH holding contact 7 closed. Switch will start to move toward the reverse position, contact 8 closes, and, as the movement unlocks, contact plunger 9 is withdrawn, which disconnects wire WM from wire NW. As the movement reaches its reverse and locked position, contact plunger 9 will connect wire RW to wire WM. This will energize magnet I through lever contact 5, but such energization will not attract the indication armature since there is no appreciable current flowing through magnet D as yet. The core of magnet I will provide flux, which will circulate through the core of magnet D and through the leakage strip provided between the pole pieces of the structure and the indication armature. Since the cross-section or area of the core of magnet D is larger than the core of magnet I, it will act as a magnetic shunt and prevent magnet I from attracting the indication armature. The core of magnet I and the magnetic structure are so proportioned that at 90 volts the core is saturated; therefore, at higher voltages there will be no increase in the attracting power of magnet I. When the switch machine has reached its reverse position and locked, contact 6 will open and contact 10 connects motor armature A to normal field NF, and the dynamic current generated by the free run of the motor will flow over normal wire NW to contact 1 of knife switch, to magnet D, to the terminal of magnet N and over wire WC to opposite side of motor armature A. This current through D now reverses the flux in the core of magnet D and provides sufficient magnetization to attract indication armature thereby unlocking lever slide and allowing lever to be moved to the reverse position.

Signal operation.

The complete operation of a non-automatic signal is as follows: assume that signal lever marked 2-position non-automatic signal, Fig. 21, is moved to the reverse position indicated by dotted line; contacts 1 and 2 of the double pole knife switch will close and contacts 3 and 4 will open. Indication contact 5 will pass through and disengage its contacts since no reverse indication is necessary for a signal. Current will flow from positive bus GBH, through fuse F, to contact 2 of knife switch, over wire HG, through contact 0-44 of signal circuit controller, through the motor, to contact 0-6, to GM wire, to contact 1 of the lever knife switch, and to negative signal bus GCH. The signal will operate from the stop position until contact 4-45 closes, after which and beyond 6 degrees the signal will operate with the motor connected to negative GCH at the signal instead of at the lever.

It will be noted that the signal starts and moves to 4 degrees from the stop position with the operating current flowing back to the lever, over wire GM, to signal negative GCH. For positions above 4 degrees, the current will flow from the motor to the signal negative bus GCH at the signal. The indication and cross-protection device applied to a signal lever is the same as that described for a switch lever, except that magnets N and D are of a higher resistance, as shown in Fig. 21, and are arranged to indicate when all are in series. Magnet D alone controls the cross-protection armature XPA.

With the signal in the clear position and the lever moved toward the indication position, contacts 3 and 4 of knife switch, and contact 5, will close. As the signal moves toward the stop position, at 6 degrees therefrom, current will flow from positive bus GMBH through contact 5, to magnet I, to magnet N, to contact 3 of knife switch, to wire GM, and while contact 4-45 on the signal is still closed current will flow to GCH at the signal. This will not attract indication armature until contact 4-45 opens, leaving contact 0-6 closed; then this current will be diverted from wire GCH at the signal, through the motor, through contact 0-44 to the HG wire, to contact 4 of knife switch, to magnet D, to negative GCH at the machine. This will energize magnet D in combination with magnets N and I. Upon acceptance of the indication by moving the lever to the normal position, contact 5 will open, leaving the HG wire connected, through magnet D alone, to negative GCH.

The operation of a semi-automatic two or three position signal is identical in its operation and indication with the non-automatic signal, except that the application of operating energy to the HG or DG wire is controlled through contacts of relays for the 45 and 90 degree positions of the signal.

Signal cross-protection.

Since the indication is dependent upon the signal being disconnected from wire GCH at the signal and connected to GCH at the machine through wire GM and magnet D, it will be apparent that to move the signal from the stop position by means of a cross or ground, two such crosses or grounds of proper polarity would be necessary, even though cross-protection magnet D was not employed. Since wires HG and GM are not connected directly to positive or negative energy at the interlocking machine, two crosses, positive energy to wire HG and negative to wire GM would be necessary to clear the signal even if no protective devices were employed. Magnet D is a positive operating element necessary for the functioning of the indication armature and is checked as to its adequacy to perform its intended function at each operation of the lever to the normal position.

Should positive energy be connected improperly in any way to either HG or GM wire while the lever is in the normal position, current will flow to negative GCH through magnet D alone, which will cause magnet D to attract armature XPA and thus cause the main circuit breaker to open, disconnecting all energy from the machine.

Table Machine

The table interlocking machine is used for the control and operation of electric interlocking plants. It, generally, is used for controlling a small number of units at locations where the space available for the control machine is limited. As the name implies, it is a small interlocking machine that may be placed on a desk or table and is composed of one or more assemblies approximately 6½ inches wide, mounted side by side and the levers interlocked, if required.

Generally, each assembly comprises the following apparatus in addition to the lever: one circuit controller usually with ten contacts, one forced drop electric lock, and four indicators.

When more than one assembly is used, they are mounted on sub-bases and the bases bolted together.

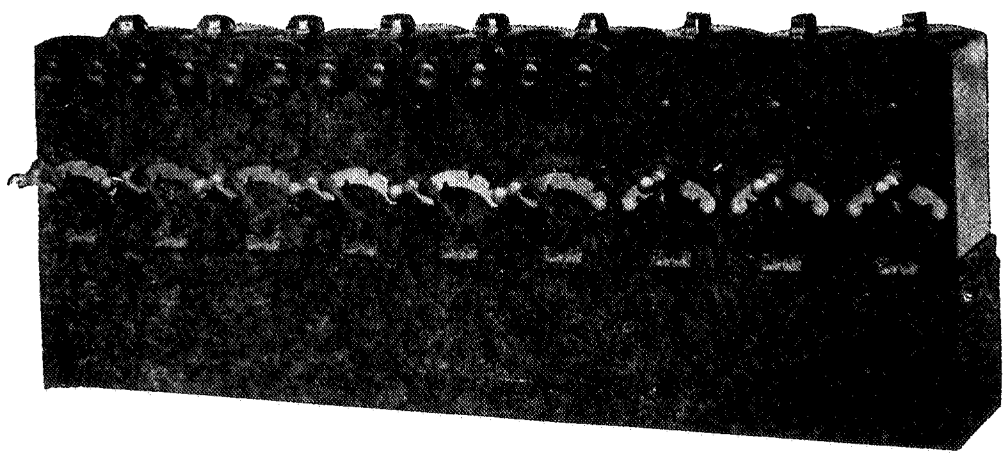


Fig. 22.
Table Machine with Nine Units, Light Type Indicators and Vertical Locking Bed.

Locking.

The locking is miniature Saxby and Farmer which is described in Chapter XVI—Interlocking. In the earlier types, the locking was placed in the sub-bases. In later types the locking is in an extension of the sub-bases located in front of the machine, as shown in Fig. 23, or in a vertical position, as shown in Fig. 22.

Lever.

The switch and signal levers operate in practically the same manner as those of the electro-pneumatic interlocking machine described in Chapter XVIII—Electro-Pneumatic Interlocking.

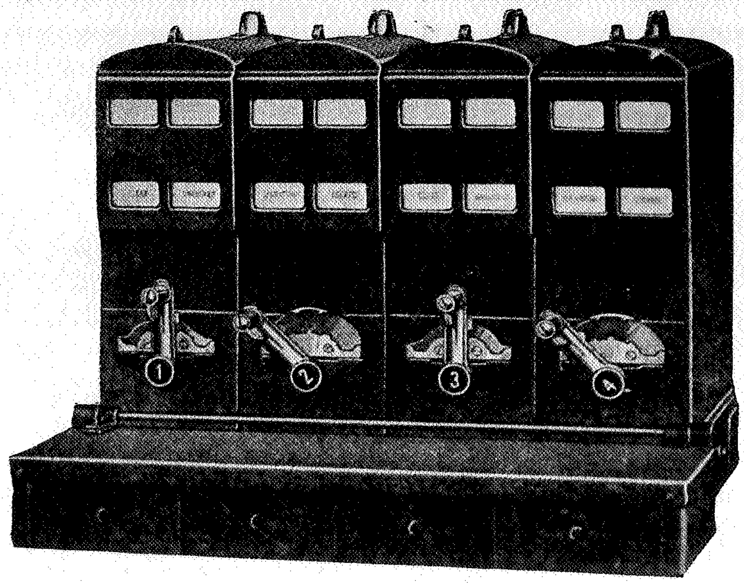


Fig. 23.
Table Machine with Four Units, Magnetic Type Indicator and Extended Locking Bed.

As shown in Fig. 24, a locking segment 32 is attached to the lever handle. These segments may be provided so that latch 41 of the electric lock may lock either switch or signal levers in any position desired. Locking shaft 3 is driven from the segment by a connecting link 7.

The circuit controllers are equipped with contacts which may be adjusted to open or close at any desired position of the lever stroke. An auxiliary circuit controller may be added to any assembly when required to increase the number of contacts, and is mounted below the unit as shown in Fig. 24. Each assembly may be equipped with four indicators for conveying information to the operator, as shown in Fig. 23. When these are of the magnetic type they are usually lettered to convey the information desired, such as "normal" and "reverse" on switch lever assemblies and the other two spaces sometimes used to show track occupied or unoccupied to indicate that the switch lever is free to be moved. On signal levers indicators are usually lettered "stop" and "clear." Other spaces are used for annunciators, etc.

Indicators are sometimes operated mechanically from the armature of the electric lock and marked "locked" and "unlocked." Lamps are sometimes used instead of the magnetic type indicators as shown on the machine in Fig. 22.

As previously mentioned, units of the electric dynamic indication system are sometimes controlled from table interlocking machines. Figure 25 shows a machine of this type.

Interlocking system controlled by centralized traffic control type machine.

Interlocking systems are sometimes controlled by a machine of the centralized traffic control type having no mechanical locking between the levers or their equivalent. The proper sequence of the operation of the signal and interlocking units is obtained by the use of relays which provide control only when the conditions for their operation are correct.

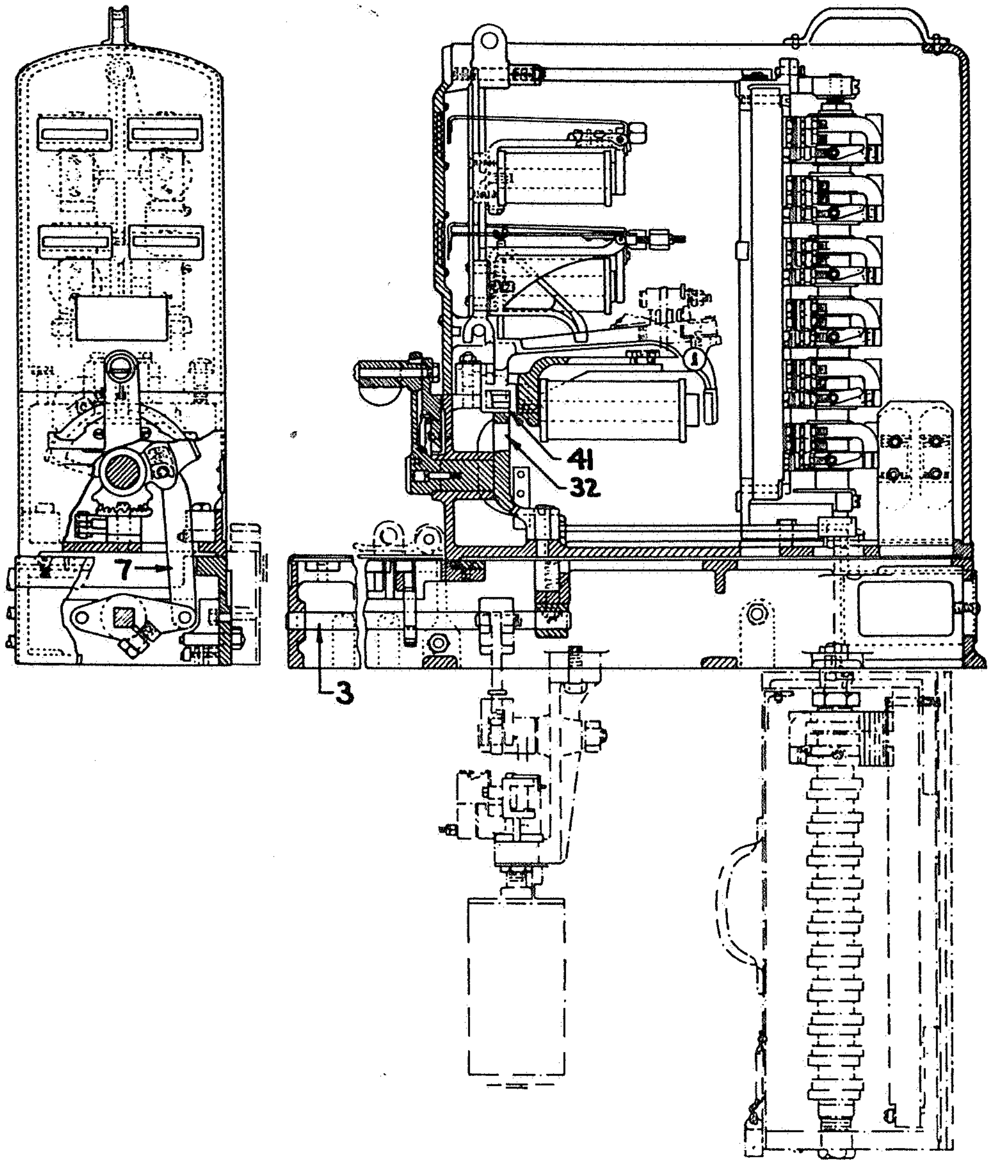


Fig. 24.
Cross-Section of Table Machine.

This type of control machine is generally employed when it is to be operated by a person who has other duties to perform and speed of operation is essential. Machines of this type are shown in Figs. 26 and 27.

A machine of this type may be operated by a person seated and the complete route set up without waiting for the units to operate. Circuits covering this type of interlocking are described in Chapter XX—Interlocking Circuits. A detailed description of the control machine will be found in Chapter IV—Centralized Traffic Control.

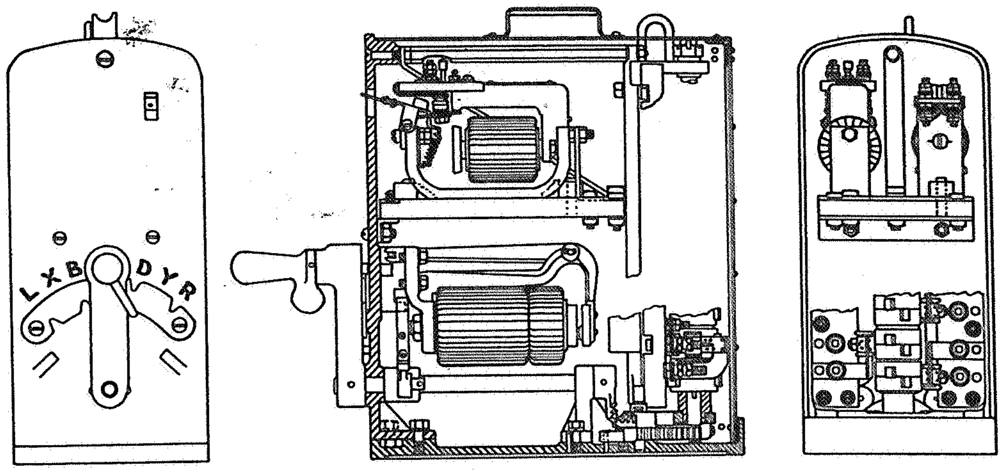


Fig. 25.
Table Machine Equipped with Polar Relay and Indication Selector for Controlling Units Employing Dynamic Indication.

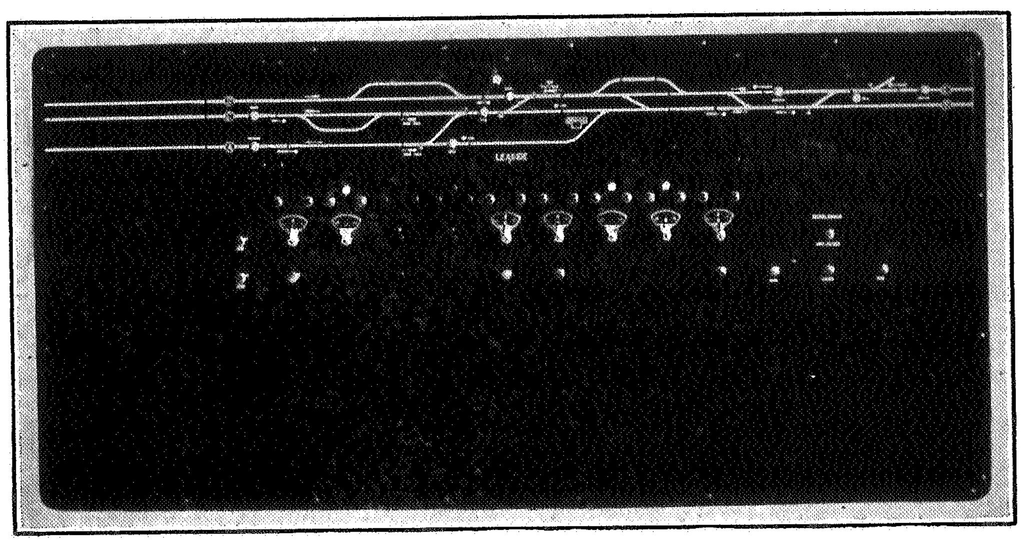


Fig. 26.
Centralized Traffic Control Type Machine.

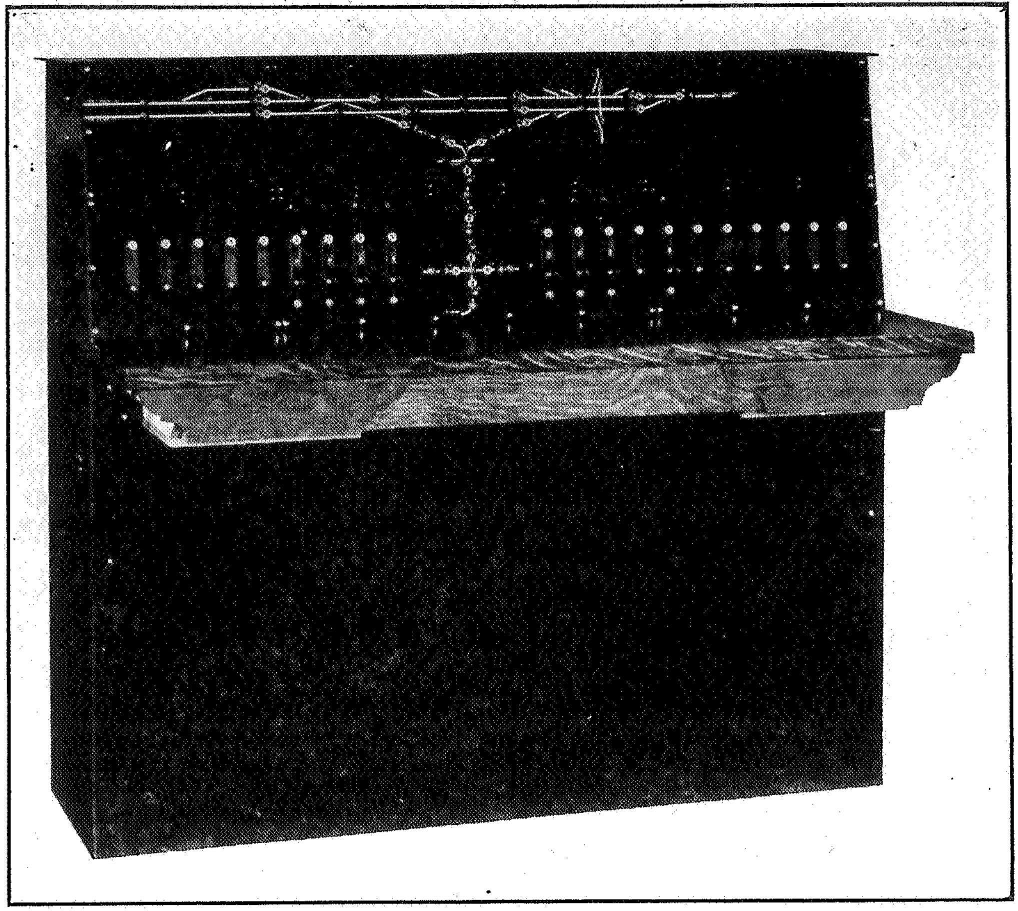


Fig. 27.
Centralized Traffic Control Type Machine.

Automatic Interlocking

The Signal Section, A.R.A. defines Automatic Interlocking as: An arrangement of signals at railroad grade crossings which function through the exercise of inherent power as distinguished from those whose functions are controlled manually.

An automatic interlocking is operated through the medium of track circuits upon the approach of a train. Referring to Fig. 28 and assuming that no trains are within the limits of the interlocking on either road, a train entering upon track circuit E will automatically clear the route for movement of this train over the crossing, and home signal 3 and approach signal 4 will indicate "proceed." Before these two signals display the "proceed" indication, home signals 6 and 7 on the crossing line must be in the stop position and approach signals 5 and 8 in the approach position. Therefore, should a train approach on the crossing line at this time, it will not receive signals to proceed over the crossing until the train which has entered track circuit E has passed over the crossing and cleared track circuit C, or in other words, has passed beyond the opposing home signal 2 on that line.

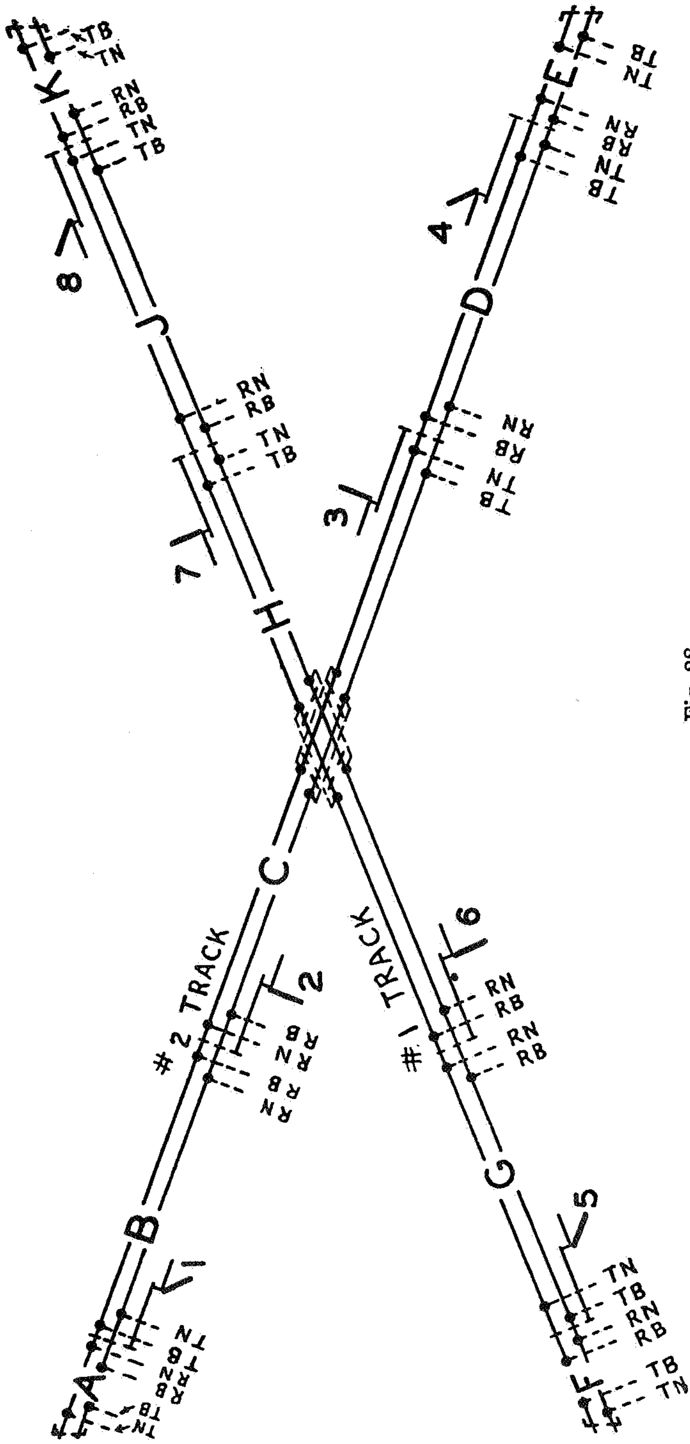


Fig. 28.
Diagram of Automatic Interlocking Layout.

Provision is generally made at automatic interlockings whereby a train which may be stopped at a home signal on one line due to a train standing on the approach circuit of the crossing line and not ready to proceed over the crossing, may send a trainman to the crossing and by operating a device, cause the signals already cleared for the standing train to assume the stop position and thereby allow those for the second train to assume a proceed position. A time interval is sometimes imposed in the circuits of the signals. In other cases, a trainman proceeds to the crossing and opens a switch which disconnects all energy from the system and then by the use of hand signals advances the train over the crossing. Many other devices are used at automatic interlockings to suit the track layout involved. Detail circuits for an automatic interlocking are described in Chapter XX—Interlocking Circuits.

Switch-and-Lock Movement

There are many types of switch-and-lock movements used in electric interlocking.

The Signal Section, A.R.A. defines Switch-and-Lock Movement as: A device, the complete movement of which performs the three operations of unlocking, operating and locking a switch, movable point frog, or derail.

Model 2 switch machine.

This is one of the earliest types of electric switch-and-lock movements and is illustrated in Fig. 29. It operates on 110 volts direct current.

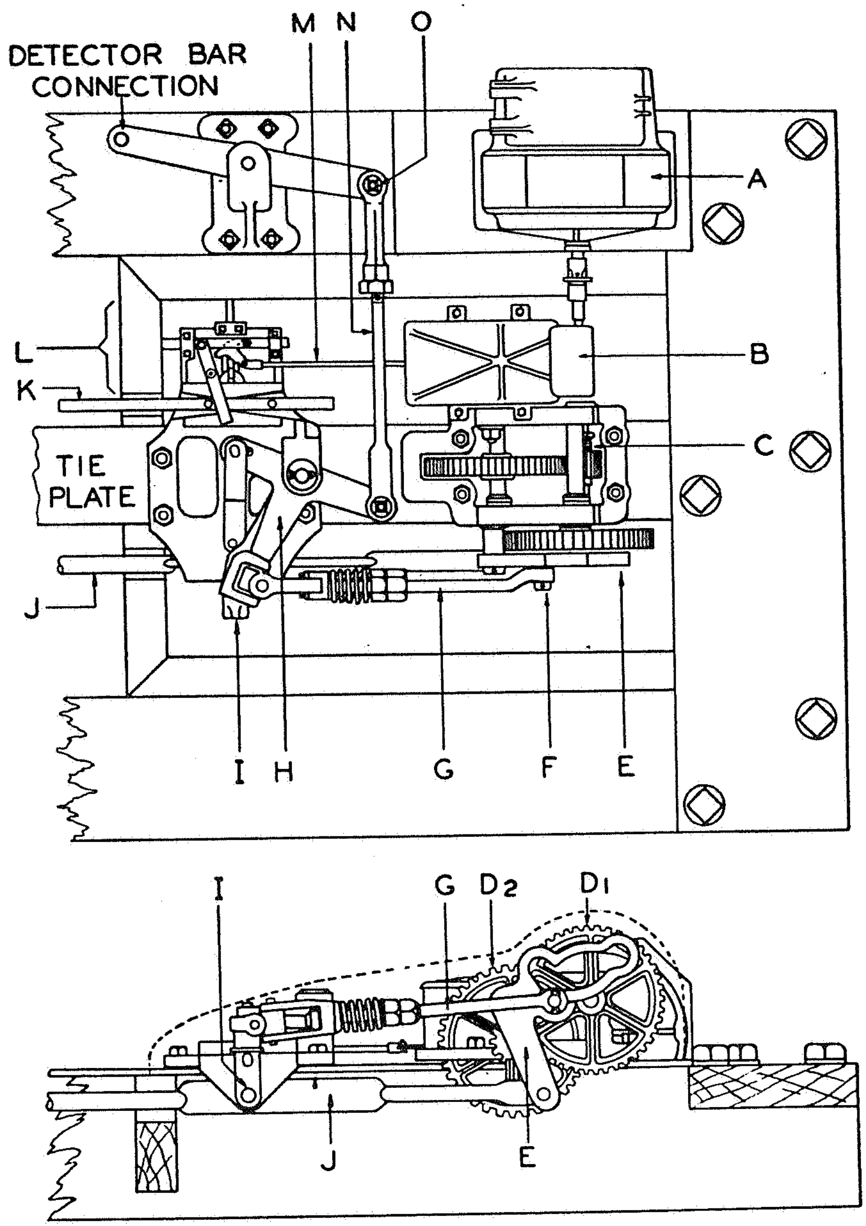
The gear frame and locking movement are bolted to the tie plate as shown. Movement is transmitted to the switch by the motor through a train of gears. The switch points are moved by rod J and cam crank E due to stud F on main gear D_1 engaging with the cam crank.

Locking plunger I and detector bar (if used) are actuated through crank H and driving rod G, the latter directly connected to stud F on main gear D_1. Where detector bars are not used a buffer spring is sometimes connected to rod N. The movement of pole changer B is effected through the medium of pole changer movement L, which is operated by the last ⅛ inch movement of lock plunger I after it has passed through lock rod K. The design of the mechanism is such as to allow switch motor A, because of its acquired momentum, to continue its rotation for the generation of the indication current, which checks the speed of the motor and brings it to rest without shock.

A friction clutch C is introduced into the connection between the motor and main gear D_2 to relieve the switch mechanism from any injurious strain should it suddenly be brought to stop by an obstruction in the switch points. Provision is made for operating the movement by hand by inserting a crank in a socket attached to the motor armature shaft.

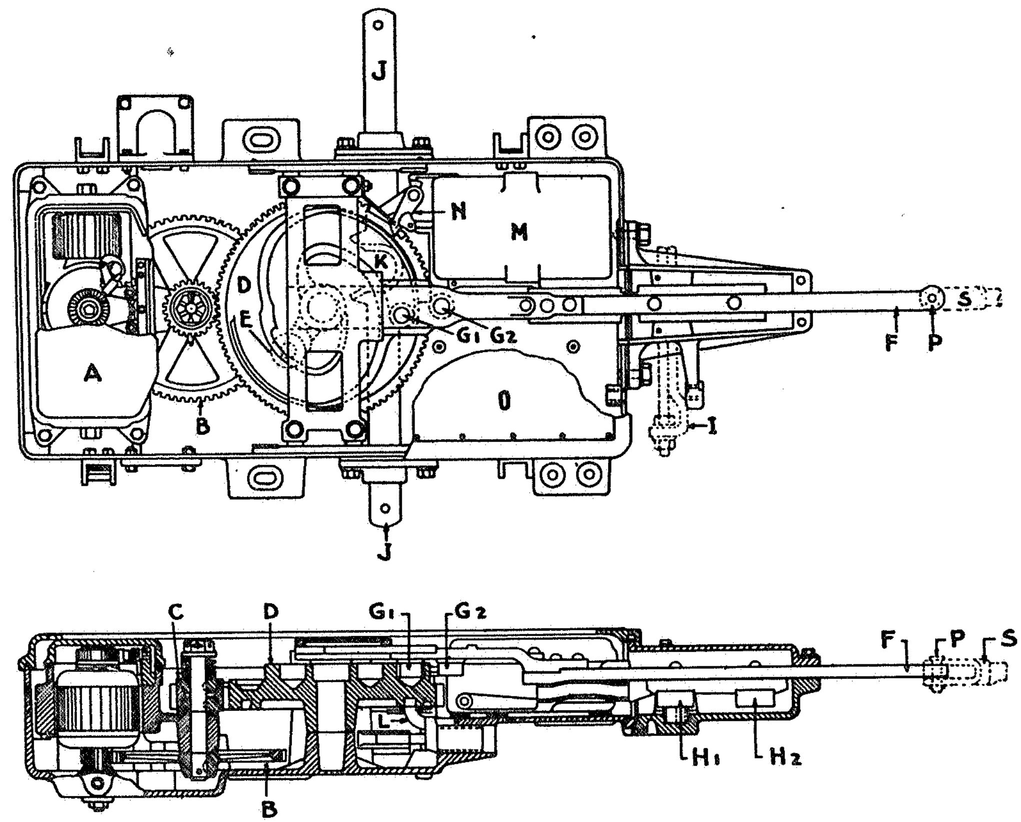
Model 4A switch machine.

The Model 4A switch machine, shown in Fig. 30, is designed with all operating parts within one case, which, besides affording protection against the weather, also provides a base plate for the mechanism. It operates on 110 volts direct current.



A—Motor.
B—Pole changer.
C—Friction clutch.
D1—Main gear.
D2—Intermediate gear.
E—Cam crank.
F—Stud on main gear.
G—Driving rod.
H—Lock crank.
I—Lock plunger.
J—Throw rod.
K—Lock rod.
L—Pole changer movement.
M—Pole changer connecting rod.
N—Detector bar driving link.
O—Pin.

Fig. 29.
Model 2 Switch Machine.



A—Motor.
B—Intermediate gear.
C—Friction clutch.
D—Main or cam gear.
E—Roller on main gear.
F—Locking bar.
G1, G2 } Rollers on locking bar.
H1, H2 } Locking dogs.
I—Lock rod.
J—Throw rod.
K—Jaw in throw rod.
L—Locking bolt.
M—Pole changer.
N—Tripper arm.
O—Switch circuit controller location.
P—Pin.
S—Detector bar connection.

Fig. 30.
Model 4A Switch Machine.

The operating parts consist of motor A, a train of spur gears, the main or cam gear D, pole changer M, throw rod J and locking bar F. The motor through the medium of the train of gears drives the cam gear, from which gear the various parts of the switch machine are operated.

The intermittent movement of the locking bar and detector bar is accomplished by the engagement of rollers on the locking bar with the cam slot on the upper side of the main gear. Staggered locking is provided by the arrangement of the dogs on the locking bar, these dogs being placed so that after one dog has been withdrawn to release the lock rod, the switch must be moved to the opposite position before the other dog can enter its slot in the lock rod. The throw rod is locked in both extreme positions of the switch by a bolt operated from the cam movement. The switch points are thrown at the proper time by a roller on the lower side of the main gear engaging a jaw in the throw rod.

The principles of the pole changer movement, shown in Fig. 31, are essentially the same as in the Model 2 switch machine, although the mechanical method of effecting this action is accomplished through the main gear movement and locking bar, instead of through the pole changer movement and locking plunger as in the Model 2. Contact blocks S_1 and S_2 are operated from tripper arm N which engages at the proper time with a cam either on the upper or lower surface of main gear D, depending on the direction of travel of the mechanism. The tripper arm is placed in a position to engage with the proper cam only after the switch has been locked in position at the end of its movement. This is accomplished through the medium of cranks T_1 and T_2, a roller U on the latter working in a cam slot on locking rod F_1. Contact arm V (which corresponds with commutator T on the Model 2 pole changer, Fig. 29), is operated by this same crank movement.

The cam gear is designed to permit a free run of the motor at the end of the operation of the mechanism for the purpose of generating the indication current. A friction clutch is provided to protect the mechanism from shock should its movements be obstructed.

A circuit controller, as shown in Fig. 32, when furnished is located within the mechanism case at the point indicated by letter O. The operating part consists of a frame carrying contact fingers and a cylindrical commutator W upon which are mounted contact segments. As the switch is unlocked, a disengaging arm X with roller Y working in a cam slot on locking bar F_1 lowers the commutator out of engagement with the contacts. During the movement of the switch the commutator is rotated on its axis through motion transmitted from the switch points by means of a crank connection, a sector (not shown) and pinions Z_1 and Z_2. After the switch points are locked in position the commutator is raised into engagement with the contacts by the engaging arm and cam slot movement. It will be seen that this control insures that the switch points are in position and locked before the contacts of the circuit controller can close. The maximum capacity of the controller is ten independent contacts, these being adjustable in pairs to close as desired at the normal or reverse position of the switch.

The switch machine may be used for a right or left-hand layout, without change, as the lock and throw rods may be connected from either side. A double locking cage is furnished when the machine is to operate a movable point frog.

Provision is made for operating the machine by hand by inserting a crank in a socket on the motor armature shaft.

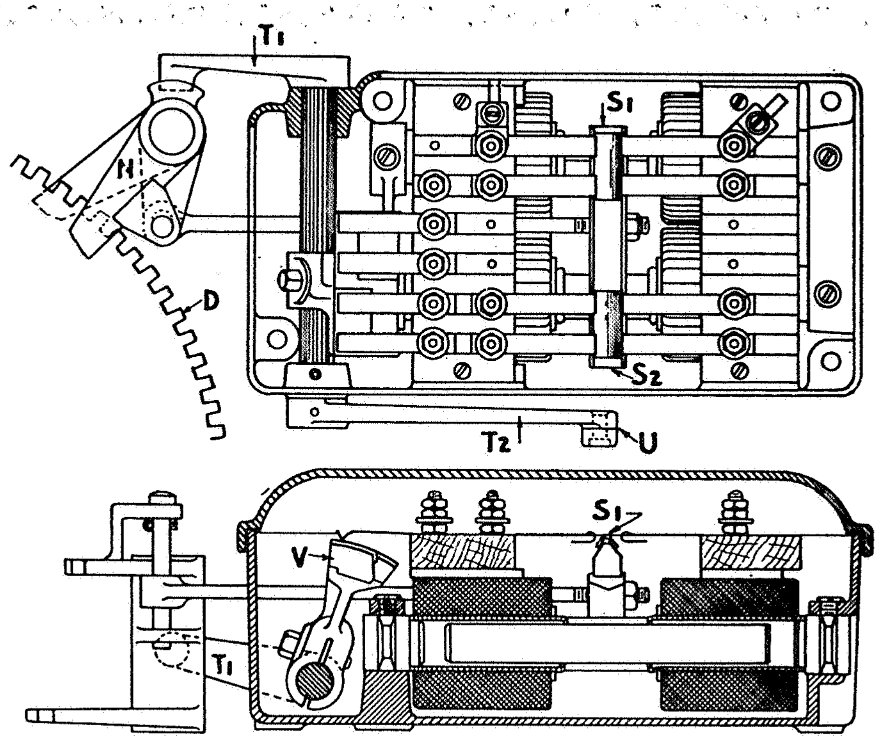


Fig. 31.
Pole Changer for Model 4A Switch Machine.

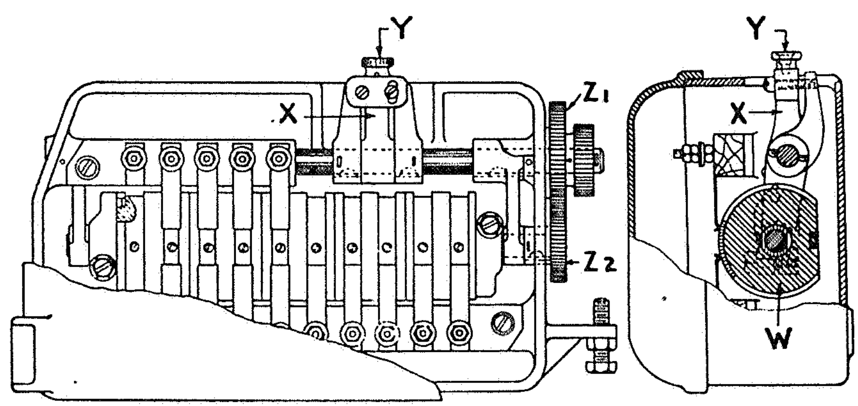


Fig. 32.
Switch Circuit Controller for Model 4A Switch Machine.

Model 5 switch machine.

The Model 5 switch machine consists of a motor train of gears, operating and locking members, a pole changer, clutch and magnetic brake. Except for the magnetic brake, its operation is practically the same as the Model 4A switch machine.

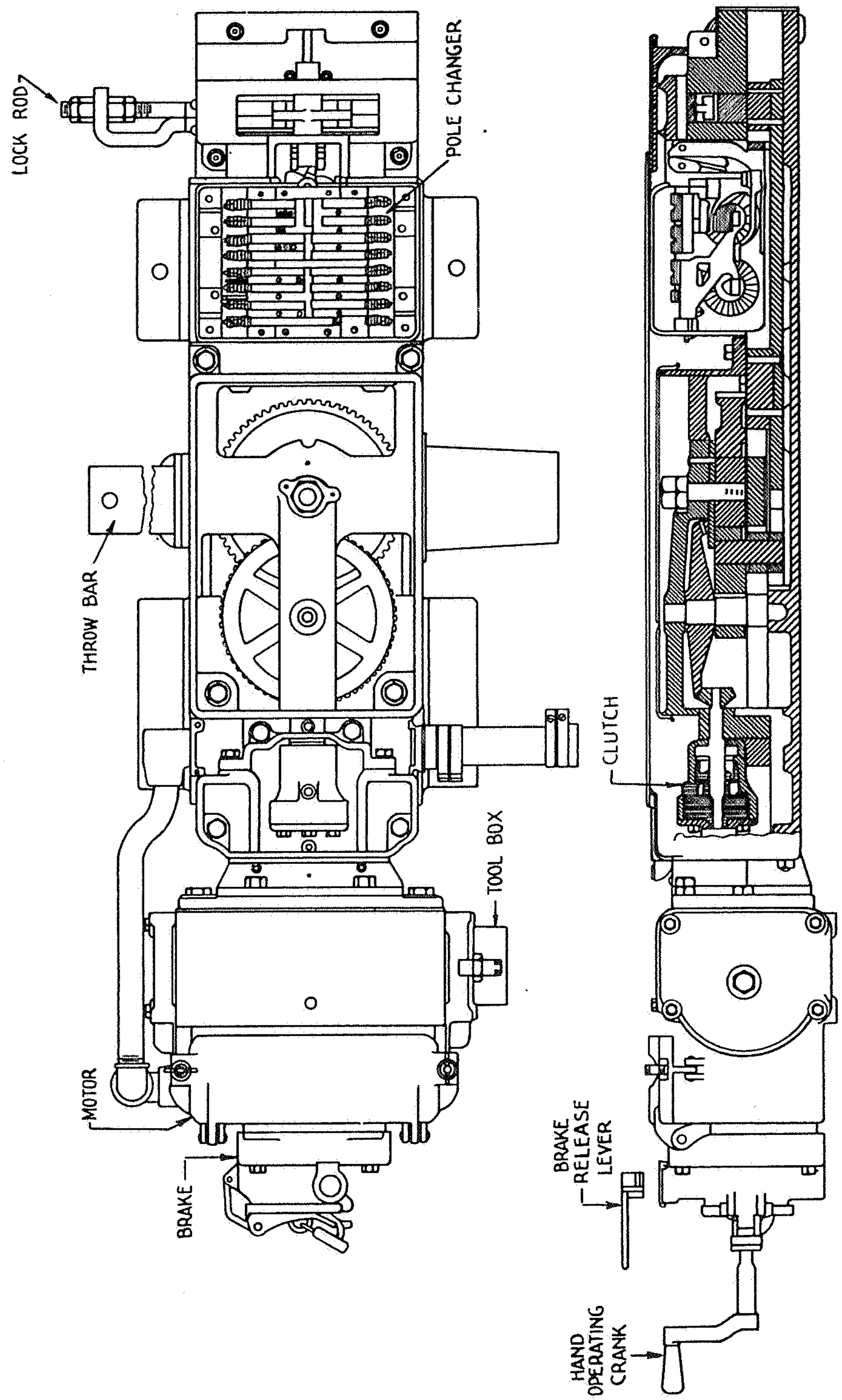


Fig. 33.
Model 5 Switch Machine.

The motor is bolted direct to the end of the machine frame in such manner that it can be readily detached. The magnetic brake is mounted on the motor frame and provides a front bearing for the motor armature thereby making the motor and brake a complete unit. Provision is made for operating the movement by hand by inserting a crank in an opening in the end of the motor frame as shown in Fig. 33. Before this crank can be inserted, a motor cut-out contact arm must be moved to one side which prevents current being applied to the motor while crank is inserted.

The magnetic brake is provided primarily to prevent the switch machine from operating due to vibration of a passing train should the switch be unlocked. It consists of a friction disc which rotates with the motor shaft and which is normally held against the brake housing by spring tension. A coil connected in series with the motor field causes this friction disc to be released whenever current is applied to the motor. The brake magnet is made "slow release" so that the brake will not set immediately after the motor cut-out contact is opened, to allow the motor a free run for the generation of the dynamic indication. The brake is adjustable so that wear on the friction disc can be taken up.

When operating the machine by hand, the magnetic brake must be released mechanically and an opening on top of the brake housing is provided for this purpose; the brake release lever shown in Fig. 33 is inserted in this opening and pushed in a clockwise direction and held there while cranking the machine by hand.

The Model 5 switch machine is narrower than the Model 4A and may be mounted in locations where the clearances are restricted such as in subways, etc. It may be provided with one or two lock rods by changing the locking bar and locking frame; it is regularly furnished for operation on 110 volts direct current although there are a number of these machines furnished for operation on 20 volts direct current, which machines are not equipped with a magnetic brake. Early designs of these machines for operation on 110 volts direct current were furnished with the motor detached and separately mounted.

Model 5A switch machine.

The Model 5A switch machine is similar in appearance to the Model 5, the principal difference being that it is equipped with a point detector. It may also be equipped with a magnetic brake, if required. It is regularly furnished as follows: 220 or 110 volts direct current, high or low speed with dynamic indication; 110 volts alternating current, 25 to 60 cycles with dynamic indication; and 20 volts direct current, low speed with dynamic or battery indication.

The motor is housed in a separate waterproof case which is bolted direct to the end of the machine frame, no change of the frame being necessary in changing from one type of motor to another. Different gear ratios are required for the various motors and no change in the machine frame is necessary in changing these gears.

Its application is universal as it is suitable to operate a single switch, derail, double-slip switch or movable point frog without change except the omission or addition of lock and point detector rods.

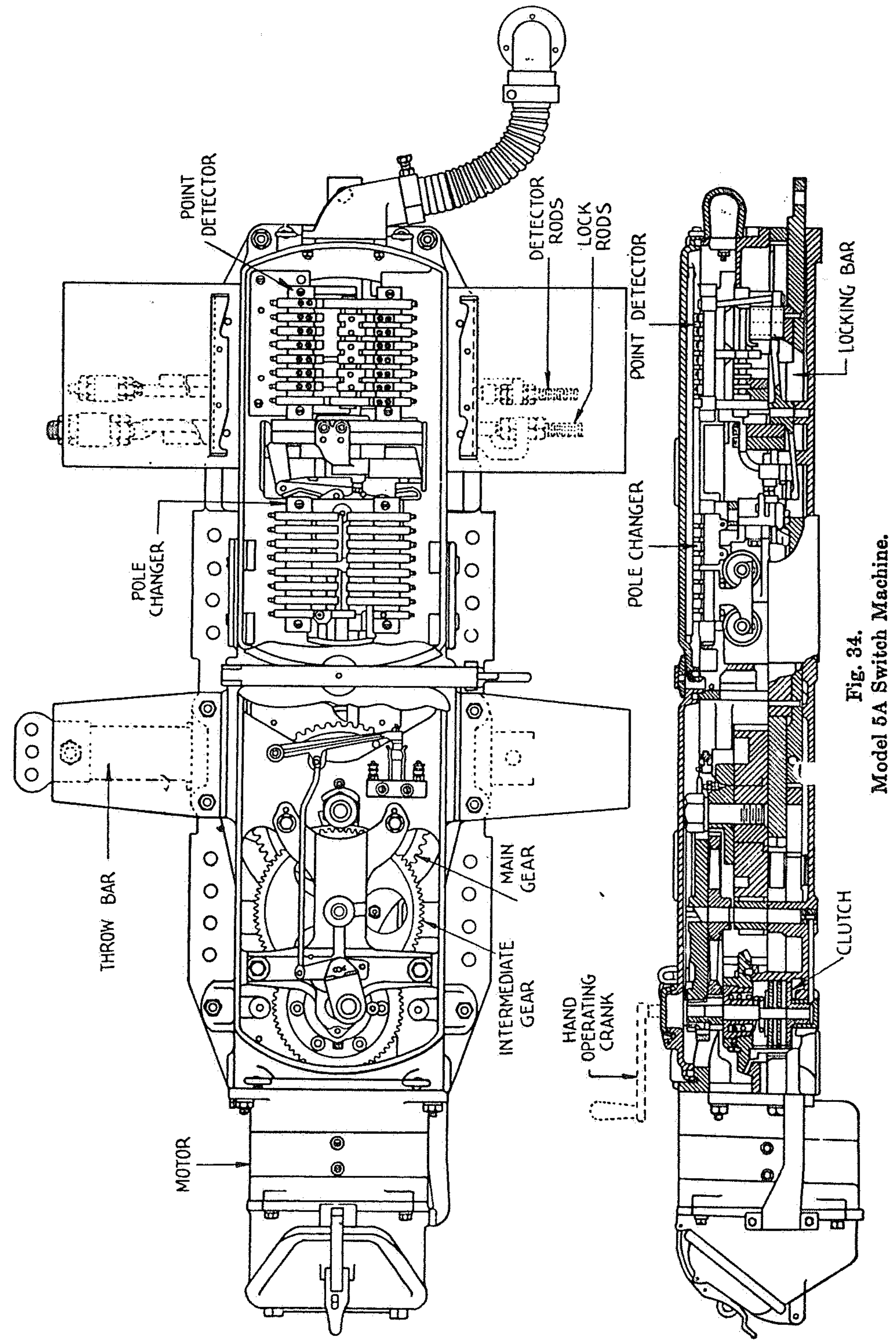


Fig. 34.
Model 5A Switch Machine.

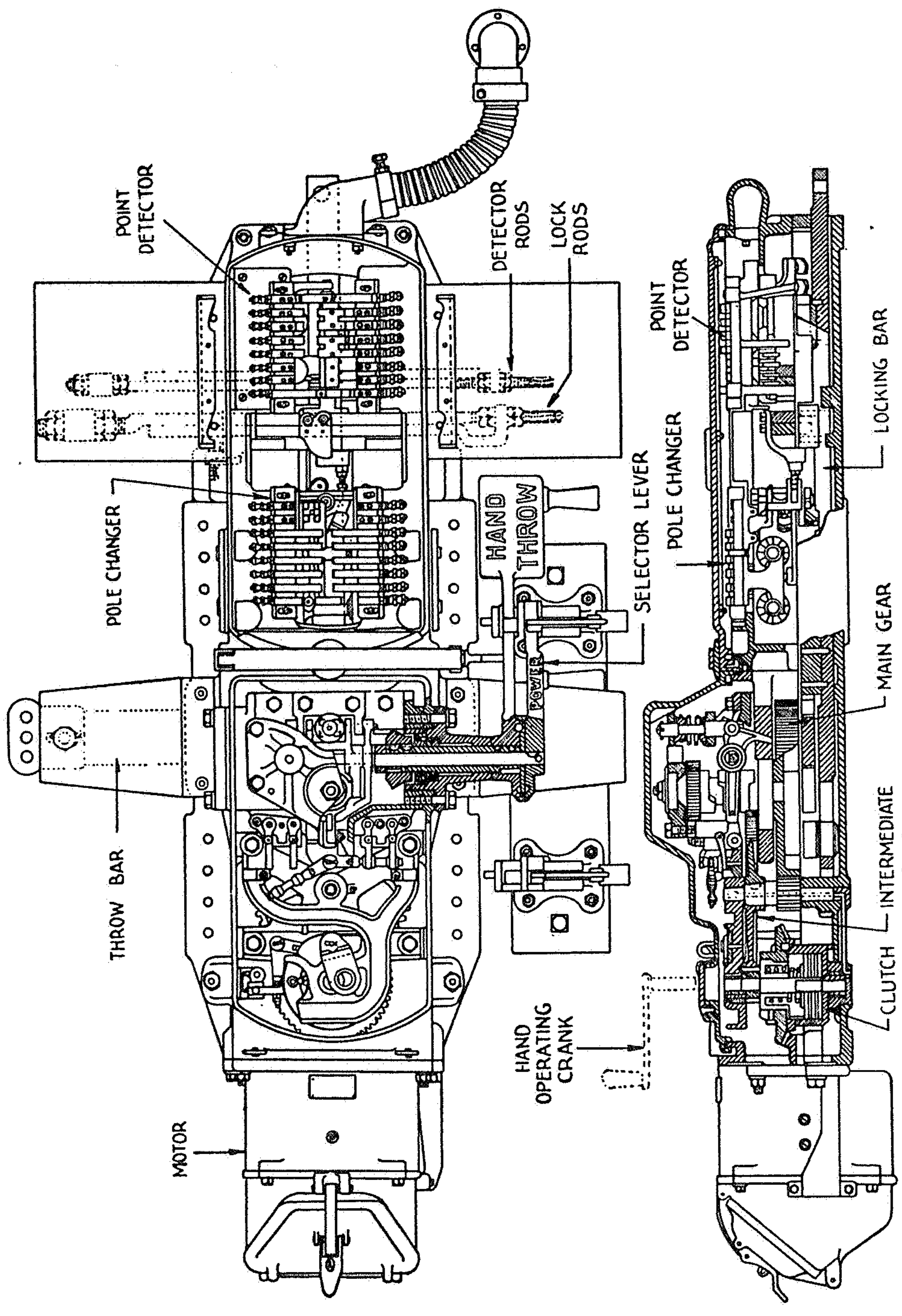


Fig. 36.
Model 5B Dual-Control Switch Machine.

As the cam bar moves to unlock the switch, roller F is forced into a slot in cam bar, as shown in 4 and 4A, which forces the contact member to the central position as shown in 2A. This opens all normal and reverse contacts and closes shunt contacts. As the switch completes its stroke and the cam bar moves back, locking the switch reverse, the slot in cam bar moves free of roller F. Then as point detector rods reach their reverse position, the left-hand rollers on contact member E drop into depressions in detector rods as shown in 2B, because of the pressure of spring H. This closes the reverse contacts. Roller F assumes the position shown in 4B. Unless the lock rods have, in the meantime, moved to the reverse position, arms J and K, by engaging rocker G, as shown in 3, 3A and 3B, will prevent the operation of contact member E from the central position. Thus it is evident that unless all detector rods and lock rods are in place and operative, contact member E of the point detector will remain in the central position holding all normal and reverse contacts open.

A crank is provided for hand operation which is inserted into the friction clutch mechanism through a small opening in the gear case cover, as shown in Fig. 34. Before the crank can be inserted, it is necessary to open a contact which prevents current being applied to the motor while crank is inserted.

Model 5B switch machine.

The Model 5B switch machine is equipped for dual control, that is, it can be operated either by power or hand. The purpose of dual control is explained in Chapter IV—Centralized Traffic Control. It is essentially the same as the Model 5A machine, except for the introduction of the parts required for hand operation.

Externally, these parts consist of two levers: one for selecting the method of operation, *i.e.*, power or manual, and one for the manual operation of the switch. These levers are referred to as hand throw levers and both are marked as shown in Fig. 36, the selector lever being marked "power" on one side and "hand" on the opposite side, while the hand throw lever is marked "hand throw" on each side.

The position of the selector lever determines whether the switch machine is in condition for hand or power operation. An interlocking feature between these levers makes it necessary that the selector lever be reversed before the hand throw lever can be moved. The reversal of the selector lever mechanically disconnects the motor-operated gear train, opens the motor operating circuit, releases the magnetic brake and connects the throw and locking members to the hand throw lever.

The reversal of the hand throw lever unlocks and throws the switch points and leaves the switch operating rod locked in the reverse position. Both the normal and reverse contacts in the point detector are opened and the shunt contacts are closed.

Figures 37 and 38 illustrate the arrangements of the selector and hand throw lever mechanisms. These sketches have been distorted or exaggerated more or less to show as clearly as possible the functioning of the various parts and their relations one to another. Figure 37 shows the manner in which the

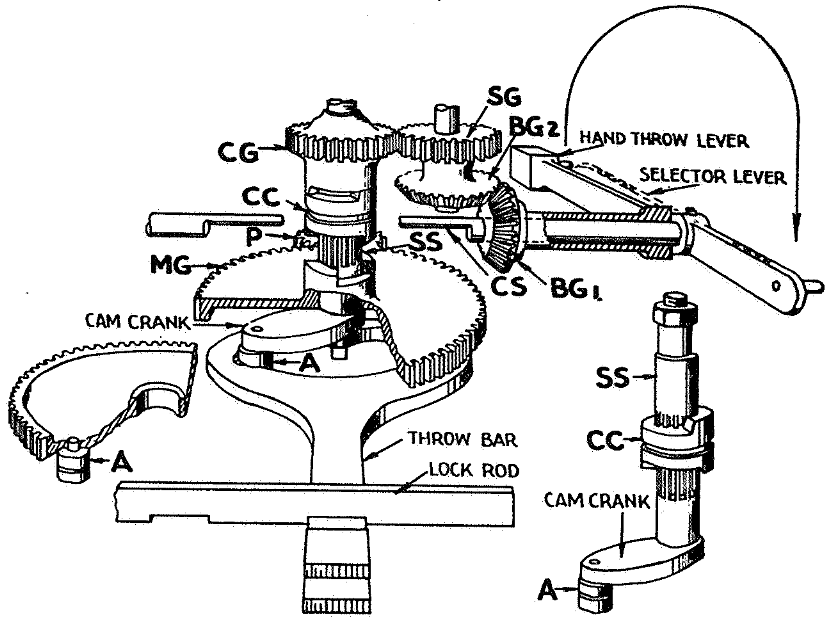


Fig. 37.
Arrangement of Selector and Hand Throw Lever Mechanism.

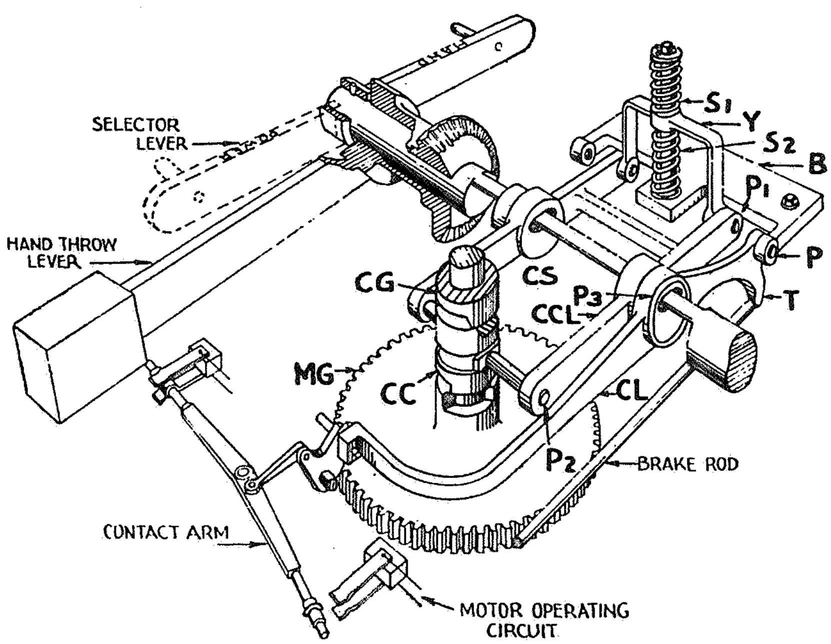


Fig. 38.
Arrangement of Selector and Hand Throw Lever Mechanism.

selector and hand throw levers are built into the switch machine and illustrates the principal difference between the Model 5A and Model 5B switch machines.

In the Model 5A machine, cam roller A is a part of the main gear assembly as shown in the small section at the left. In the Model 5B dual-control machine, roller A is mounted on a cam crank which may be actuated either by main gear MG or clutch gear CG depending upon the position of clutch coupling CC. When clutch coupling CC is up as shown, it is coupled with clutch gear CG, therefore the selector lever must have been reversed and the switch machine is in position for manual operation by the hand throw lever. When clutch coupling CC is down it couples with the main gear and is in position for power operation of the switch and the selector lever must be in its normal or power position.

Clutch coupling CC is mounted on a splined shaft SS and while free to move up and down when actuated by the selector lever, it will always turn with the shaft. The clutch coupling is moved up and down by a suitable mechanism actuated by cam shaft CS when the selector lever is moved from one position to the other. This mechanism is shown in Fig. 38, and is explained in detail in the following paragraphs. However, it is sufficient here to assume that the clutch coupling moves up or down as required.

Either main gear MG or clutch gear CG is engaged by the clutch coupling; there is no intermediate position where the switch is not under full control by hand or by power operation. When the selector lever is reversed, as shown, clutch coupling CC is up and engaged with clutch gear CG. If the hand throw lever is reversed as indicated by arrow, it will cause bevel gears BG1 and BG2 and spur gear SG to rotate driving clutch gear CG. Clutch gear CG being engaged with coupling CG drives splined shaft SS. The cam crank carrying roller A is a part of the splined shaft and therefore roller A is driven against the cam surface of the throw and locking bars causing them to operate in a manner already explained.

For power operation the selector lever would, of course, be in the normal or power position when clutch coupling CC would be down and engaged with main gear MG. The main gear is actuated through the motor and gear train of which pinion P is a part. Clutch coupling CC being down and engaged with main gear MG, movement of the main gear is transmitted through the coupling to the spline shaft, cam crank and roller A which causes operation of the throw and locking members as already described. During power operation, movement of the hand throw lever is impossible because the hand throw lever is locked by the selector lever in the normal or power position.

Figure 38 illustrates the manner in which clutch coupling CC is caused to move up or down when the selector lever is moved to the reverse or normal position.

The selector lever performs three main functions: it raises or lowers clutch coupling CC to transfer control of the machine from power to manual or from manual to power as the case may be; opens the motor operating circuit during manual operation and closes it during power operation; and it mechanically releases the brake mechanism for manual operation. The purpose of the brake mechanism has been explained under Model 5 switch machine.

The selector lever is mounted on a shaft that passes axially through the hand throw lever shaft. Inside the mechanism the selector shaft is formed crank fashion as shown at CS. When the selector lever is in the normal or power position the crank portion of the shaft will be down and when the selector lever is reversed or in the hand throw position the crank portion of the shaft will be up as shown. It is obvious that the turning of this crank shaft CS will operate in the slots in the clutch coupling levers CCL causing them and contact lever CL to move up or down at this point. When the selector lever is moved from normal to reverse as shown, crank shaft CS raises levers CL and CCL. Levers CL being pivoted at P, will raise the full amount of their movement, and the outer ends engaging with a small crank connected to the contact arm open the motor operating circuit. One of the levers CL has a tail T suspended at the pivot end P and as the lever is raised this tail lever engages a brake rod causing it to move forward and release the motor brake.

Levers CCL have three pivot points, P1, P2 and P3, any or all of which may function when the selector lever is thrown. When the selector lever is reversed the turning of shaft CS raises clutch coupling levers CCL where the shaft passes through them, but the action differs from that of lever CL with its fixed pivot P.

When levers CCL start to move up because of the turning of shaft CS, they first pivot at point P1 and raise clutch coupling CC. If the position of the coupling jaws on clutch coupling and clutch gear are such that they will enter and engage one another the levers will continue to pivot at P1 but if they are not in this position and cannot engage, as shown in Fig. 38, then the levers will pivot at P2. As the turning of shaft CS continues to lift the levers it will cause the spring supported pivot point P1 and yoke Y to move up compressing spring S1 which is held in position by a stud supported by fixed bracket B. This action stores up the energy necessary to move clutch coupling CC into proper engagement with clutch gear CG when the coupling jaws are in the proper position. Movement of the hand throw lever will bring the jaws into proper position and spring S1 which has been compressed will then move yoke Y down causing levers CC1 to pivot on shaft P3 and raise clutch coupling CC into proper engagement with clutch gear CG.

In going from manual to power operation, if the jaws on the clutch coupling fail to register with the jaws on the main gear as the coupling moves down, then spring S2 is compressed and functions to complete the downward movement of the clutch coupling when the jaws are in proper alignment.

The Model 5B switch machine is regularly made for operation on 220, 110 or 20 volts direct current and 110 volts alternating current.

Model 5C and 5D switch machines.

The Model 5C and Model 5D switch machines are the same as the Model 5A and 5B switch machines, respectively, except they have a switch machine controller resiliently supported in a metal case in the forward portion of the contact compartment in place of the pole changer. The Model 5D machine is shown in Fig. 39.

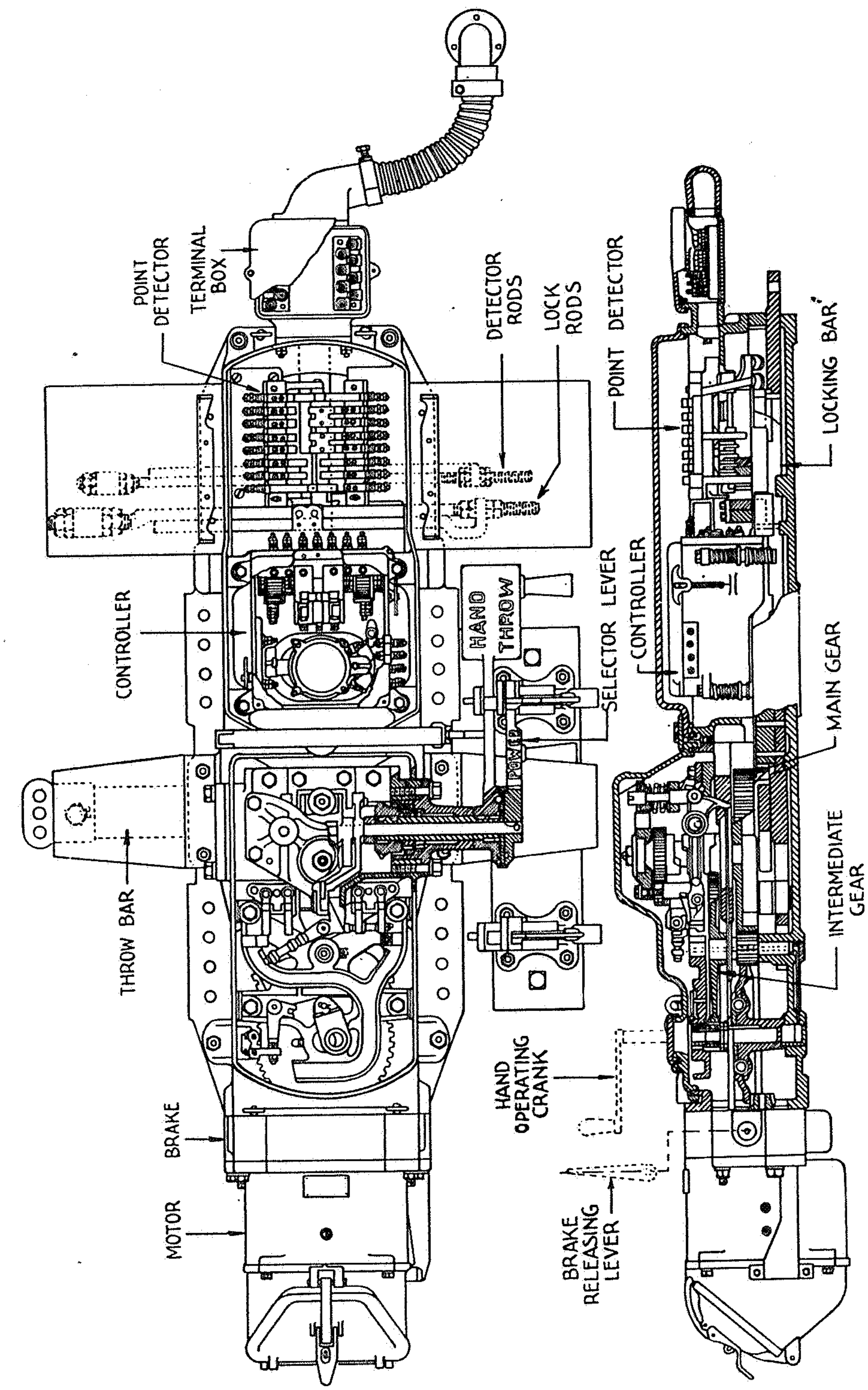


Fig. 39.
Assembly of Model 5D Switch Machine, Dual Control.

The switch machine controller is made up of two operating contactors (one normal and the other reverse) and two overload relays (normal and reverse) and a master relay when required. Figure 40 shows the controller complete with master relay.

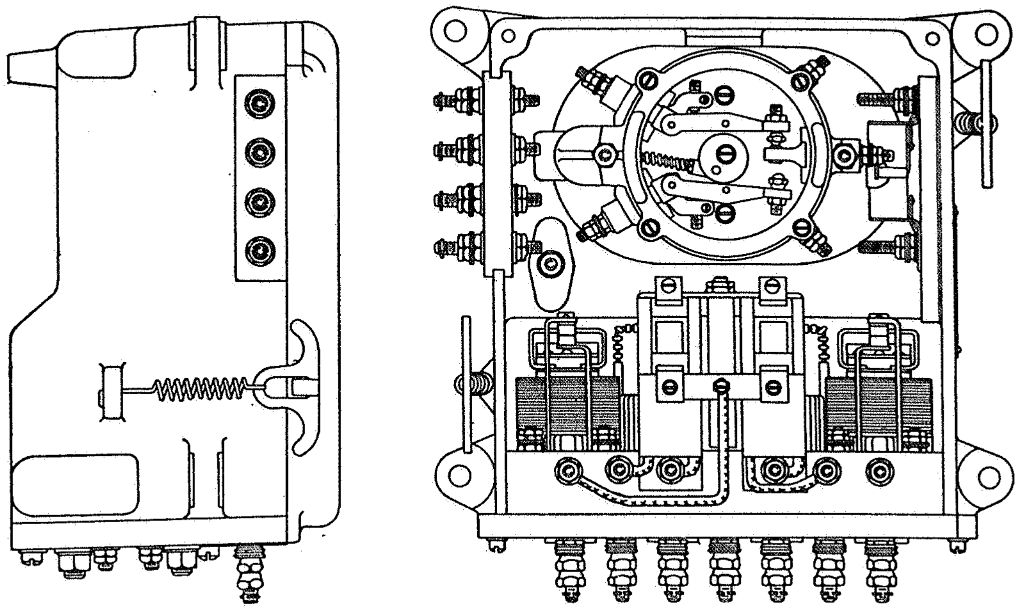


Fig. 40.
Switch Machine Controller for Model 5C or 5D Switch Machine.

The operating contactors are provided with magnetic blow-outs so designed that an arc occurring in the ordinary operation of the machine, or in case the machine is stalled, will be suppressed. The overload relays act to open the circuit to the proper operating contactors only when and if the machine becomes stalled. The reversal of the controlling relay will automatically reset the contacts of the overload relay ready for the next operation. They are usually set to operate at 11 amperes and are adjustable by means of a screw located in the lower part of the armature. The master relay is a two-position polarized device strongly biased in normal and reverse positions by a toggle spring.

The operation of a switch machine equipped with this machine controller can be seen by referring to Fig. 41 which is a simplified circuit of the control of Model 5C and 5D switch machines. For a detailed explanation see Chapter XX—Interlocking Circuits.

The normal and reverse operating contactors are controlled through normal and reverse contacts of the master relay in series with motor control contacts on point detector. During the unlocking of the machine these contacts move

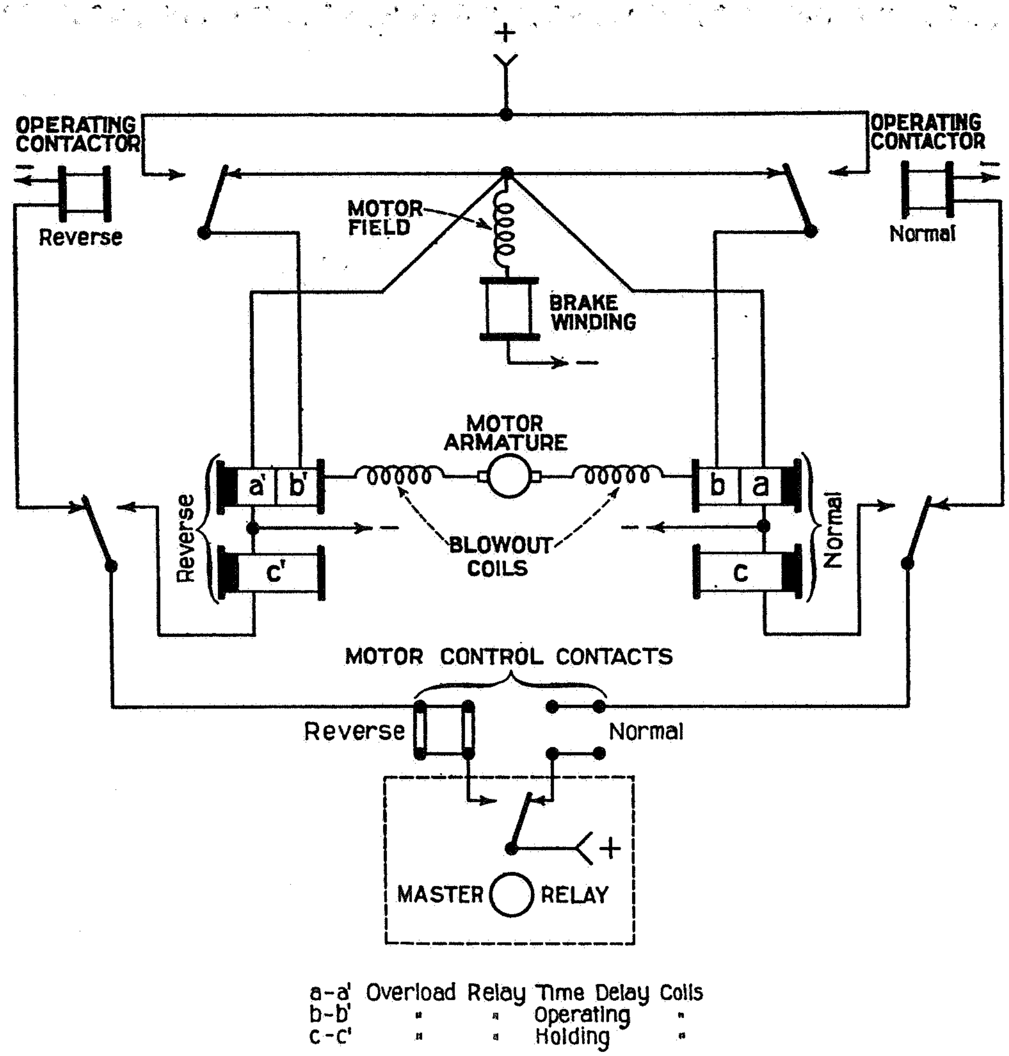


Fig. 41.
Simplified Circuit Showing Control of Model 5C and 5D Switch Machines.

to a central position and both remain closed at all times except when the machine is fully locked, their function being to de-energize the proper contactor at the end of the movement and to provide a circuit for energizing either contactor in midstroke.

The motor operating circuit is controlled through the contacts of normal and reverse operating contactors in series with normal and reverse overload relays operating coils B and B[1] and the blow-out coils. Each of the overload relays has three coils, an operating coil, a time delay coil and a stick or holding coil. Due to the time delay coils A and A[1], the relay will not respond to a surge of current such as occurs at starting, but will respond to a sustained overload of predetermined value. The stick or holding coils C and C[1] are provided to hold the overload relays energized after being energized by a sustained overload until released by the master relay contacts on moving the control lever to its opposite position. Blow-out coils suppress the arc caused by the contactors breaking the motor circuit.

The magnetic brake is connected in series with the motor field and is released when current is applied to the motor. The master relay may be omitted from the machine controller and the operating contactors operated from a polar relay located near the switch machine.

The Model 5C and 5D switch machines are regularly made for operation on 220, 110 or 20 volts direct current.

Style "M" switch machine.

A Style "M" switch machine with covers removed is shown in Fig. 42.

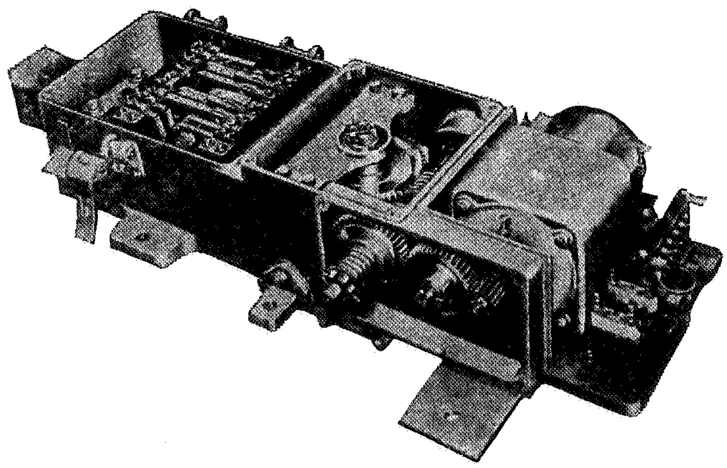


Fig. 42.
Style "M" Switch Machine with Covers Removed.

This machine consists of a motor, a clutch, gear train, a cam arrangement, a locking device and a circuit controller. These units are housed in a cast-iron case, separate compartments house the motor, the gear train and the circuit controller, with separate covers for each compartment.

Power from the motor is transmitted by means of the gear train which includes a worm gear to a combined crank shaft and arm X in Fig. 43 which drives the switch operating bar and the locking bar motion plates Y and Z.

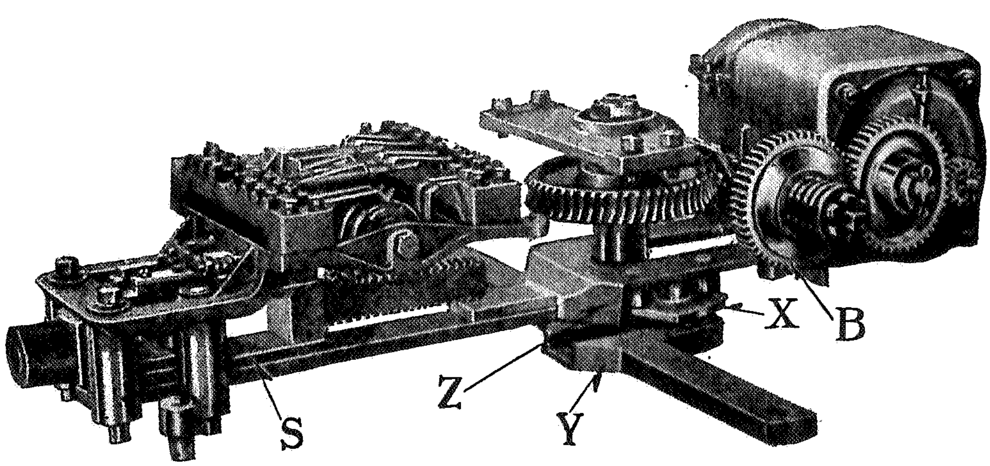


Fig. 43.
Gear Arrangement for Style "M" Switch Machine.

Connection to the switch points can be made at either end of the operating bar Y. The position of the switch points is checked and secured by the action of the lock box S which forms a part of the locking bar. The circuit controller is mounted over and operated by a rack fastened to lock box S.

Motors for direct current or alternating current are interchangeable. A friction clutch is provided to protect the motor against overload or shock and is a part of gear wheel B, Fig. 43.

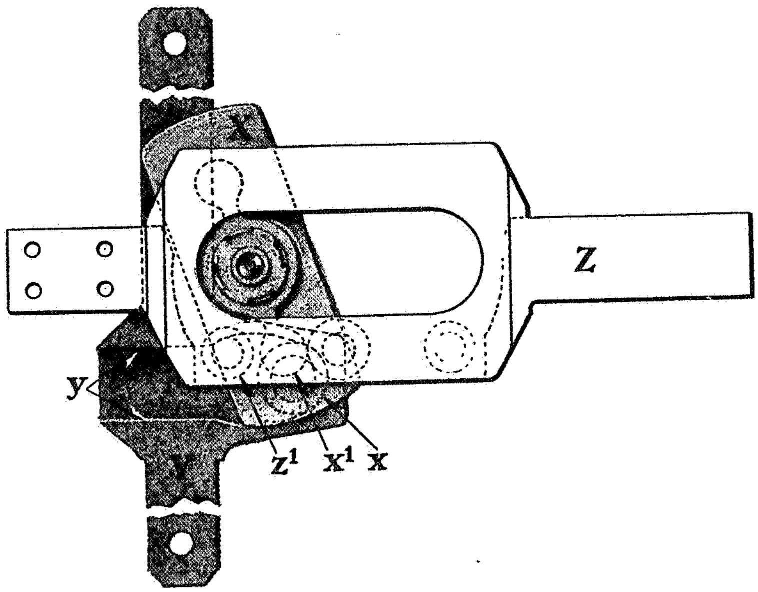


Fig. 43a.
Driving Parts in Normal Position, Style "M" Switch Machine.

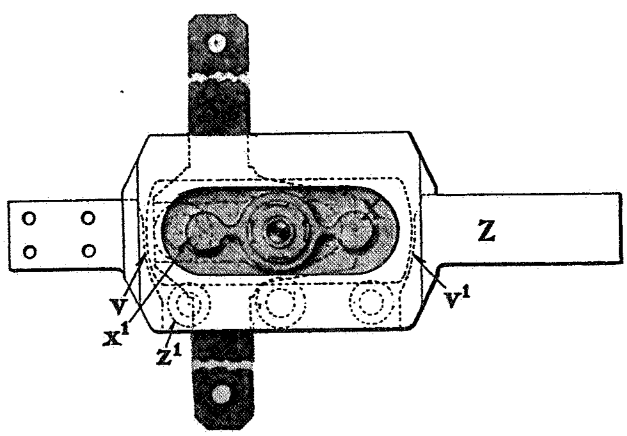


Fig. 43b.
Driving Parts in Mid-Position, Style "M" Switch Machine.

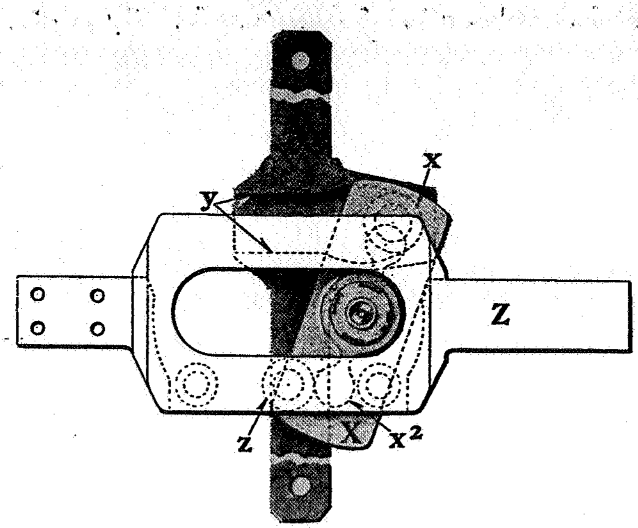


Fig. 43c.
Driving Parts in Reverse Position, Style "M" Switch Machine.

The operation of the parts for throwing and locking the switch is shown in Figs. 43a, 43b and 43c. Figure 43a shows the normal position. Starting from this position a reverse movement is started by a clockwise rotation of combined shaft and crank arm X. Lug x^1 on the top of crank X acting against roller z^1 on motion plate Z effects the unlocking of the lock rod by causing motion plate Z to move to the left one-half of its stroke. Meanwhile, roller x on the underside of crank X has moved through an arc of 40 degrees in groove y in switch operating bar Y, thus freeing the bar for the reverse stroke. During the next 140 degree revolution of crank X roller x engages the reverse operating face of groove y and throws the switch operating bar Y to the reverse position.

Figure 43b shows the relative midstroke positions of switch operating bar Y and lock bar Z, crank X is still rotating clockwise, but is not transmitting motion to lock bar Z, as lug x^1 has become disengaged from roller z^1 and the arcs of contact at v and v^1 between crank X and lock bar Z are radial to the center of the shaft.

The complete reverse position is shown in Fig. 43c. Roller x on crank X acting in groove y has moved operating bar Y to the reverse position and secured it; lug x^2 has come into contact with roller z thus driving locking bar Z to the reverse position.

In Fig. 43 it will be noted that lock box S rests on top of locking bar Z, two holes in the lock box fitting over two studs on the locking bar. The lock box S is inverted when changing from right to left-hand movement, or vice versa. This feature allows the same lock rod to be used for both right and left-hand movements.

Provision is made for operating the machine by a hand crank. The machine is also furnished with double locking box for two lock rods for movable point frogs. A point detector may be applied and since it is similar in operation to that on the Style M-22 switch machine, its operation will not be described here. Style "M" switch machines are made for operation on 220, 110 or 20 volts direct current and 110 volts alternating current.

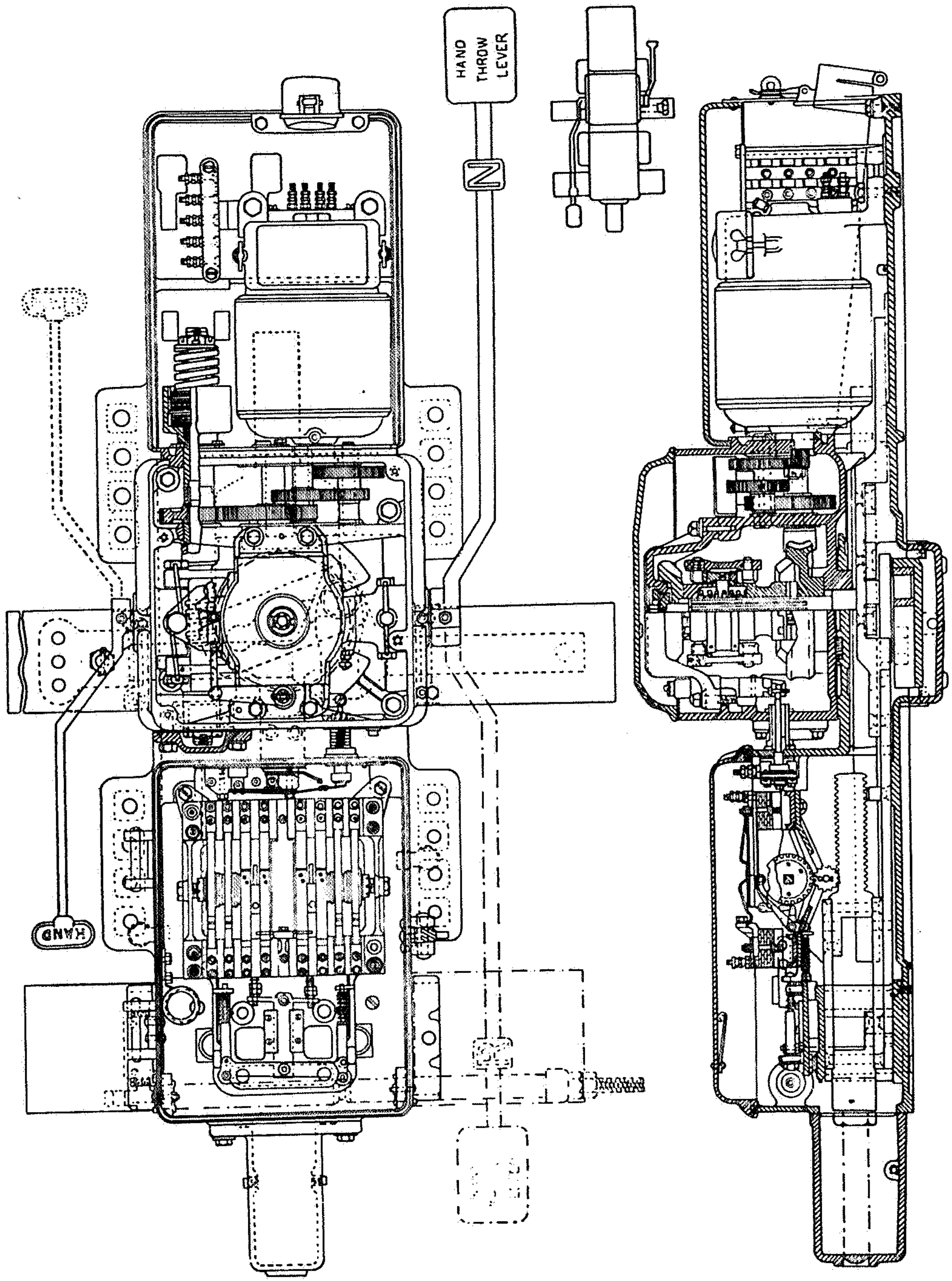


Fig. 44.
Sectional View of Style M-22 Switch Machine.
(Mechanism in hand-operation position.)

Style M-2 switch machine.

The Style M-2 switch machine is the same as the Style "M" except the motor and train of gears have been rearranged, also a crank contact has been added which opens the motor field circuit when the crank is inserted for hand operation.

Style M-22 switch machine.

The Style M-22 switch machine shown in Fig. 44 is equipped for dual control, that is, it can be operated either by power or hand. It is similar to the Style M-2 machine except for the addition of the selector and hand-operation levers and change in the main gear case. This description will be confined to the operation of the gear case. This gear case permits the operation of the machine by means of the motor, or by means of the hand throw lever.

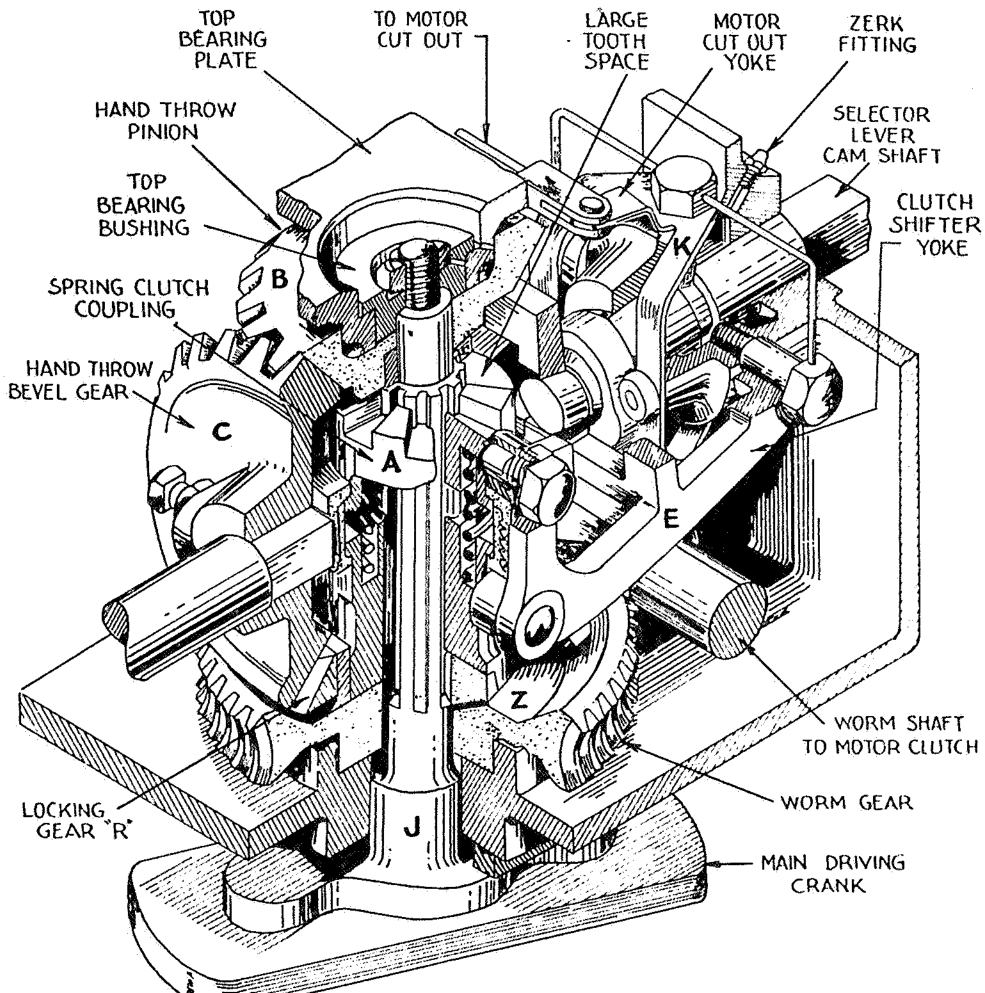


Fig. 45.
Perspective View of Gear Case for Style M-22 Switch Machine.

Figure 45 shows that the shaft of the main driving crank is mounted vertically and supported by two bearings. The top bushing, which is secured against the shoulder at the top of the shaft by a castellated nut and cotter, rides in a recess in the top bearing plate, thus obtaining both horizontal and vertical support. The worm gear is fitted to turn freely on the main shaft and its hub is supported in a recess located in the bottom of the gear case. On the upper surface of the worm gear is a ring of symmetrically spaced teeth of uniform size. Immediately above this gear is the spring clutch coupling which consists of two members forced apart by a coil spring and limited in their vertical travel by a coupler which holds the clutch together as a complete unit. The clutch is splined to the shaft, being free to move up or down, but rotates with the shaft as a unit. The lower member of the clutch has a similar set of teeth to that on the upper face of the worm gear, and Fig. 45 shows them in mesh. The teeth of the upper clutch member are similar to those on the worm gear, except that one tooth is left out for a reason explained later.

Hand throw pinion B rotating on a bushing around the top of the main shaft is driven by hand throw bevel gear C and teeth on its lower hub engage with spring clutch coupling A when the latter is forced to the "up" position by throwing the selector lever to the hand-operation position. However, the engagement between these two members cannot be made until the hand throw lever and the switch mechanism agree in position, as one large tooth and one large space, respectively, in otherwise symmetrical sets of teeth, are provided to prevent this.

Since neither the motor-driven worm gear Z nor the manually-actuated hand throw pinion B are directly connected to the main shaft, it is necessary to transmit motion to the main driving crank through the spring clutch which is splined to the main shaft. Selection between these two sources of power is obtained, through the operation of the selector lever, by throwing it to either the "hand" or the "motor" operation position. The selector lever cam shaft has two cams: one operates clutch shifter yoke E and the other operates motor cut-out yoke K which opens the motor circuit the instant the selector lever is moved from the motor operation position. Both yokes in effect are cam followers and are positive in action.

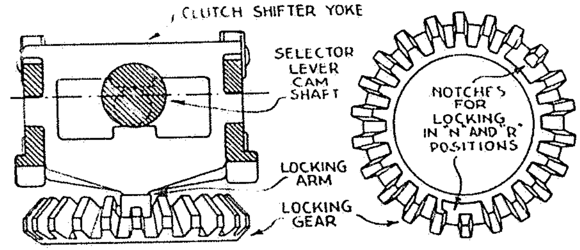


Fig. 46.
Illustrating Locking between Clutch Shifter Yoke and Locking Gear to Insure That Hand Throw Lever is Left in One or the Other Extreme Positions.

The clutch shifter yoke has two pairs of rollers straddling the spring clutch housing at 180 degrees and raises the clutch to engage with the hand throw pinion for "hand" operation, or lowers the clutch for engagement with the worm gear to allow "motor" operation. As shown in Fig. 46, there is also a locking arm on the lower end of the clutch shifter yoke which engages in a notch cut in a bevel locking gear located just above the worm gear, but meshing with the hand throw bevel gear. When the selector lever is thrown to the hand-operation position, the locking arm is disengaged from the locking gear, and, what is more vital, the complete movement of the selector lever to the motor position is contingent upon the switch mechanism being in either the normal or reverse position. The design of the spring clutch coupling allows the selector lever (except when locked out, as explained in the description of Fig. 46) to be moved from one extreme position to the other regardless of the positions of the sets of teeth which must mesh to permit either "hand" or "motor" operation. Should these teeth not mesh when the selector lever is thrown, the spring inside the clutch coupling is compressed and as soon as the teeth on the adjacent gear, against which the clutch has been forced, are moved to a meshing position the teeth on the spring clutch will automatically snap into engagement.

The Style M-22 machine is furnished to operate on 110 volts direct or alternating current and 20 volts direct current.

Style M-25 switch machine.

The Style M-25 switch machine is the same as the Style M-22 machine except that the contactor type controller is housed within its case.

The Style "M," M-2 and M-22 machines, furnished for operation on 20 volts direct current, may be obtained with three different gear ratios as follows: one for 30 seconds operation with current of 3.7 amperes, one for 14 seconds operation with current of 5.4 amperes, and one for 7.5 seconds operation with current of 7.5 amperes, these values being considered as average.

Machines equipped with the first two gear ratios may be controlled by standard polarized relays but the 7.5 seconds ratio on account of its high current is usually controlled by a contactor controller.

Contactor type controller.

The contactor type controller, shown in Fig. 47, has included the necessary thermal relays for overload protection. These controllers are furnished with or without latch which prevents the relay from resetting once it has been opened due to an overload. The latch must be released by hand in order to reset the relay. Those without the latch will reset automatically when the heater element cools after heating due to an overload.

These controllers may be mounted in a cast-iron box similar to the Type "F" controller described under Type "F" system or mounted in an instrument case, when it is supplied with a wall mounting.

The method of controlling a switch machine by means of this controller is shown in Fig. 48 which is a simplified circuit.

In Fig. 48 the switch machine is shown in the normal position and upon the operation of the switch control lever, the reverse polar contacts of the switch control relay will close causing reverse contactor coil R to be energized, which in turn causes the motor of the switch machine to operate. It will be noted that the heater element of the reverse thermal relay is now connected

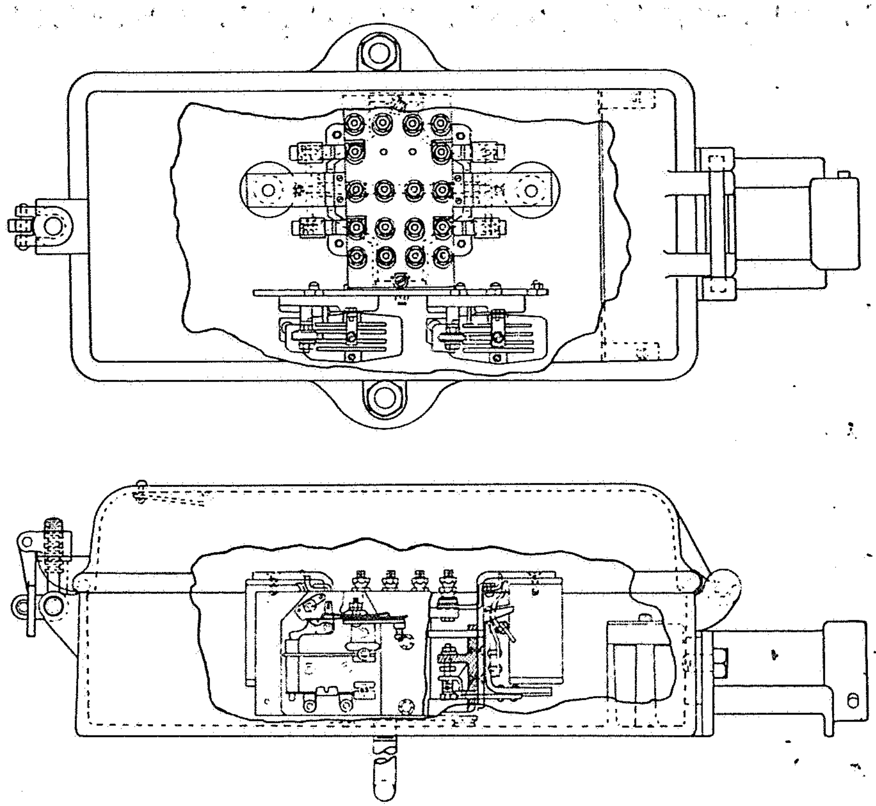


Fig. 47.
Contactor Controller with Case.

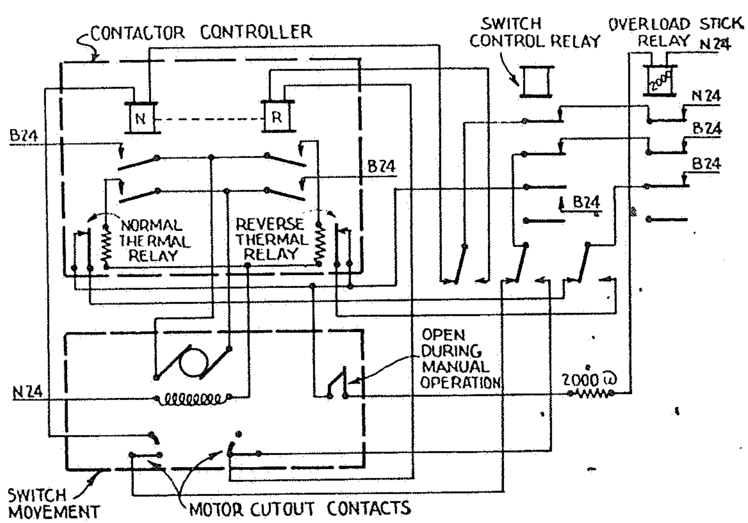


Fig. 48.
Simplified Circuit of Contactor Controller Wiring.

in series with the motor field and should the motor be overloaded and a current of more than 9 amperes flow through the heater element, same will open its contact after heating allowing overload stick relay to de-energize opening battery N-24 and B-24, causing the reverse contactor controller to de-energize, stopping the motor. After the heater element cools and allows its contact to close, the overload stick relay cannot energize until the switch control lever has been operated to the opposite position and the normal polar contacts of switch control relay have closed. Therefore, the switch motor will not operate after the heater element cools until the switch lever has been placed in opposite position.

The Type "F" controller, previously described, may be also used for operating 20-volt switch machines.

Instructions

Electric interlocking should be maintained and tested in accordance with the following instructions:

1. Interlocking machine must be kept in good condition, free from dust, grease, dirt and excessive lost motion. Levers and locking must be kept clean. All bearing parts must be kept lubricated but excessive lubrication is to be avoided. Bolts, dowel pins, etc., must be kept tight, cotters properly spread and sufficient tension in latch springs. Contacts must be kept clean and properly adjusted.

2. The following instructions and advice must be given to levermen when necessary:

   (a) How to disconnect and secure switches, derails, and other units in emergency.

   (b) How to operate time releases and other special apparatus.

   (c) How to read the various indicators or lights, etc.

   (d) How to handle levers with special reference to the undesirability of forcing the lever or latch when the switch points may be obstructed or other undesirable conditions exist.

   (e) Any other information which is necessary for the efficient operation of the plant.

3. During snow and sleet storms interlocking plants must be carefully watched to see that switches, pipe lines, etc., are kept clean and in operation. Sufficient force should be available to keep switches, etc., free from obstruction. Snow and ice must be removed from signal blades, roundels, lenses and other apparatus to maintain proper operation and indication. Where snow melting oil or open flame devices are used, care must be exercised to prevent damage to wires, wire conduits, insulations, etc.

4. Levers or other operating appliances must not be operated by other than leverman except for inspection or test and then only after a thorough understanding with the leverman.

5. Periodic inspection and tests must be made to insure that all appliances, including machine locking, are in proper condition and that levers can be operated only in the predetermined order.

6. Locking of an interlocking machine must not be changed nor removed from the machine without proper authority. If it becomes disarranged or broken, signals affected must be set to display their most restrictive indication; switches, etc., in the route affected must be securely spiked until repairs are made. In all such cases .... must be notified by wire.

7. Seals and padlocks, where provided, must be maintained and handled in accordance with instructions from ....

8. Opening or short circuiting circuits, or taking any other action which may cause failure of signals or other apparatus with resultant train delays must be avoided.

9. Relays must not be turned over. Contacts of relays or other controlling devices must not be bridged nor any other action taken which will endanger the safety of trains. All train movements must be properly safeguarded.

10. Standard clearances must be maintained.

11. Foundations must be rigid, level and in alignment.

12. Paint must be applied as often as required to prevent deterioration. Rusty surfaces must be cleaned before painting. The entire surface of pipe and other exposed parts must be covered, except paint must not be applied to threads of screw jaws, adjustable screws, cotters or gaskets.

13. Threads and bearings of all movable parts must be kept clean, and, except pipe carriers, must be lubricated. Sufficient oil must be used, but not wasted. Parts must be cleaned before being lubricated. Special oil must be used where required.

14. Cotter pins of the proper size must be in place in every hole provided for that purpose, must be in good condition and properly spread.

15. Gaskets for relay boxes and other housings must be in place and in good condition.

16. When movable parts are worn to such an extent as to create excessive lost motion, they must be replaced.

17. Signals should be maintained and tested in accordance with the instructions covered in Chapter XII—Semaphore Signals and/or Chapter XIII—Light Signals.

18. Relays should be inspected and tested in accordance with the instructions covered in Chapter VI—Direct Current Relays and/or Chapter X—Alternating Current Relays.

19. Electric locking should be tested in accordance with the instructions covered in Chapter XVIII—Electro-Pneumatic Interlocking.

20. Rectifiers should be maintained and operated in accordance with the instructions covered in Chapter IX—Rectifiers.

21. Batteries should be maintained in accordance with the instructions covered in Chapter V—Batteries.

22. Switch points must be so adjusted that they cannot be locked when ¼ inch rod is placed between stock rail and switch point 6 inches back from point of switch. Locking edges must be kept square.

23. Switch circuit controllers must be so adjusted that when the switch point is open more than ¼ inch circuit will be shunted or opened, or both. They must be securely fastened to the tie and contacts must be clean and of minimum resistance.

24. Fouling circuits must be so maintained that there are no breaks, leaks, or undue resistance.

25. Wires must be so supported that there will be no interference with proper operation of apparatus.

26. Wires must be kept tight on binding posts to insure good conductivity.

27. Insulated wire must be protected from mechanical injury. Insulation must not be punctured for test purposes.

28. Wire joints must be made in accordance with A.R.A. Signal Section Specification 11033; they must not be made in insulated wires underground or where they cross tracks.

29. Lightning arresters must be properly connected and grounds maintained with resistance to ground of not more than 25 ohms.

30. Bootlegs and conduits must be maintained in good condition.

31. Fibre insulations must be renewed in ample time to prevent interruptions. Section foreman must be notified promptly when an insulated joint or insulated switch rod requires attention. Supervising officer must be notified promptly if defective conditions are not corrected.

32. Before removing rails, switch points or frogs, protecting signals must be secured so as to display the most restrictive indication. Signals must not be restored to regular operation until it is known that the track is safe.

33. Maintainers should know that section foremen understand that where rails are bonded for electric circuit, new rails must not be put in or electric connections broken without facilities to promptly restore the signals to working order. In emergency cases repairs may be made by track forces and maintainer notified promptly.

34. When a signal, switch, movable point frog, derail, lock, detector bar or locking circuit is disconnected, the maintainer must give to the leverman an "out of service" notice in duplicate, showing the part or parts affected; this must be signed by each leverman on duty and one copy handed to the maintainer. All points affected must be safely secured.

35. Line wire must be supported by insulators properly tied in and excessive slack taken up. Broken insulators must be replaced.

36. Pole lines carrying signal wires must be frequently inspected, and maintainers must see that they are properly maintained. Signal wires or cables crossing the track must clear the top of rail not less than .... feet.

37. Top of rail must be kept free from sand, rust, and other foreign matter that would affect proper shunting of track circuit.

38. Switch movements must be kept in good condition, free from dust, grease, dirt and excessive lost motion. All bearing parts must be kept lubricated but excessive lubrication is to be avoided. Lubricants used should be suitable to the weather conditions encountered and should be in accordance with the recommendation of the manufacturer. Bolts must be kept tight

and cotters properly spread. Contacts must be kept clean and properly adjusted.

39. While adjusting a switch movement energy must be cut off the switch motor. Where facilities are not provided to open switch motor circuit, motor brushes must be lifted and fuse at interlocking machine removed until the work on switch movement is completed.

40. Switch movements must be operated by hand after making adjustments to see that they operate properly and without undue strain on any part before operated by power and then by power from the control point for checking operation after making adjustments.

41. Commutator or brushes of switch motor should not be disturbed unless necessary. Commutator should be cleaned with chamois skin moistened with a fine grade of oil. Any surplus oil must be wiped off by using dry chamois skin. When installing new brushes in switch motor they should be placed in position and carefully seated on the commutator by drawing fine sandpaper under the brush while pressing brush against the commutator. The smooth side of the sandpaper must be against the commutator. When finished, sand and dust must be carefully removed.

42. Friction clutch in switch movement must be adjusted so that motor will operate switch under normal conditions but will permit the clutch to slip if there is an obstruction in the switch points.

43. When it is necessary to work on switch movements during snow or rain a rubber cloth or its equivalent should be provided to protect the electrical parts while work is being performed.

44. Magnet brake and overload relays must be checked periodically for proper operation.

45. Coils and wires in switch movements must be kept free from oil.

46. Lock and detector rod connections must be maintained with a minimum of lost motion, inspected and tested periodically for proper adjustment.

47. Wiring must be maintained in such a way that it will not touch any moving part nor become caught between cover and case.

American Railway Signaling Principles and Practices

QUESTIONS ON

CHAPTER XIX

Electric Interlocking

QUESTIONS ON CHAPTER XIX

ELECTRIC INTERLOCKING

General.

1. What is meant by electric interlocking?
2. When was the first machine installed in America?
3. What are the essential elements for a complete electric interlocking system?
4. In power interlocking, what check is necessary between the switch, signal or other unit controlled and the lever, and what is the check known as?
5. How many systems of electric interlocking are in general use?
6. Describe the systems and explain what they are known as.
7. What other system is similar to the electric dynamic system?

Principles of interlocking systems using machines with mechanical locking.

8. What three features essential to safe operation are afforded?

Power supply.

9. When the switch and signal units are operated by direct current, how is the supply usually obtained?
10. What is generally used for the control of relays, etc.?
11. When the units are operated by alternating current, how is the supply furnished?
12. Where is the storage battery with its charging apparatus together with the switchboard in connection therewith usually located?

Electric interlocking machine.

13. How is electric interlocking machine defined by the Signal Section, American Railway Association?

Electric Dynamic Indication System

Machine.

14. What is one type of interlocking machine used to control the electric dynamic system known as?
15. How are the interlocked levers with their guides, indication magnets and circuit controllers mounted and spaced?
16. What is the general practice with respect to units, such as signal and switch units, handled by individual levers?
17. Where two switches are operated together, such as a crossover, how are the controlling levers arranged?

Locking.

18. In what chapter is the locking described?

Lever.

19. What comprises a complete unit in the interlocking machine, and what is the advantage in its design?

20. With what maximum number of tiers of contacts can the lever circuit controller be provided, and how many normal and reverse independent circuits will it control?

21. Where are additional contacts available?

Lamp case and number plate.

22. Where is the combined lamp case and number plate mounted?

23. At what angle is the number plate designed to set?

24. With what levers are lamps and lamp sockets furnished, and in conjunction with what are they generally used?

25. What type of lamp case is furnished if it is desired that two separate lamp indications be given?

Polar relay.

26. What kind of core is provided with the polar relay, and how does the core set with relation to the permanent magnet?

27. What effect does current passing in one direction, through a winding on the core, have upon the relay armature and the contact, and what does current in the opposite direction tend to do?

Indication selector.

28. With what levers are indication selectors used?

29. What does the indication selector consist of, and in what direction does it move?

Lever lock.

30. To what levers may the electric lock be applied, and for what kind of current may it be provided?

31. Where is the lock designed to be mounted?

32. In what position does it lock a lever, and by what means?

33. Why is the circuit for the lock broken through a contact actuated by the lever latch?

Operation of lever.

34. Into what three parts may the lever movement be considered as divided?

35. Why is each switch lever provided with a cam slot?

36. What do the dotted circles 1 to 5 in the cam slot indicate?

37. In the preliminary movement of a lever from position 1 to 2, to what extent is the locking tappet moved, and what effect does this movement have upon all levers which conflict with the new position of the lever in question?

38. In the preliminary movement of the lever is any change made in the switch operating circuits?

39. During the intermediate part of the travel from position 2 to 4, what is the effect on tappet bar, and how are the circuits set up for the operation of the switch?

40. How is the lever held at this point, and what effects the release of lever and permits its movement to position 5?

41. When is the stroke of the locking tappet completed, and what is the effect of the complete stroke of this locking tappet upon levers which do not conflict with the position of the lever operated?

42. Illustrate the method by which the lever is prevented from completing its stroke until the switch has moved to a corresponding position and has sent in its indication.

43. How is the movement of the lever from reverse to normal performed?

44. When the lever has been moved to, or beyond, position 3 when can it be moved forward beyond position 4 or backward beyond position 2?

45. Is the movement of the signal lever identical with that of the switch lever?

46. What insures that before a signal lever can be reversed all levers controlling switches and derails in that route are in the proper position?

Cross-protection.

47. How are the various signal and interlocking units protected against unauthorized energy, and what is the principal element?

48. With what are the lever contacts which form a part of the cross-protection system checked as to their integrity?

49. Explain how current supplied through a cross X will de-energize the polar relay.

50. How does de-energizing the polar relay cut off current from the entire interlocking system?

51. What indication system and type locking is used with the Model 5 machine?

52. Why are two indication magnets used mounted one over the other?

53. How is the frame of this machine designed?

Switch machine control.

54. By what are switch and derail units in this system operated?

55. How many wires are required for the operation of these switch movements, and for what are they used?

56. What wires are used for indication purposes, and how are they used?

57. To what is the circuit connected at the switch location?

58. Describe the circuit that causes the movement of the switch machine when the lever is moved to a position to cause its operation.

59. Describe, in the order in which they perform, the functions of the switch machine and switch points, from the time the lever is placed in operating position until the operation has been completed.

60. Explain what means are provided for the generation of the current which energizes the indication magnet and permits the final movement of the lever to be completed.

61. How is the operation of the switch machine in the opposite direction accomplished?

62. By what is the changing of the motor operating connections at the end of the switch operation effected?

63. How is a circuit set up for the movement in the opposite direction if the switch should not complete its movement?

64. What is the advantage of having the circuit set up if the switch fails to complete its stroke?

65. In what manner is the switch machine, at all times, safeguarded from improper operation and its lever from improperly indicating?

66. What does the safety magnet insure against?

67. Where is the safety magnet mounted, and how is it arranged?

68. What other magnet actuates the armature, and how does the actuation of the two magnets compare?

69. Why are the safety magnet coils so connected into the operating circuit that the operating current flows through them?

70. Why will not the indication magnet armature be lifted by current resulting from crossed wires?

71. From the time the lever is moved to the other operating position until the operation of the switch machine is completed, what further insures against the possible receipt of any improper indication, and how is it accomplished?

72. How are both the indication selector and safety magnet coils connected, and why?

73. When does current cease to flow through the safety magnet?

74. How does the armature of the indication magnet permit the indication to be effected upon receipt of the dynamic current generated by the motor?

75. In what manner is the mechanism now at rest protected against an unauthorized movement?

76. What prevents the switch from being moved by the use of a hand crank from the position occupied, except through breaking the operating circuits by some such means as lifting the brushes from the motor?

77. If brushes are removed and the machine is operated to a position out of correspondence with its controlling lever, what will be the effect upon the switch upon replacement of the brushes?

78. What effect will the manipulation of the pole changer by hand have upon the movement of the switch?

Signal control.

79. How are motor-driven signals operated?

80. How many types of signal mechanisms are used for the signal control?

81. Describe the non-automatic type and explain when it is furnished.

82. How is the semi-automatic type operated?

83. When is the semi-automatic also furnished for non-automatic high signals?

84. In the two-position non-automatic signal how many wires besides the common are required for its operation?

85. For what is this wire used?

86. When the signal is to operate in three positions, how many control wires are required?

87. In the case of semi-automatic control, how many wires are required?

Non-automatic signal control.

88. Explain the circuit of the non-automatic signal control after reversing the controlling lever.

89. To what position does the reversing of the lever cause the semaphore arm to move, and how does the movement connect the holding field of the motor with the operating field and armature?

90. What retains the signal in the desired position as long as the circuit is intact?

91. What reduces the current used to hold the signal in the desired position to a minimum?

92. Why is the signal lever not indicated in the reverse position?

93. Explain the effect on the signal when the lever is returned to the normal indication position.

94. Explain how the indication, which permits the lever to be put in the normal position, is accomplished.

95. What checks the speed of the returning mechanism and brings it to rest without shock?

96. Is the operation of the three-position signal from the zero to the 45 degree position the same as for a two-position signal?

97. Upon what is the operation from the 45 to the 90 degree position ordinarily dependent?

98. How is the signal held in the 90 degree position?

99. When the signal is returning from the 90 degree position and is to be held at the 45 degree position, how is its movement arrested?

100. How is the signal retained in the 45 degree position?

Semi-automatic signal control.

101. When it is desired to have the signal controlled semi-automatically, how does the operation differ from the operation of the two-position signal, and how is the indication accomplished?

102. When is the preliminary movement of the mechanism under control of the lever, and why is such control necessary?

103. Upon what is any movement beyond the preliminary movement dependent?

104. Trace the circuit for a two-position semi-automatic signal, shown in Fig. 12, and explain when the mechanism will travel to the zero degree position and when it will be carried on to the proceed position.

105. When and how is the signal mechanism and semaphore arm retained in the proceed position?

106. What effect does the entrance of a train into the track section controlling the signal have upon the semaphore arm and mechanism?

107. How is the speed of the returning mechanism checked at the zero degree position?

108. During what time is the mechanism retained in the zero degree position?

109. What action is necessary, with some control circuits, before a second clearing of the semaphore arm can be secured?

110. In what position of the lever is current cut off the motor, and what drives the mechanism to its minus (—) 40 degree position?

111. In what position of the mechanism are the motor armature and operating field connected into a closed circuit?

112. What permits the lever to be restored to its normal position?

113. What action of the mechanism takes place should the controlling lever be placed in the normal indication position before the entrance of a train into the controlling track section?

114. How does the operation of the signal mechanism, from the time the semaphore arm begins its movement to the stop position until its return to that position, compare with the non-automatic signal?

Type "F" System

Machine.

115. In what chapter is the interlocking machine described?

Type "F" switch circuit controller.

116. How is the electrical energy for operating the switch machines of this system carried to these units?

117. How is each switch machine controlled?

118. How is the Type "F" controller housed, and where is this mounted?

119. Is the Type "F" controller integral with the switch machine?

120. When only does the Type "F" controller for direct current interlocking require current?

121. Describe the operation of the Type "F" controller shown in Fig. 15.

122. How are the pole changing contacts actuated?

123. Describe the circuit for magnet N of the pole changer.

124. Describe the circuit for the operation of the controller when the lever is moved from the normal to reverse, and returned to its normal position.

125. What is the effect when magnet N is energized?

126. Describe the action when magnet N is energized.

127. Describe the operating circuit for the Type "F" controller.

128. Why is a local circuit through the other front contact operated by magnet N also closed?

129. How does the energization obtained by electrically energizing this magnet compare with a plain permanent magnet?

130. Why is there a permanent magnet core in this coil?

131. How does current flowing in the direction stated affect the polar armature, and how is magnet N then connected?

132. How does current, flowing as indicated, lock polar armature P?

133. How will current flow when the other two sets of contacts, actuated by polar armature P, are connected to switch motor and field?

134. What effect will the switch motor in revolving have upon the switch points?

135. What action must take place with regard to neutral magnet N and in turn polar magnet P before current will cause reversal of switch movement?

136. What action finally allows the switch control lever to be moved to the reverse position?

137. Describe the movement of the lever and the circuit that causes the movement of the switch from reverse to the normal position.

138. What causes current to flow through the motor armature in a direction opposite to that when the switch movement traveled from normal to reverse?

139. When will contact again be broken at the motor cut-out circuit controller, and how will the position of the controller springs compare with those shown in Fig. 15?

140. At what position of the motor are the motor cut-out circuit controller contacts shifted to the middle position, and when are they moved to the reverse position?

141. What is the reason for the motor cut-out circuit controller maintaining both circuits closed in the middle position during the entire movement of the switch?

142. How does the automatic overload circuit breaker R compare in operation with the overload circuit breakers on power switchboards?

143. Describe the automatic overload circuit breaker R.

144. When is there a heavy surge of current through the motor circuit, what is the cause, and when is the current reduced to what is usually known as the motor operating current?

145. What would be the result if an ordinary circuit breaker were employed, adjusted to open for a heavy current, and why is this prevented with the breaker R?

146. If the breaker opens due to high current for an excessive length of time, how can it be restored, and how is it accomplished?

147. How is a crossover wired as compared with single switches, and how many Type "F" controllers are used?

SS scheme of control.

148. Describe the SS system or scheme of control.

149. Of what two interlockings is this control characteristically a part?

150. What does complete protection require, and how can it be secured?

151. What do the KR relay contacts in conjunction with switch lever contacts insure?

152. How may provision be made, so that the switch points must be in proper position and locked when a signal to proceed is displayed?

153. In the SS scheme of control why is a ground or cross a remote possibility, and what are some of its advantages?

154. With the SS scheme of control should a switch not respond to a lever movement and through some fault or series of faults the lever movement be completed, would subsequent operation of any signal lever cause a signal to clear?

155. Should a switch be accidently or maliciously changed in position, how would any signal cleared for train movement over the switch be effected?

Switch Indication Circuits

156. How do the switch indication circuits compare with the polarized switch indication circuits described in Chapter XVIII—Electro-Pneumatic Interlocking?

157. Describe the normal indication circuit for a crossover where the quick switch is used as shown in Fig. 15a.

158. Describe the reverse indication circuit using the quick switch.

159. Why are there two additional contacts in the indication circuit controller on each end of the crossover?

160. Describe the shunt on the KR relay with switch machine operating from normal to the reverse position.

161. Explain the action that will cause the KR relay to become energized in the reverse position, and explain how the lever stroke is effected.

162. How is the shunt applied to the far end of the crossover?

163. How does the wiring of a turnout or single switch compare with that of a crossover?

164. What is the main change in the circuit outside the interlocking station where the quick switch is not used?

165. How does the indication circuit in the interlocking station, shown in Fig. 15b, compare with that using the quick switch?

166. Describe the circuit.

167. How does the wiring of a single switch compare with the wiring of the crossover?

168. By eliminating the quick switch and installing the checking contacts in the Type "F" controller, how may the lever be operated as compared with the operation with the quick switch?

Cross-protection.

169. What safeguards are inherent in the circuits employed which make cross-protection devices unnecessary?

170. How does the alternating current switch circuit controller compare with the direct current type?

171. How is an overload on the switch movement taken care of?

172. How are the contacts of this controller operated?

173. Describe the salient pole induction motor.

174. How does the moving of the switch lever in the interlocking machine operate the motor of the switch machine?

175. How is the restoring circuit maintained even though the control circuit or the local circuit of the controller should become open?

176. Describe an earlier type of this alternating current switch circuit controller.

Switch and signal levers.

177. In what chapter are switch and signal levers as well as their operation described?

Type 341 System

178. How does the Type 341 electric interlocking compare with the electric dynamic indication system?

Machine.

179. How are the rocker links connected to the locking tappet?

180. Where are the electric locks located, and how do they prevent the lever latch being raised unless the electric lock is energized?

181. Where are the low-voltage circuit controllers mounted, and how are they operated?

182. Where are the high-voltage circuit controllers mounted, and how are they operated?

183. Where are the indication and safety magnets, and how is the indication slide attached?

184. Is it necessary to disturb adjacent units to remove the indication slide or magnet?

Operation of switch and signal levers.

185. Describe the diagram of circuits for Type 341 system shown in Fig. 21.

186. What is the condition for the attraction of the indication armature and what is the result on the lever?

187. Referring to the switch machine, what are the two windings marked 300 ohms, and what is their purpose?

188. How many wires does this system of switch control require, and how are they designated?

Switch cross-protection.

189. Describe how the switch cross-protection is effective.

Switch operation.

190. Describe the circuit for the complete operation of a switch.

Signal operation.

191. Describe the circuit for the complete operation of a non-automatic signal.

192. How does the operating current flow while the signal starts and moves to 4 degrees from the stop position?

193. For positions above 4 degrees how does the current flow?

194. How does the indication and cross-protection device applied to a signal lever compare with that described for a switch lever?

195. What is it that controls the cross-protection armature XPA?

196. Describe the indication circuit when the lever is moved toward the indication position and finally placed in the normal position.

197. How does the operation of a semi-automatic two or three-position signal compare with the non-automatic signal?

Signal cross-protection.

198. Since the indication is dependent upon the signal being disconnected from wire GCH at the signal and connected to wire GCH at the machine through wire GM and magnet D, what combination of crosses or grounds would be necessary to move the signal from the stop position, even though cross-protection magnet D was not employed?

199. Since wires HG and GM are not connected directly to positive or negative energy at the interlocking machine, what combination of crosses would be necessary to clear the signal even if no protective devices were employed?

200. When is magnet D checked as to its adequacy to perform its intended function?

201. Should positive energy be connected improperly in any way to either HG or GM wire while the lever is in the normal position, what would be the result?

Table Machine

202. What form of interlocking machine is used for the control and operation of electric interlocking plants, and when is it generally used?

203. Describe the table machine.

204. Generally, what does each assembly comprise?

205. When more than one assembly is used, how are they mounted?

Locking.

206. How was locking arranged in the earlier types of these machines, and how is it arranged in later types?

Lever.

207. How do the switch and signal levers operate as compared with those of the electro-pneumatic interlocking machine described in Chapter XVIII—Electro-Pneumatic Interlocking?

208. To what is a locking segment attached?

209. What levers and in what position may these segments be provided so as to be locked by latch 41 of the electric lock?

210. How is locking shaft 3 driven?

211. In what position of the lever stroke may circuit controller contacts be adjusted to open or close?

212. When required to increase the number of circuit controller contacts how can it be accomplished?

213. With how many indicators may each assembly be equipped?

214. When indicators are of the magnetic type what information are they usually lettered to convey?

215. How are indicators on signal levers usually lettered?

216. For what are other spaces used?

217. How are indicators sometimes operated and marked when used with electric locks?

218. What is sometimes used instead of the magnetic type indicators as shown in Fig. 22?

Interlocking system controlled by centralized traffic control type machine.

219. What type of interlocking system has no locking between the levers?

220. How is the proper sequence of the operation of the signal and interlocking units obtained with this type machine?

221. When is the centralized traffic control type machine generally employed?

222. What advantage in operation is there with this type of machine?

Automatic Interlocking

223. How is automatic interlocking defined by the Signal Section, A.R.A.?

224. How is an automatic interlocking operated?

225. Referring to Fig. 28 and assuming that no trains are within the limits of the interlocking on either road, how will a train entering upon track circuit E effect signals 3 and 4?

226. Before signals 3 and 4 display the "proceed" indication, in what position must home signals 6 and 7 and "approach" signals 5 and 8 be?

227. Should a train approach on the crossing line at this time when will it receive signals to proceed?

228. What provision is generally made whereby a train which may be stopped at a home signal on one line due to a train standing on the approach circuit of the crossing line and not ready to proceed, may get signals to proceed?

Switch-and-Lock Movement

229. How is switch-and-lock movement defined by the Signal Section, A.R.A.?

Model 2 switch machine.

230. On what voltage and kind of current does the Model 2 switch machine operate?

231. How is movement transmitted from the switch machine to the switch?

232. How are the switch points moved?

233. How is the locking plunger and detector bar (if used) actuated?

234. Where detector bars are not used what is sometimes connected to rod N?

235. How is the movement of pole changer B effected and how is it operated?

236. How is the indication current provided, and what checks the speed of the motor and brings it to rest without shock?

237. What provision is made to relieve the switch mechanism from injurious strain should it suddenly be brought to stop by an obstruction in the switch points?

238. How is provision made for operating the movement by hand?

Model 4A switch machine.

239. How is the Model 4A switch machine assembled, and on what voltage and kind of current does it operate?

240. Of what do the operating parts consist?

241. How are the various parts of the switch machine operated?

242. How is the intermittent movement of the locking bar and detector bar accomplished?

243. How is staggered locking provided and operated?

244. How is the throw rod locked in both extreme positions?

245. How are the switch points thrown at the proper time?

246. How do the principles of the pole changer movement, shown in Fig. 31, compare with the Model 2 switch machine?

247. How are contact blocks S_1 and S_2 operated?

248. When is the tripper arm placed in a position to engage with the proper cam, and how is it accomplished?

249. What provision is made for generating the indication current?

250. What provision is made to protect the mechanism from shock should its movement be obstructed?

251. Where is a circuit controller, as shown in Fig. 32, when furnished, located?

252. Of what do the operating parts of the circuit controller consist?

253. When and how is the commutator moved out of engagement with the contacts?

254. When and how is the commutator rotated on its axis?

255. When and how is the commutator raised into engagement with the contacts?

256. What does this control insure?

257. What is the maximum capacity of the controller, and how are the contacts adjustable?

258. May the switch machine be used for a right or left-hand layout?

259. When is a double locking cage furnished?

260. How is provision made for operating the machine by hand?

Model 5 switch machine.

261. Of what does the Model 5 switch machine consist?

262. How does the operation of the Model 5 switch machine compare with the Model 4A?

263. What is the advantage in the way the motor is attached to the machine?

264. Where is the magnetic brake mounted, and what does it provide for the motor?

265. How is provision made for operating the movement by hand?

266. What provision is made to prevent current being applied to the motor while crank is inserted?

267. Why is the magnetic brake provided?

268. Of what does the magnetic brake consist, how does it rotate, and how is it normally held against the brake housing?

269. What causes the friction disc to be released when current is applied to the motor?

270. Why is the brake magnet made "slow release"?

271. Why is the brake made adjustable?

272. What must be done when operating the machine by hand, and what provision is made for same?

273. How does the Model 5 switch machine compare in size to the Model 4A and what is the advantage?

274. What changes are necessary when provided with one or two lock rods?

275. For what voltage and kind of current is the machine regularly furnished, and for what voltage and kind of current are a number of these machines sometimes furnished?

276. Are the 20-volt direct current machines equipped with a magnetic brake?

277. How was the motor arranged on early designs of these machines for operation on 110 volts direct current?

Model 5A switch machine.

278. What is the principal difference between the Model 5A and the Model 5 switch machines?

279. May the Model 5A machine be furnished with magnetic brake?

280. For what voltage, kind of current, speed and kind of indication is the Model 5A regularly furnished?

281. Where is the motor housed and located, and what is the advantage in changing from one type of motor to another?

282. What changes in gears are required for various motors, and is a change in the machine frame necessary in changing gears?

283. Why is its application universal, and only what omission or addition is necessary when making the different applications?

284. How does the operation of the Model 5A switch machine compare with the Model 4A?

285. How may the point detector be operated?

286. Describe the point detector as shown in Fig. 35.

287. When is roller F forced into a slot in cam bar, and where does this force the contact member?

288. How does this action affect the contacts?

289. When and why do the left-hand rollers on contact member E drop into depressions in detector rods as shown in 2B?

290. How does this affect the reverse contacts?

291. What will prevent the operation of contact member E from the central position?

292. What will be the result unless all detector rods and lock rods are in place and operative?

293. What provision is made for hand operation, and how is it accomplished?

294. What must be done before the crank can be inserted, and what protection does this provide?

Model 5B switch machine.

295. For what control and operation is the Model 5B switch machine equipped?

296. How does the Model 5B switch machine compare with the Model 5A?

297. Externally, what do the parts consist of, and what is their purpose?

298. How are these levers referred to, and how are they marked?

299. What does the position of the selector lever determine?

300. Why is an interlocking feature used between these levers?

301. What effect does the reversal of the selector lever have on the mechanism?

302. What effect does the reversal of the hand throw lever have on the apparatus?

303. In the Model 5A switch machine how is cam roller A attached?

304. In the Model 5B dual-control machine where is roller A mounted?

305. How may the cam crank be actuated?

306. When clutch coupling CC is up with what is it coupled, and in what position must selector lever and switch machine be?

307. When clutch coupling CC is down with what does it couple, for what operation of switch is it in position, and in what position must the selector lever be?

308. How is clutch coupling CC mounted?

309. Although the clutch coupling is free to move up and down when actuated by the selector lever, what effect does the movement of the shaft have on it?

310. How and when is the clutch coupling moved?

311. What gears are engaged by the clutch coupling, and is there an intermediate position where the switch is not under full control by hand or by power operation?

312. When the selector lever is reversed, in what position is clutch coupling CC, and with what gear is it engaged?

313. If the hand throw lever is reversed, as indicated by arrow, what gears will it cause to rotate, and in turn what gear will be driven?

314. Clutch gear CG being engaged with coupling CG drives what shaft?

315. What causes the throw and locking bars to operate?

316. For power operation in what position would the selector lever be, and with what would clutch coupling CC be engaged?

317. How is the main gear actuated?

318. What three main functions does the selector lever perform?

319. Where is the selector lever mounted?

320. In what fashion is the selector shaft formed inside the mechanism?

321. When the selector lever is in the normal or power position in what position will the crank portion of the shaft be, and in what position will it be when the selector lever is reversed or in the hand throw position?

322. What will the turning of crank shaft CS operate?

323. When the selector lever is moved from normal to reverse, what will be the effect?

324. What action opens the motor operating circuit?

325. What releases the motor brake?

326. How many pivot points have levers CCL, and when may any or all function?

327. In what position is the selector lever when the turning of shaft CS raises clutch coupling levers CCL, and how does the action compare with that of lever CL?

328. What raises clutch coupling CC?

329. When will the levers continue to pivot at P1 and when will they pivot at P2?

330. What action causes the compression of spring S1?

331. What action does the compression of spring S1 create?

332. What action raises clutch coupling CC into proper engagement with clutch gear CG?

333. In going from manual to power operation, if the jaws on the clutch coupling fail to register with the jaws on the main gear as the coupling moves down, what completes the downward movement of the clutch coupling when the jaws are in proper alignment?

334. On what voltage and kind of current is the Model 5B switch machine regularly made to operate?

Model 5C and 5D switch machines.

335. How do the Model 5C and Model 5D switch machines compare with the Model 5A and Model 5B switch machines?

336. What are the various parts of the switch machine controller?

337. With what are the operating contactors provided, and what is the purpose?

338. Why are the overload relays provided?

339. What automatically resets the contacts of the overload relay ready for the next operation?

340. At what current are they usually set to operate, and are they adjustable?

341. Describe the master relay.

342. How are the normal and reverse operating contactors controlled?

343. When do these contacts move to a central position, how long do they remain in that position, and what is their function?

344. How is the motor operating circuit controlled?

345. How many coils have each of the overload relays, and what are they known as?

346. Why will the overload relay not respond to a surge of current such as occurs at starting, but will respond to a sustained overload of predetermined value?

347. Why are the stick or holding coils C and C^1 provided?

348. What suppresses the arc caused by the contactors breaking the motor circuit?

349. How is the magnetic brake connected, and when is it released?

350. When may the master relay be omitted?

351. On what voltage and kind of current are the Model 5C and Model 5D switch machines regularly made to operate?

Style "M" switch machine.

352. Of what does this machine consist?

353. How are the units housed?

354. How is power transmitted from the motor, and what does it drive?

355. How may connections to the switch points be made?

356. How is the position of the switch points checked and secured?

357. Where is the circuit controller mounted, and how is it operated?

358. Are motors for direct current or alternating current interchangeable?

359. What provision is made to protect motors against overload or shock?

360. Starting from the normal position, as shown in Fig. 43a, describe the movement of the various parts of the machine during the operation to the reverse position.

361. Why is motion not being transmitted to lock bar *Z* when machine is in the relative midstroke position as shown in Fig. 43b?

362. What action has moved operating bar Y to the reverse position and secured it, thus driving locking bar *Z* to the reverse position, as shown in Fig. 43c?

363. What feature allows the same lock rod to be used for both right and left-hand movements as will be noted in Fig. 43?

364. Is provision made for hand operation, for two lock rods, and for application of point detector?

365. On what voltage and kind of current are the Style "M" switch machines made to operate?

Style M-2 switch machine.

366. How does the Style M-2 switch machine compare with the Style "M" machine?

Style M-22 switch machine.

367. For what control is the Style M-22 switch machine equipped, and how does it compare with the Style M-2 machine?

368. How does Fig. 45 show the shaft of the main driving crank mounted and supported?

369. How is both horizontal and vertical support obtained for the shaft?

370. How is the worm gear fitted to turn on the main shaft, and how is its hub supported?

371. What holds the clutch together as a complete unit, and where is it located?

372. Where is the clutch secured, and how does it rotate?

373. How do the teeth of the upper clutch member compare with the teeth of the worm gear?

374. Where does hand throw pinion B rotate, and how is it driven?

375. How do teeth on its lower hub engage with spring clutch coupling A, and when only can the engagement be made, and what prevents them engaging at any other time?

376. Why is it necessary to transmit motion to the main driving crank through the spring clutch which is splined to the main shaft?

377. How is the selection between the two sources of power obtained?

378. How many cams has the selector lever cam shaft, and what do they operate?

379. What is motor cut-out yoke K's function?

380. Are both yokes positive in action?

381. How is the clutch shifter yoke designed, and what is its function?

382. With what does the locking arm on the lower end of the clutch shifter yoke engage?

383. When the selecting lever is thrown to the hand-operation position, what is the effect upon the locking arm, and how is the complete movement of the selector lever effected?

384. What allows the selector lever (except when locked out, as explained in the description of Fig. 46) to be moved from one extreme position to the other regardless of the positions of the sets of teeth which must mesh to permit either "hand" or "motor" operation?

385. Should these teeth not mesh when the selector is thrown what is the result?

386. On what voltage and what kind of current is the Style M-22 machine furnished to operate?

Style M-25 switch machine.

387. How does the Style M-25 machine differ from the Style M-22 machine?

388. Style "M", M-2 and M-22 machines, furnished for operation on 20 volts direct current, may be obtained with what different gear ratios?

389. Machines equipped with what gear ratios may be controlled by standard polarized relays?

390. How are machines equipped with the 7.5 seconds ratio usually controlled, and why?

Contactor type controller.

391. What is included with the contactor type controller, shown in Fig. 47, for overload protection?

392. How are these controllers furnished with regard to latch for resetting overload relay?

393. How must the latch be released in order to reset the relay?

394. When will those without the latch reset?

395. How may these controllers be mounted?

396. What effect will the operation of the switch control lever have on the switch machine shown in the normal position in Fig. 48?

397. It will be noted that the heater element of the reverse thermal relay is now connected in series with the motor field and should the motor be overloaded and a current of more than 9 amperes flow through the heater element, what will be the result?

398. After the heater element cools and allows its contact to close, what other action is necessary before the stick relay will energize?

399. What action is therefore necessary before the switch motor will operate after the heater element cools?

400. What other type of controller may be used for operating 20-volt switch machines?

Instructions

401. How must interlocking machine be kept?

402. What instructions and advice must be given to levermen when necessary?

403. How must interlocking plants be handled during snow and sleet storms?

404. When only may levers or other operating appliances be operated by other than levermen?

405. What must be done to insure that all appliances including machine locking, are in proper condition and that levers can be operated only in the predetermined order?

406. What are the requirements with respect to handling locking?

407. How must seals and padlocks be handled?

408. What are the requirements with regard to opening or short circuiting circuits or taking any other action which may cause failure of signals or other apparatus with resultant train delays?

409. What are the requirements with respect to handling relays?

410. What is required with respect to standard clearances?

411. How must foundations be maintained?

412. When and how must paint be applied?

413. What is required with respect to lubrication?

414. How must cotter pins be maintained?

415. How must gaskets be maintained?

416. What must be done when movable parts are worn to such an extent as to create excessive lost motion?

417. In accordance with what instructions should signals be maintained and tested?

418. In accordance with what instructions should relays be inspected and tested?

419. In accordance with what instructions should electric locks be tested?

420. In accordance with what instructions should rectifiers be maintained and operated?

421. In accordance with what instructions should batteries be maintained?

422. What are the requirements with respect to the adjustment of switch points and the maintaining of locking edges?

423. How must switch circuit controllers be adjusted and maintained?

424. How must fouling circuits be maintained?

425. How must wires be supported?

426. Why must wires be kept tight on binding posts?

427. What are the requirements with respect to protecting and handling insulated wire?

428. In accordance with what specification must wire joints be made and where must joints not be made?

429. How must lightning arresters be maintained?

430. How must bootlegs and conduits be maintained?

431. When must fibre insulations be renewed and how must insulated joints be handled?

432. What precaution must be taken before removing rails, switch points or frogs and when may signals be restored to regular operation?

433. What understanding should maintainers and section foremen have with reference to changing rail and how may emergency repairs be handled?

434. What action must be taken by maintainer when a signal, switch, movable point frog, derail, lock, detector bar or locking circuit is disconnected?

435. How must line wire and insulators be maintained?

436. What is required with respect to inspection and maintenance of pole lines carrying signal wires and how much must signal wires or cables crossing the tracks clear the top of rails?

437. In what condition must the top of rails be kept?

438. How must switch movements be maintained?

439. What must be done before adjusting a switch?

440. How must switch movements be operated after making adjustments?

441. How should commutators and brushes of switch motor be maintained?

442. How must friction clutch in switch movement be adjusted?

443. What are the requirements when working on switch movements during snow or rain?

444. When and why must magnet brake and overload relays be checked?

445. What precaution must be taken with coils and wire in switch movements?

446. How must lock and detector rod connections be maintained, inspected and tested?

447. How must wiring be maintained?