American Railway Signaling Principles and Practices

CHAPTER XVIII

Electro-Pneumatic Interlocking

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General.

Electro-pneumatic is one of the interlockings given the general name of power interlockings and, as the name "electro-pneumatic" suggests, electricity and air are the operating agencies. Electricity is used to control the magnets which in turn control valves for the admission and discharge of compressed air to and from cylinders by which the switches and signals are operated.

Rapid strides have been made in the development of electro-pneumatic interlockings, the same as with other features of signaling, and this chapter will deal with electro-pneumatic interlockings that have been in service for quite some time, as well as the up-to-date (1930) installations.

For the operation of an electro-pneumatic interlocking certain essential elements are necessary. They may be listed as follows: a supply of compressed air at a pressure of from 50 to 100 pounds per square inch; a supply of current from 12 to 16 volts, usually furnished from a storage battery; an interlocking machine for controlling the various units; switch and signal operating mechanisms with their controlling and indicating circuits; miscellaneous units of a special nature due to local conditions, such as smashboards at a drawbridge, train stops, etc.

In addition to the above, certain other features such as track circuits, indicators, electric switch locking, etc., are necessary for the complete interlocking.

Compressed Air System

Two general methods of supplying air are used: the earlier arrangement being to have large compressors located at various points along the road, while the later installations use a local compressor for a particular interlocking. In the earlier arrangement a main air line consisting of a pipe, generally 2 or 3 inches in diameter, extends between the compressors. Duplicate sets of compressors are usually used in order to insure as reliable a supply as possible. These compressors are driven by electricity, steam or other available power as local conditions may justify, and are controlled automatically or manually. They are generally of sufficient capacity not only to take care of the signal system, but also to supply air for various other purposes, such as operation of tools in shops, ash hoists, charging train lines of trains in yards, etc. In fact, frequently the other facilities consume considerably more air than the signal system. The air is ordinarily compressed to from 100 to 120 pounds per square inch, sent out to the main air line and carried for various distances, depending on quantity of air to be used, size of air pipe, etc. The compressors are located at intervals sufficient to maintain a pressure of from 65 to 80 pounds as a minimum.

At interlockings, branch pipes ordinarily of ¾ inch diameter are tapped off the main line to supply air to the individual switches and signals, generally reducing to ½ inch at the unit to be operated.

The main air line is equipped with gate valves at the various branch locations, located at both sides of the branch line leading to the units to be operated; the valves being arranged so that a section of the main pipe may be shut off, by closing the nearest valves at adjacent locations, without air being shut off from any unit, as one compressor would supply air up to the closed valve from one side while the other compressor would supply air to the closed valve from the other side. There is a valve provided in each branch line so that renewals may be made without disturbing the main air line.

The air lines should be of best quality galvanized extra heavy wrought iron or steel pipe. In long runs of main air line there is considerable expansion and contraction which is taken care of by the installation of expansion joints. It is customary to provide for one inch of expansion or contraction for each 100 feet of pipe above ground. The expansion joint consists of a cylinder, gland, guide, collar, nut, piston, guide bolts, and packing properly assembled and arranged so that the piston can travel back and forth in the cylinder to provide for at least 6 inches of travel where two-inch pipe is used. When the line is above ground expansion joints are located not more than 500 feet apart and where the pipe is underground not more than 1500 feet apart. In some installations return pipe bends have been used instead of expansion joints. The main air line is securely anchored midway between each pair of expansion joints and at the end of line. It should be kept in good surface and graded so that condensation will run into suitable drainage tanks.

Branch air lines ordinarily are taken from the top of the main air line and connection made by means of two street or service ells so arranged to form a hinged joint to allow for expansion and contraction.

Where the line is underground the various expansion joints and valve locations are boxed in, so that ready access can be had in case of necessity.

In later installations the main air line has been restricted to a particular interlocking plant instead of having the various compressors tied together by long stretches of air pipe line. This is accomplished by using a small compressor and confining the air line to the limits of the particular interlocking, thus making each interlocking plant a self-contained unit. A new type of switch valve is used with this installation through which switches can be operated at considerably lower pressure, as well as using less air. This feature will be explained later.

The layout ordinarily consists of a duplicate set of small motor-driven compressors of as low a capacity as 10 cubic feet per minute with suitable switchboard arrangements so that one or both com-

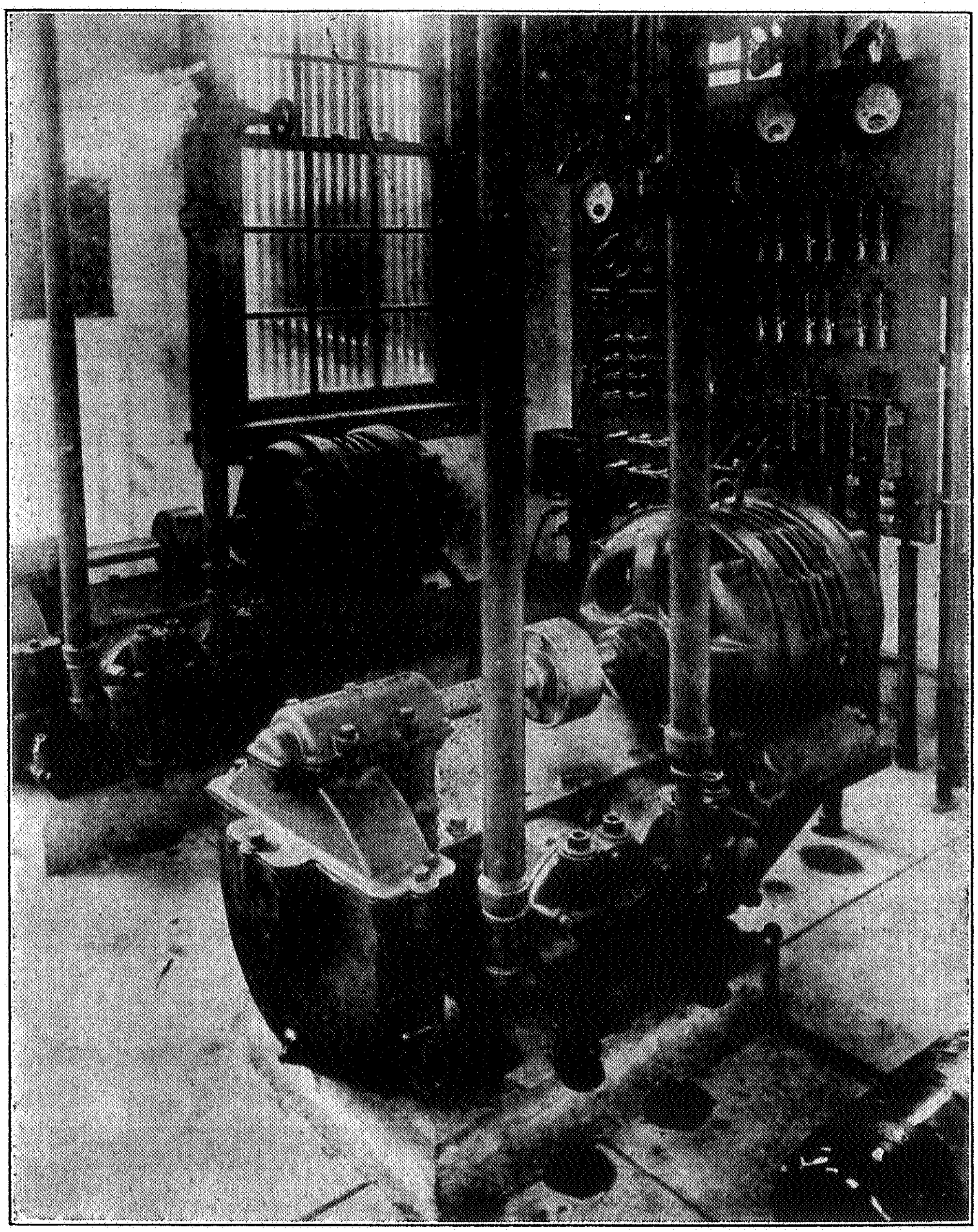


Fig. 1.
Typical Layout of Duplicate Set of Motor-Driven Low-Pressure Compressors.

pressors may be operated. They are automatic in their operation cutting in when the pressure is reduced to approximately 50 pounds and cutting out when the pressure approximates 60 pounds. Usually the arrangement provides that if the first compressor does not start at 50 pounds the second one starts when the pressure is reduced to 45 pounds. The cut-in and cut-out points vary, depending upon the practice of the individual railroad.

A typical air compressor layout is illustrated in Fig. 1.

In installations of today light signals are being installed generally so that it is necessary for the compressors to be large enough to take care of the operation of the switches only and this permits the use of much smaller compressors than required for the earlier installations.

The size of compressor needed for a particular layout where switches only are to be operated may be approximated by taking the number of switch cylinders in the interlocking and multiplying by 0.2 cubic foot of free air per minute. This should in turn be multiplied by 3 based on operating the compressor one-third of the time. This would approximately represent the capacity rating of the compressor required, the manufacturer's rating being based on piston displacement. The next higher capacity compressor as furnished by the manufacturer should then be selected. If other air units are to be operated from the same compressor the consumption of these must be known and this amount added to the amount required for switches, the size of compressor being increased accordingly.

Suitable cooling facilities are provided so that practically all the condensation will take place before the air reaches the air line. A typical layout of a cooling arrangement is illustrated in Fig. 2.

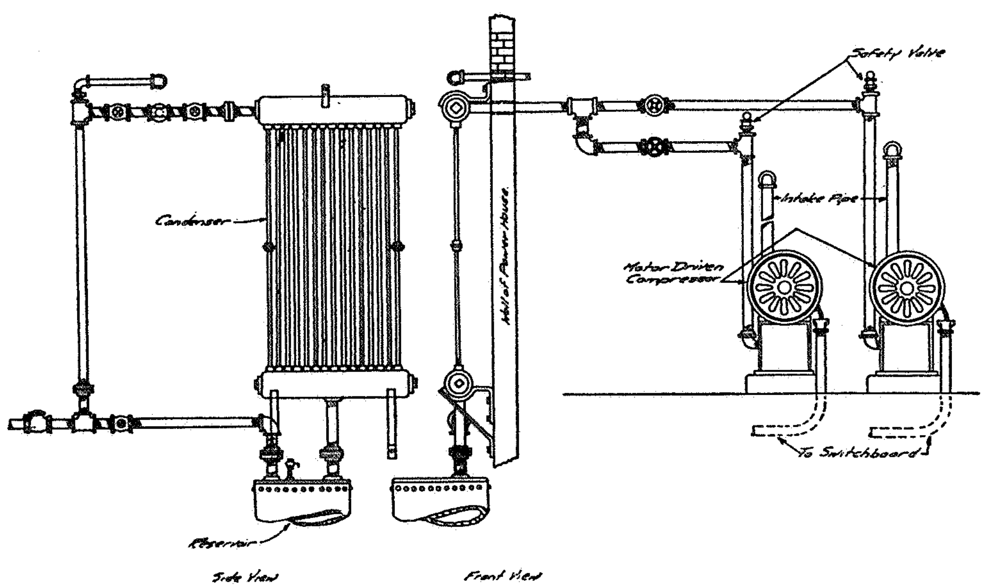


Fig. 2.
Air Cooling Layout.

On installations where large quantities of air are used, such as on subway and elevated railroads, more extensive cooling devices are utilized.

The operation of compressors is dealt with in text-books which are available from manufacturers of compressors.

Electrical Energy

The electrical energy for the control of the various units of an electro-pneumatic interlocking is ordinarily furnished from a storage battery of approximately 12 to 16 volts, although electric current from any other reliable source may be used. Some installations use alternating current instead of batteries for the operation of the various units, in which case a voltage of 55 or 110 is employed.

Whether the supply is direct current or alternating current, the amount required for each switch is quite small. For instance, with an installation using storage battery the magnets are of 130-ohm resistance. Two magnets or the equivalent are connected in series so that the current consumption amounts to approximately 46 milliamperes for each set of magnets energized simultaneously.

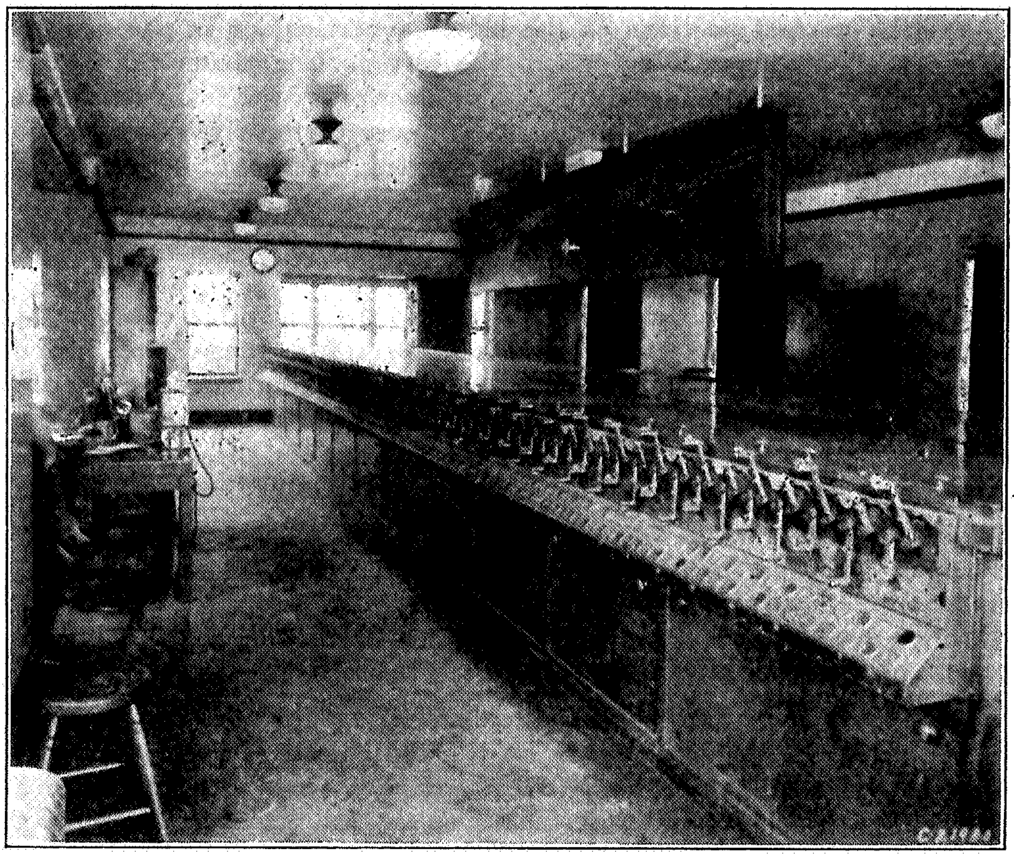


Fig. 3.
Electro-Pneumatic Interlocking Machine.

The valves controlling the supply of compressed air which move the switch, signal or other unit, are controlled by electromagnets. The electric locks, indicators, relays, etc., are controlled electrically.

Interlocking Machine

The Signal Section, American Railway Association, defines Electro-pneumatic Machine as: An interlocking machine designed to control the units electrically and operate them pneumatically or electrically. While the machine is generally spoken of as an electro-pneumatic machine, this is not strictly correct as air does not enter into the control of the machine itself. In fact the same type of interlocking machine may be used for the control of an electric interlocking. It consists of small levers spaced 2½ inches apart, conveniently arranged in a common frame, the odd-numbered levers extending upward, the even-numbered levers downward. This type of machine is illustrated in Fig. 3.

The odd-numbered levers are used generally for controlling switches and similar units; the normal position of the lever is to the left, and the reverse position is to the right. The even-numbered levers are used generally for controlling the signals and similar units; the normal position of the lever is vertical or in the center. When a signal lever is moved to the left or L position the signal governing a train moving in the same direction as the lever is moved will be cleared, while moving the same lever to the right or R position will clear the signal for a train moving in that direction. This method of control permits controlling opposing signals from the same lever instead of using a separate lever for each signal with the necessary mechanical locking between them.

While the odd-numbered levers are used generally for controlling switches, etc., and the even-numbered levers for signals, etc., there is nothing to prevent the odd-numbered levers being used for signals or the even-numbered levers being used for switches if desired. This is accomplished by installing the proper fittings for the use intended.

Mechanical locking between the levers is provided in order that the movements of the various levers precede each other in a predetermined order so that when the signal lever is reversed it locks that particular route as well as prevents the setting up of any conflicting route. The mechanical locking feature is covered in Chapter XVI—Interlocking.

Each lever operates a shaft that extends from the front to the back of the machine. On the forepart of the shaft is the driver that operates the mechanical locking. Near the center of the shaft is a beveled gear drive which operates a vertical shaft equipped with a hard rubber roller on which the contact bands (hereinafter called bands) are located for closing and opening electric circuits for the control of the operative interlocking units. While the lever only travels 60 degrees the vertical shaft travels 120 degrees due to the beveled gear drive previously referred to, having a ratio of 1 to 2. The object of having this shaft travel 120 degrees is to permit a very liberal opening of the various contacts with the lever in certain positions. In the early types of machine this vertical roller did not exist and the middle portion of the horizontal shaft was used for mounting the bands. This shaft being connected direct to the lever, moved through an arc of only 60 degrees which required very close adjustment of certain contacts. To assist in this adjustment a large hard rubber collar was placed over the roller on which the bands for the switch control and electric lock circuits were placed, which permitted a wider margin to be maintained. This part of the machine is called the spring combination and is further designated as horizontal or vertical spring combination, depending upon whether the horizontal or vertical roller is used.

The rear portion of the shaft is equipped with the various segments, which, through the operation of magnets connected thereto, lock or release the levers in different positions. The function of these magnets will be explained later.

Switch lever.

Figure 4 is a perspective diagram of a complete switch lever. From a study of this diagram will be found the items previously referred to, as well as a few other important items that will be covered later.

The lever is equipped with a handle or knob which actuates a locking device on a quadrant through a strong spring. This quadrant is notched so that the jar or strain of moving the lever from normal to reverse, or vice versa, will be taken up on the more rugged quadrant instead of the projection on the segment. To further insure the quadrant taking the strain, a latch depressor is used which necessitates releasing the lever latch in moving the lever from normal to reverse or from reverse to normal position. These features are more fully represented in Fig. 5, which also indicates the different positions of the lever, the letters corresponding to the positions in which bands on the roller are made and correspond to the circuit symbols shown in Chapter II—Symbols, Aspects and Indications.

Below the front part of the lever in Fig. 4 is shown a set of contacts operated by a cam which in turn is operated by a pin or stud connected to the lever latch. It will be noted the contacts are normally open and will close only when the lever latch is moved. The function of these contacts is explained more fully in the detailed circuits for electric switch locking.

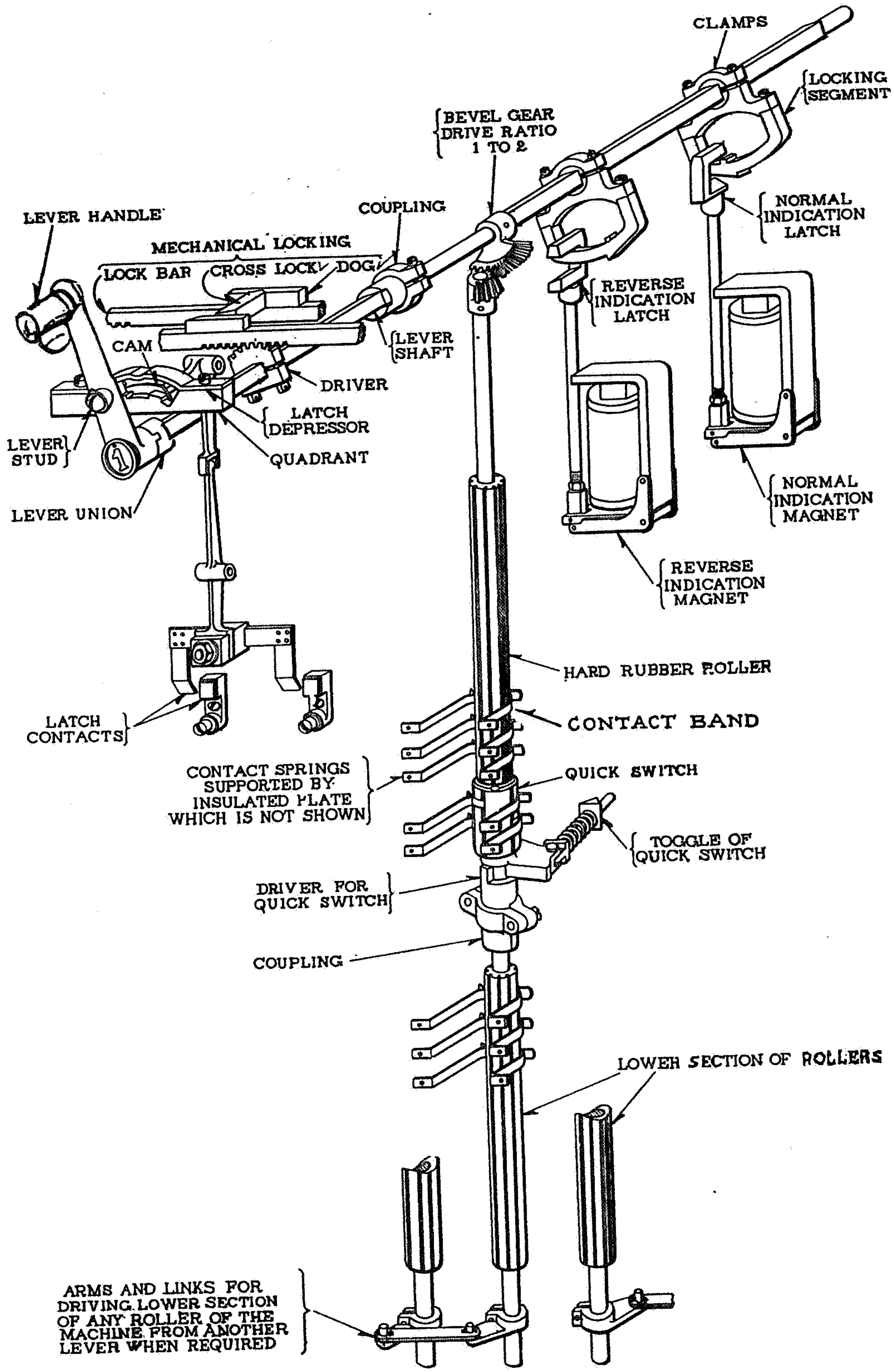


Fig. 4.
Perspective Diagram of Switch Lever Complete.

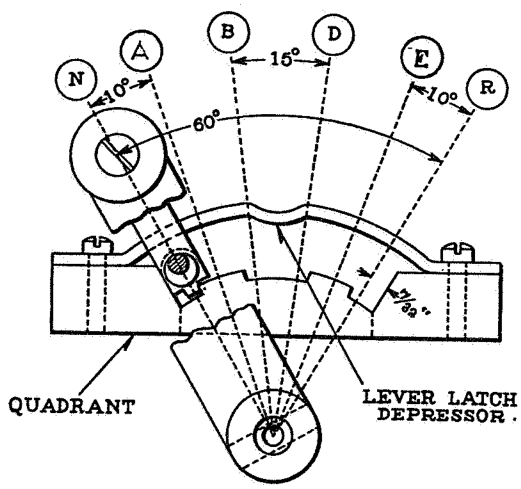


Fig. 5.
Diagram of Switch Lever Quadrant.

Near the middle of the vertical roller in Fig. 4 will be noticed what has been designated as a quick switch, which is a section of the hard rubber roller, and while mounted on and operated by the roller shaft, does not move continuously with the lever shaft, but is restrained from following it during the first part of the lever movement by a spring actuated toggle, until the final movement of the lever occurs, after which the device operates to its full opposite position. Figure 6 illustrates the quick switch quite fully and its function is covered under the switch indication circuits.

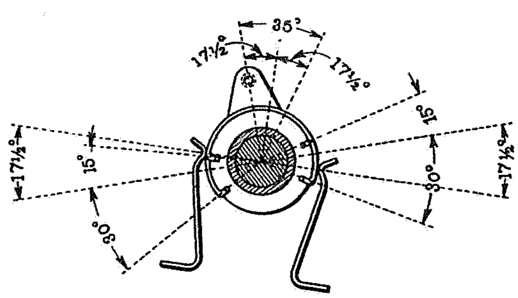


Fig. 6.
Diagram of Quick Switch.

Signal lever.

The general arrangement of the signal lever is about the same as the switch lever and is illustrated in Fig. 7.

From this illustration it will be noted the mechanical locking driver and bevel gear are the same as shown for the switch lever.

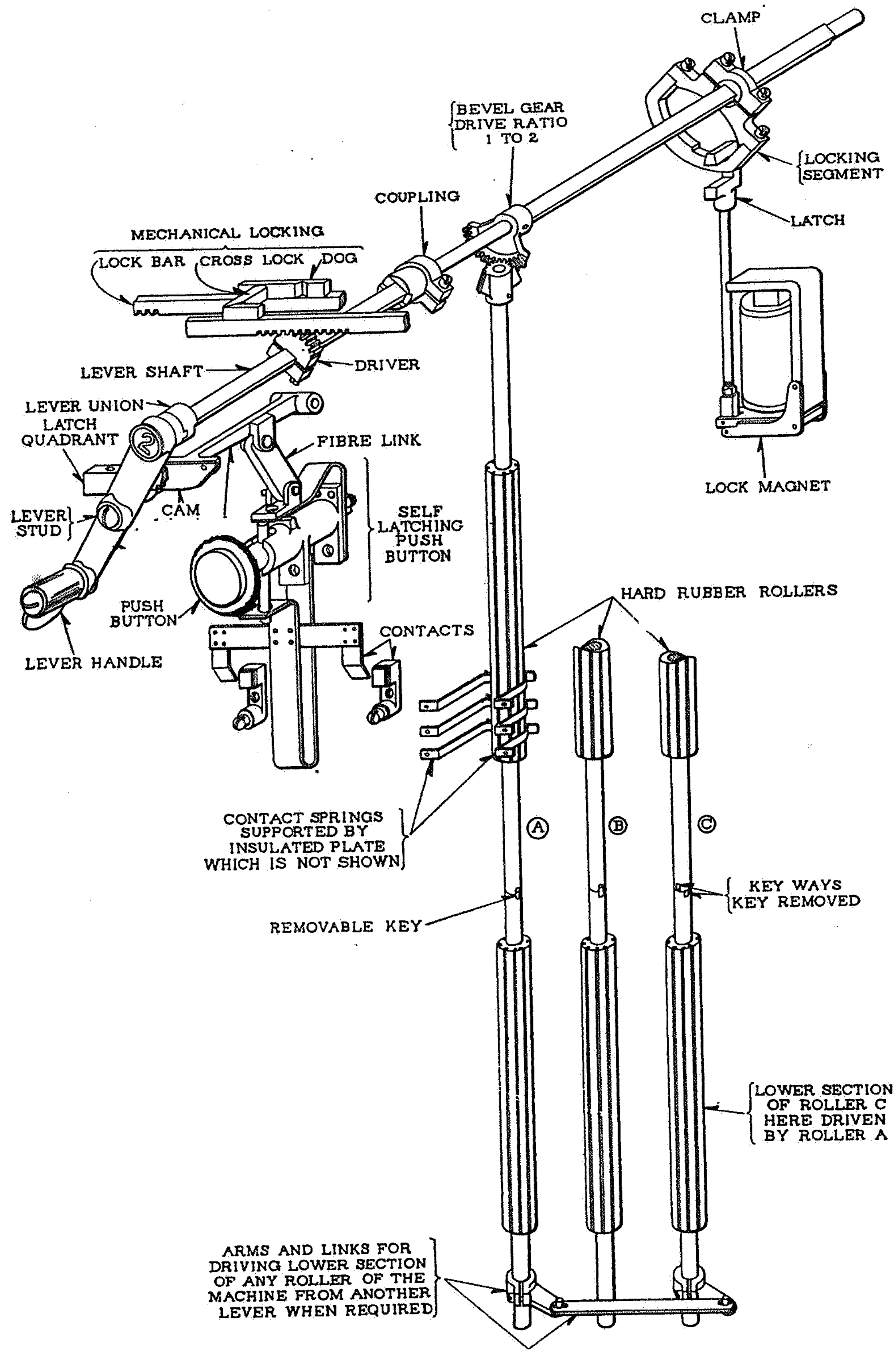


Fig. 7.

Perspective Diagram of Signal Lever Complete.

There is only one segment and magnet. A different type of circuit controller is shown than on the switch lever; this circuit controller is operated by a push button that can be pushed only when the lever is moved from the center position as the lever is directly in front of the push button when in the normal or center position. When the lever is moved to the right or left the push button may be operated to close the contacts connected thereto. These contacts remain closed until the lever is restored to normal position which causes the lever stud to operate the cam and releasing arm forcing the push button to its normal position, opening the contacts. This push button is generally known as a mechanical stick push button and its function is to operate or display the slow-speed or track-occupied indication of the signal the lever controls. The function of the push button and circuit controller is covered in Chapter XX—Interlocking Circuits.

Operation of switch lever.

Moving a switch lever from normal to reverse is performed in two movements: the first movement operates the switch mechanism and places the switch in the desired position after which the lever is released and can then be moved to its extreme reverse position; the releasing of the lever to make the second movement is accomplished by what is known as the indication circuit.

While the first movement of the lever is accomplished in one operation, three separate actions take place. The following switch lever operation pertains to the combination of contacts entering into the control circuit where the non-cut-off type of valve is used: When the lever has moved from the N position approximately 22 degrees or to the B position, the circuit known as the lock circuit is closed, which unlocks the switch mechanism as will be explained later. As the lever moves through the next few degrees (slightly beyond the B position) the normal control band is opened, then as the lever continues to move through the next 10 degrees the reverse control band closes, which brings the lever to the D or reverse indicating position which is as far as it can be moved for the time being and is within approximately 22 degrees of its complete stroke. With the lock circuit closed, normal control open and reverse control closed the valves in the switch mechanism are shifted causing the switch to be moved to its reverse position. After the switch has moved and locked mechanically it completes the reverse indicating circuit energizing the reverse indication magnet shown in Fig. 4 causing the indication latch to raise off the segment a sufficient distance to clear the tooth on top of segment which permits the lever to be moved to the extreme position R. On this final movement of lever the lock band is opened just beyond the D position or approximately 22 degrees from the extreme reverse position which locks the switch mechanism in the reverse position, also the quick switch is operated opening the reverse indication band and closing the normal indication band for the next movement of the lever.

Moving the lever from reverse to normal position the opposite conditions apply; that is, the first movement of lever from R closes the lock circuit approximately at D, opens reverse control shortly beyond the D position, closes the normal control just before reaching the B position. After the switch mechanism has responded and locked, the normal indication magnet is energized which permits the lever to be moved to the extreme normal position, N, opening the lock circuit just beyond B, shifting the quick switch, opening the normal indication and closing the reverse indication ready for the next movement of the lever.

Figure 8 illustrates a typical circuit for the control and indication of a single switch, using the non-cut-off valve and quick switch.

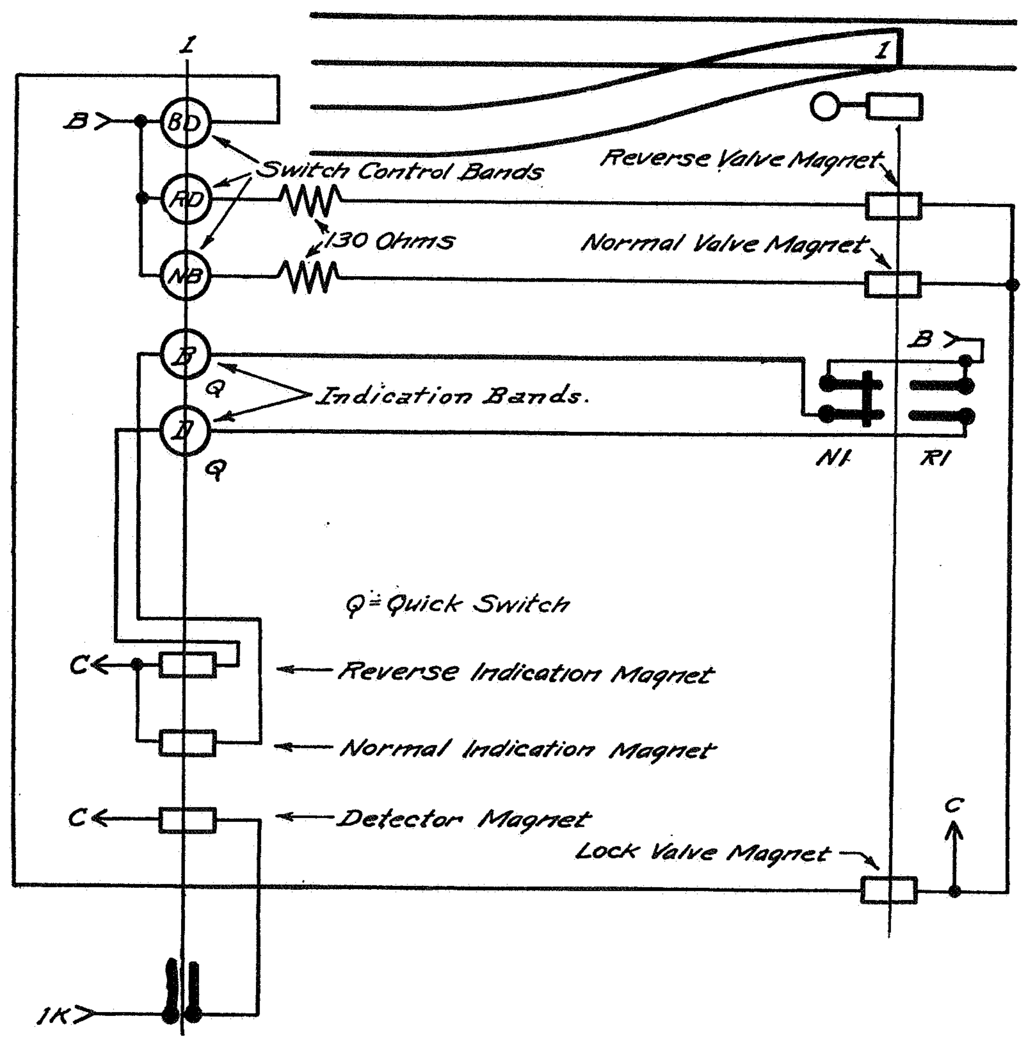


Fig. 8.
Typical Switch Control and Indication Circuit.

Ordinarily, the arrangement of the lock control band depends on the type of electric switch lock used on the particular lever, and the band is arranged so that it will not be closed until the lever has been moved beyond the point where the electric switch locking would stop it, so that the switch valves cannot be unlocked with a train passing over the switch. By referring to Fig. 8 it will be seen that the lock circuit is simply a circuit from battery, through a BD band on the lever, to the lock magnet at the switch, to common. The normal control is from battery, through an NB band, to the normal control magnet, to common. The reverse control is from battery, through an RD band, to the reverse control magnet, to common.

A close study of the segments in Fig. 4 shows a tooth projecting from the bottom of both normal and reverse indication magnet segments which is called the "safety tooth." Its purpose is to eliminate the chance of a false switch indication. For instance, it is desired to move a switch from normal to reverse position, but there is a cross on the reverse indication wire. With this cross the reverse indication magnet would be energized so that the under projection would catch against the indication latch, preventing the lever from being moved farther so that the signal governing movements over the switch could not be cleared. Therefore, it is quite necessary that the normal and reverse control bands do not close until after the safety tooth has been passed. If they close before the safety tooth is passed and the lever is moved only far enough to close them, the switch could move and indicate, but with the safety tooth not passed, the lever would be tied up the same as with an improper indication. On levers equipped with 60 degree rollers this adjustment must be checked quite frequently as there is very little movement of the lever between the safety tooth and indication tooth for the control bands to close. With the 120 degree rollers there is twice the travel of the roller within which to maintain the above mentioned adjustments. It is still, however, essential that this be checked from time to time to see that the control bands close only at the proper time. This can readily be determined by raising the indication latch and then moving the lever so as to bring the safety tooth against the indication latch, then noting that the control band in the direction the lever is being moved is not yet closed; also that the other control band is open. After completing the movement of the lever make same test on other safety tooth by moving lever in opposite direction.

In moving the lever from the normal to the reverse position and after reaching the indicating point, it is necessary to wait until the switch has responded. This will close contacts marked RI in indication box at the switch, completing circuit from battery, through contacts RI to D band, to reverse indication magnet, to common, raise the indication latch off top of segment permitting stroke of lever to be completed, also move the quick switch, opening the D band and closing the B band.

To restore lever to normal position it can first be moved as far as the normal indicating point where it is locked until switch has responded. This will close contacts NI in indication box, completing circuit from battery, to B band in machine, to normal indication magnet, to common, raise indication latch off top of segment, permitting stroke of lever to be completed which moves the quick switch, opens the B band and closes the D band.

Quick switch.

If a switch lever is moved from its normal position toward its reverse position, or vice versa, it is necessary to complete the stroke before it can be returned to its original position, due to the action and arrangement of bands on the quick switch. Before the lever stroke can be completed it is first necessary for the switch mechanism to operate, placing switch in corresponding position to that in which the lever is being moved, after which the lever stroke can be completed.

In the electro-pneumatic system of interlocking the switch is moved by controlling a set of valves from the interlocking machine lever and this set of valves governs in turn the admission to and exhaust of air from the switch cylinder. It is to be remembered that the indication circuit does not check the position of the control valve, but checks the position of the switch points. Therefore, if it is necessary to receive an indication to the effect that the switch is in the reverse position and locked before the control lever can be placed in the full reverse position, it is certain that the intermediate control device (switch valves) has responded to the control lever. In other words, after having placed the control lever toward the reverse position, the switch would not have moved to the reverse position and given a reverse indication unless the control valves had also moved to the reverse position. The action of the quick switch guarantees, therefore, that the switch control valve and the position of the switch correspond before an indication can be received to permit the switch control lever stroke to be completed, thereby releasing the mechanical locking. Another feature accomplished by the quick switch is to prevent either indication magnet from being energized while lever is being moved from one extreme position to the indicating point in the opposite position, as otherwise the under projection or safety tooth would have to force the armature of the energized indication magnet down every time the lever was moved which would cause undue wear as well as unnecessary binding.

A new type of switch valve has recently been designed which eliminates the necessity for a quick switch. This feature will be covered later.

Operation of signal lever.

The normal position of the signal lever is usually in the center and it is moved to the right or left to clear a signal. Moving the lever from the center to the right or left is accomplished by an uninterrupted movement. In returning the lever to the normal position, however, the movement is not continuous. If the lever is to the right or R position, it can be moved toward the center or normal position approximately 14 degrees, where the lever is stopped until the latch is raised off the locking segment. This is accomplished by completing the circuit for the indication lock magnet through a contact on the signal or signals controlled by the lever. This circuit is known as the indication lock circuit. After this circuit has been closed the lever may then be restored to the center or normal position. Figure 9 illustrates a typical signal indication lock circuit.

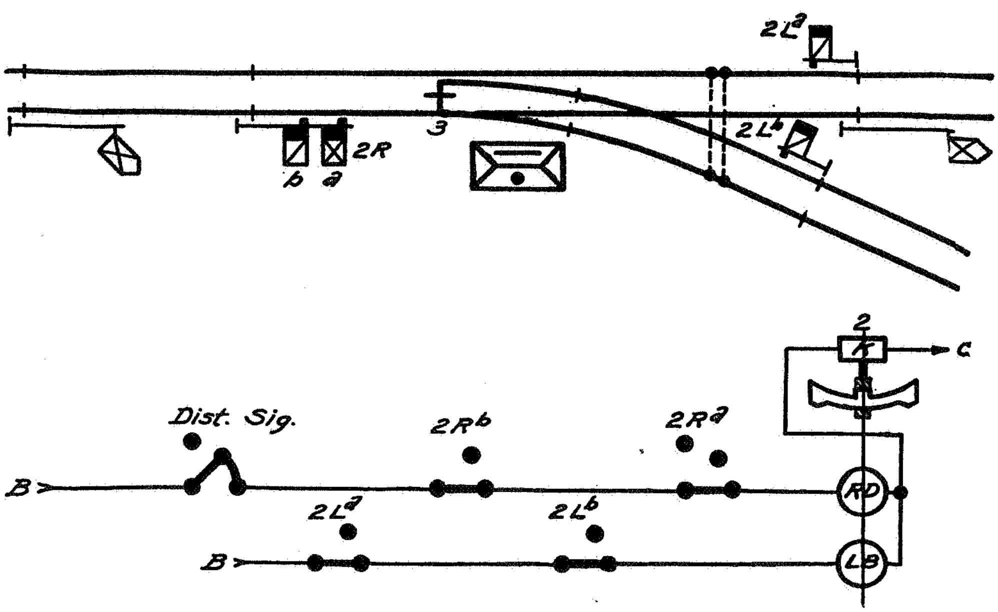


Fig. 9.
Typical Signal Indication Lock Circuit.

From a study of Fig. 9 it will be noted that with lever No. 2 in center or normal position the indication magnet is de-energized which means that the LB and RD bands not only act as a means of separating the R and L circuit, but also as a battery saving device. Therefore, the only time the indication magnet is energized is when the lever is between the L and B positions or the R and D positions with the corresponding signal or signals in normal position.

The main purpose of the signal indication lock circuit is to insure that all signals controlled by that lever have returned to their normal position before the lever can be placed in its normal position and release the mechanical locking, but other results are accomplished by controlling this circuit through other devices as explained in Chapter XX—Interlocking Circuits.

Electric switch locking.

Detector bars were used quite generally in the early stages of electro-pneumatic interlocking plants, but they have now been replaced in practically all instances by electric switch lever locking and in no instance are they incorporated as a part of new installations. The elimination of detector bars was also necessary due to the increased size of rails.

Electric switch lever locking prevents the manipulation of the switch lever from either normal or reverse position while a train occupies a given section of a route, and two general schemes are used in doing this: one scheme utilizes the indication magnets, while the other uses a separate and distinct magnet for the purpose.

By referring to Fig. 4 and observing closely the two locking segments, it will be seen that the tooth on top of these segments is square on both sides and in order to move this lever from the position shown it is necessary to energize the normal indication magnet, raising the indication latch off the segment, so the projection or tooth on top of the segment will pass under the latch. With the lever in the reverse position it is necessary to raise the reverse indication latch off the reverse segment before the lever can be moved from the reverse position.

To accomplish this type of locking the track circuit extending through the switch is utilized by controlling the electric locking circuit to the two indication magnets as shown in Fig. 10.

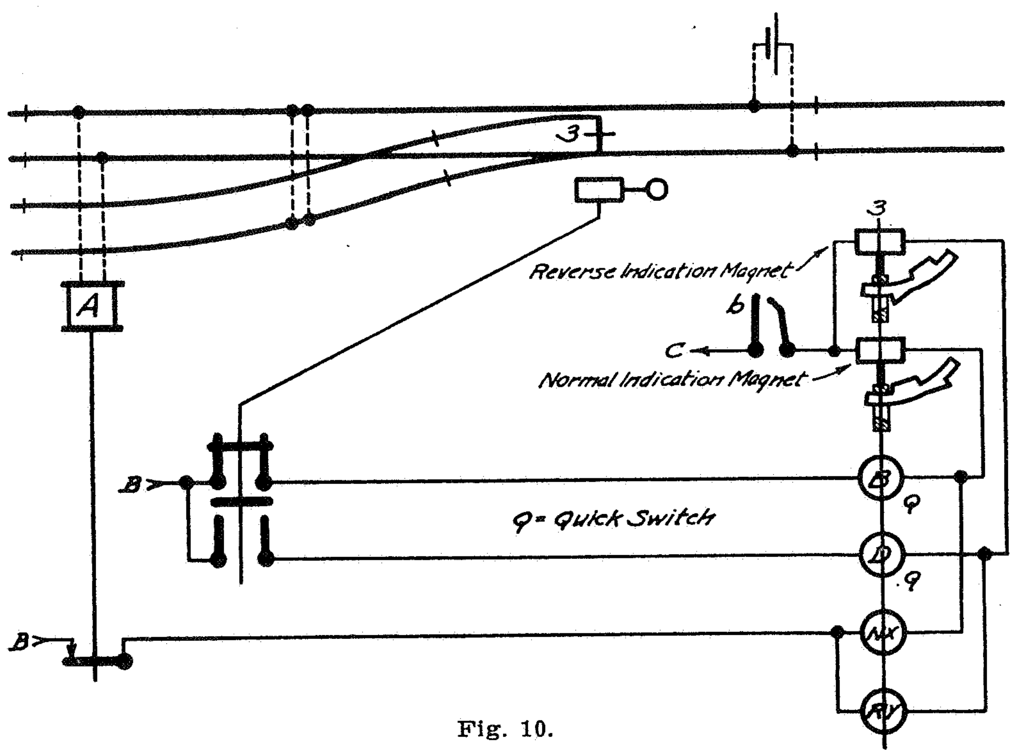


Fig. 10.
Electric Switch Locking Circuit Using the Indication Magnets.

From a study of Fig. 10 it will be seen that when track relay A is de-energized neither indication magnet can be energized. When the track relay is energized the switch lever can be moved from one position to the other by turning the lever handle that closes latch contact b, which, with lever in the normal position, closes the circuit through the NX band to the normal indication magnet, lifting the indication latch off the normal indication segment, releasing the lever. If lever is in the reverse position when the latch contact is closed the circuit will then be completed through the RY band to the reverse indication magnet, lifting the indication latch off the reverse segment, thereby releasing the lever for movement to the normal position.

The latch contact is in the circuit regardless of the position of the lever and its purpose is to keep the switch locking circuit normally open avoiding unnecessary consumption of energy. This contact may, therefore, be classed as a current-saving device.

As previously explained, the normal and reverse indication magnets are utilized for electric switch locking. The indication and electric locking circuits to the same magnet are controlled through bands made with the lever in different positions; for instance, the normal

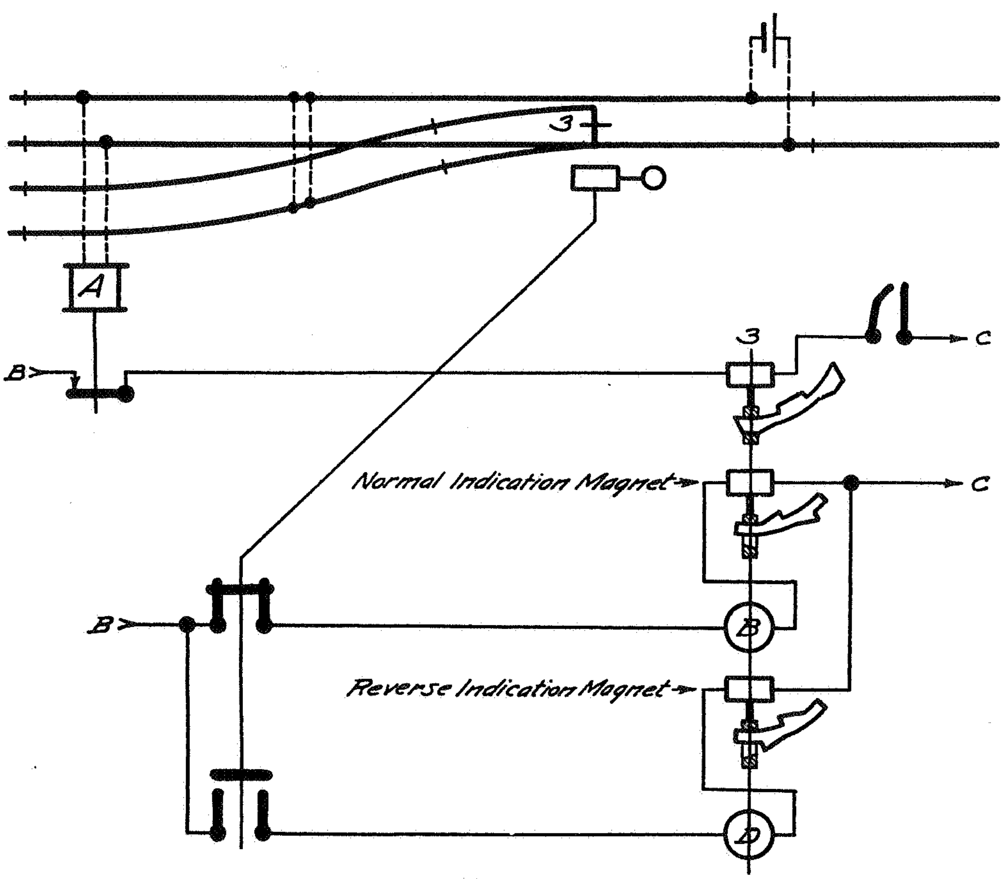


Fig. 11.
Electric Switch Locking Using Independent Lock.

indication magnet is energized by the switch locking circuit with lever in the NX position, while the normal indication circuit is closed with lever in the B position. The reverse indication magnet is energized by the switch locking circuit with lever in the RY position, while the reverse indication circuit is made with lever in the D position.

Another arrangement of switch lever locking uses a separate magnet for the switch locking circuit, reserving the indication magnets for their original purpose. This circuit is shown in Fig. 11, from which it will be seen that it is somewhat the same as that shown in Fig. 10, except that it is not controlled through any bands on the lever.

In the earlier machines of this type the magnet was located on the back of the machine with an arm attached to the lever shaft extending to the lock and is illustrated in Fig. 12.

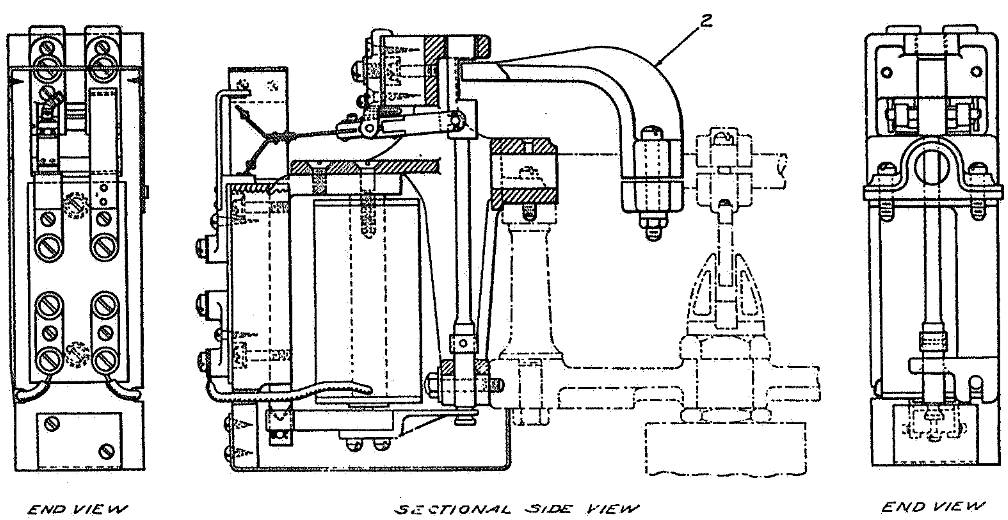


Fig. 12.
Independently Mounted Electric Switch Lock.

From a study of Figs. 11 and 12 it will be seen that if track relay A is de-energized the armature of the switch lock could not pick up. Therefore, arm 2, Fig. 12, would not pass the locking dog connected to the armature and which holds the lever in whatever position it might be (normal or reverse) until the track relay was energized.

This type of lock was applied generally to machines that originally used the indication magnets for the electric switch locking and has been given the name of independently mounted detector or electric switch lock.

In the later machines of this type, the electric switch lock is located under the particular lever shaft in line with the regular indication magnets as illustrated in Fig. 13, the segment on this lock being shown in the same figure. Thus with lever in the normal or the reverse position it cannot be moved without the electric switch lock being energized and lifting the latch off the segment.

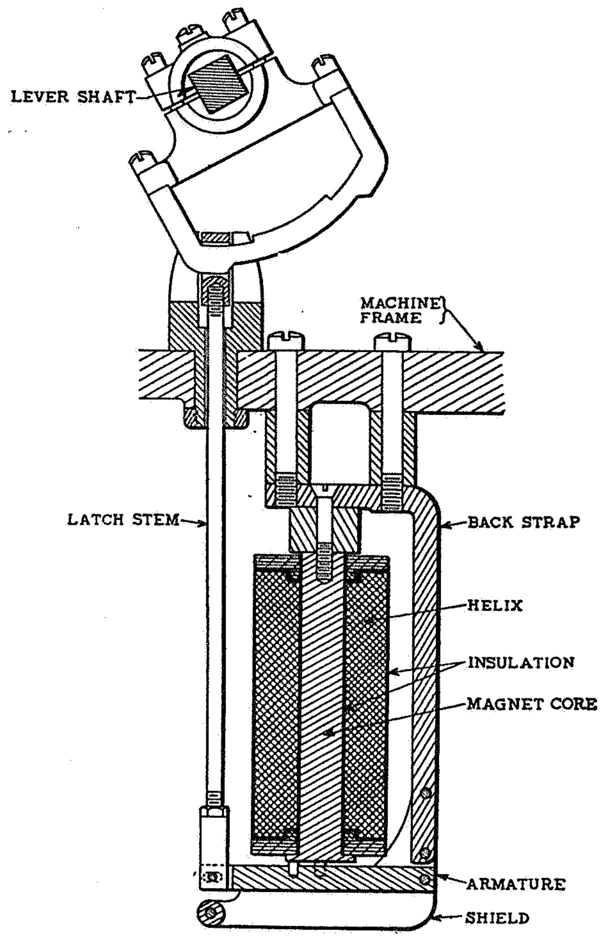


Fig. 13.
Electric Switch Lock.

SS protection.

While a circuit to lock the switch lever is quite desirable and necessary, it is equally important to know that before clearing a signal to proceed over a switch there is no likelihood that the switch does not correspond to the position of its control lever. While the indication circuit is used to show that the switch has responded and is locked in the position desired there is no assurance that it will remain in that position. Therefore, what is known as the SS circuit is used. There are two general types of SS circuits: neutral and polarized. In the earlier installations the neutral type was installed, but in later installations the polarized type has generally superseded the neutral type.

Figure 14 illustrates the neutral type, and the polarized type will be explained later in this chapter. From the figure it is seen that the SS circuit is the same as the indication circuit from the contacts in the indication box to the machine. A tap is taken from the normal indication wire through an N band, then to a relay or indicator, to the common return wire, while a tap is taken from the reverse indication wire through an R band, to the same relay or indicator. In order for the SS relay to be or remain energized the switch must correspond to the position of the lever in the machine. The signal control circuits are taken through the contacts of the SS relay and a signal that governs a movement over this switch cannot be cleared unless the positions of the switch and lever correspond.

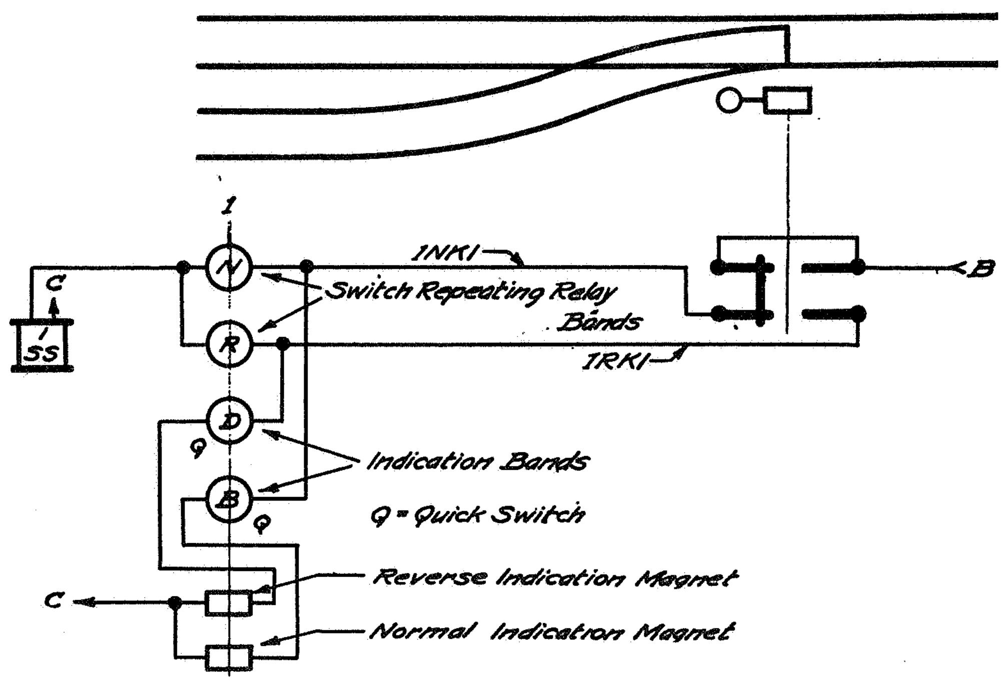


Fig. 14.
Typical SS Circuit.

There are various modifications of the SS circuit in use, but they all have the one main feature of insuring that the position of lever and switch correspond in order to clear a signal governing movements over the switch.

While this circuit shows the SS bands as N and R they are sometimes arranged as NB and RD bands or a similar combination due to it being necessary to keep the SS relay picked up in case the lever is moved as far as the electric switch locking segment will permit with a train passing over the switch. Sometimes the switch valve lock circuit is energized through the back contact of the SS relay, in which event it would be undesirable for the SS relay to open should the switch lever be moved as far as the locking would permit.

Crossovers, slips and movable point frogs.

The arrangement of circuits has so far only dealt with single switches and straight indication circuits. Crossovers, slips and movable point frogs must also be taken care of and in the electro-pneumatic layout it is possible to operate more than a single switch or set of valves from one lever. Figures 15 and 16 illustrate two typical layouts with necessary circuits which can be readily traced along the lines previously explained.

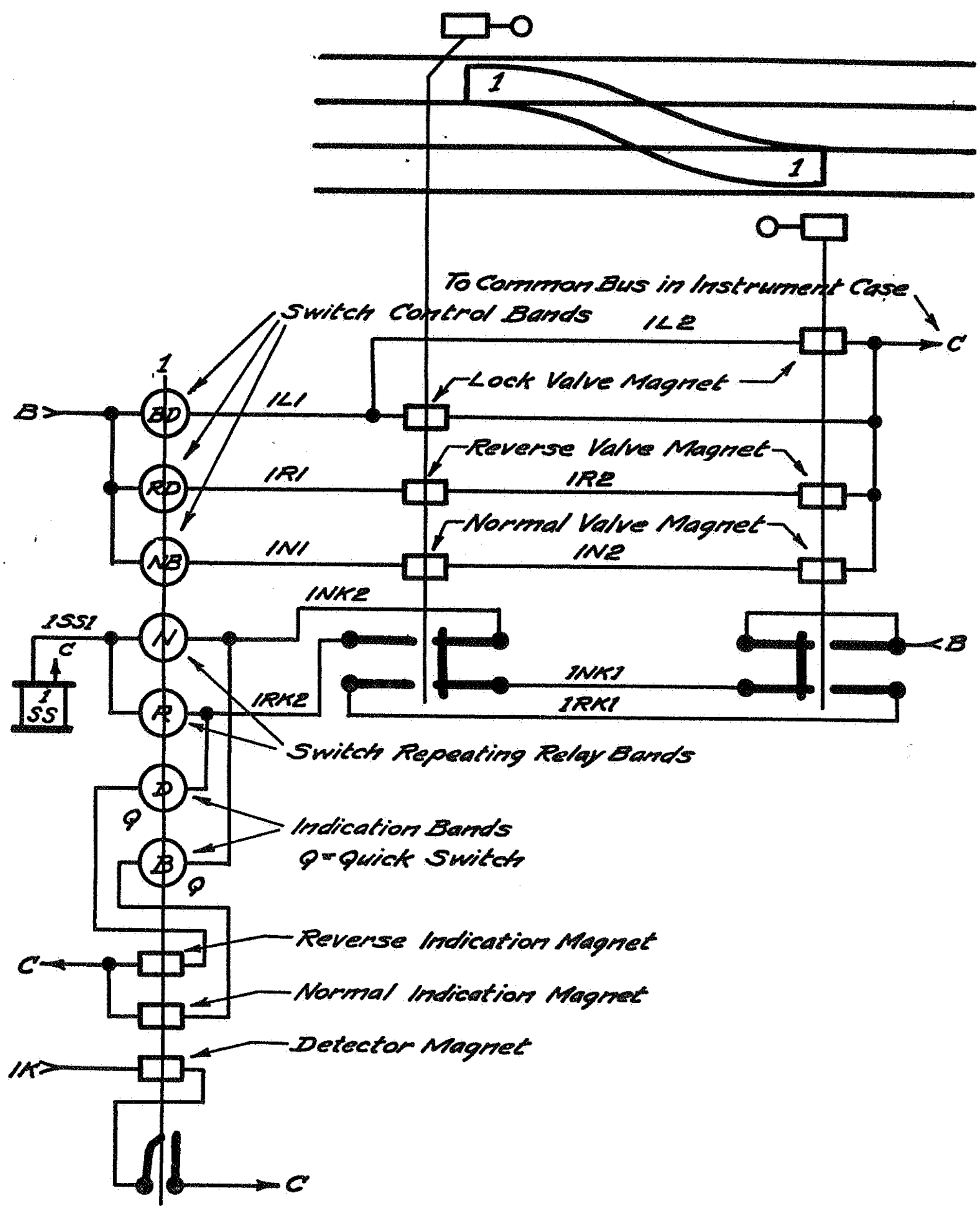


Fig. 15.
Typical Circuit for Crossover.

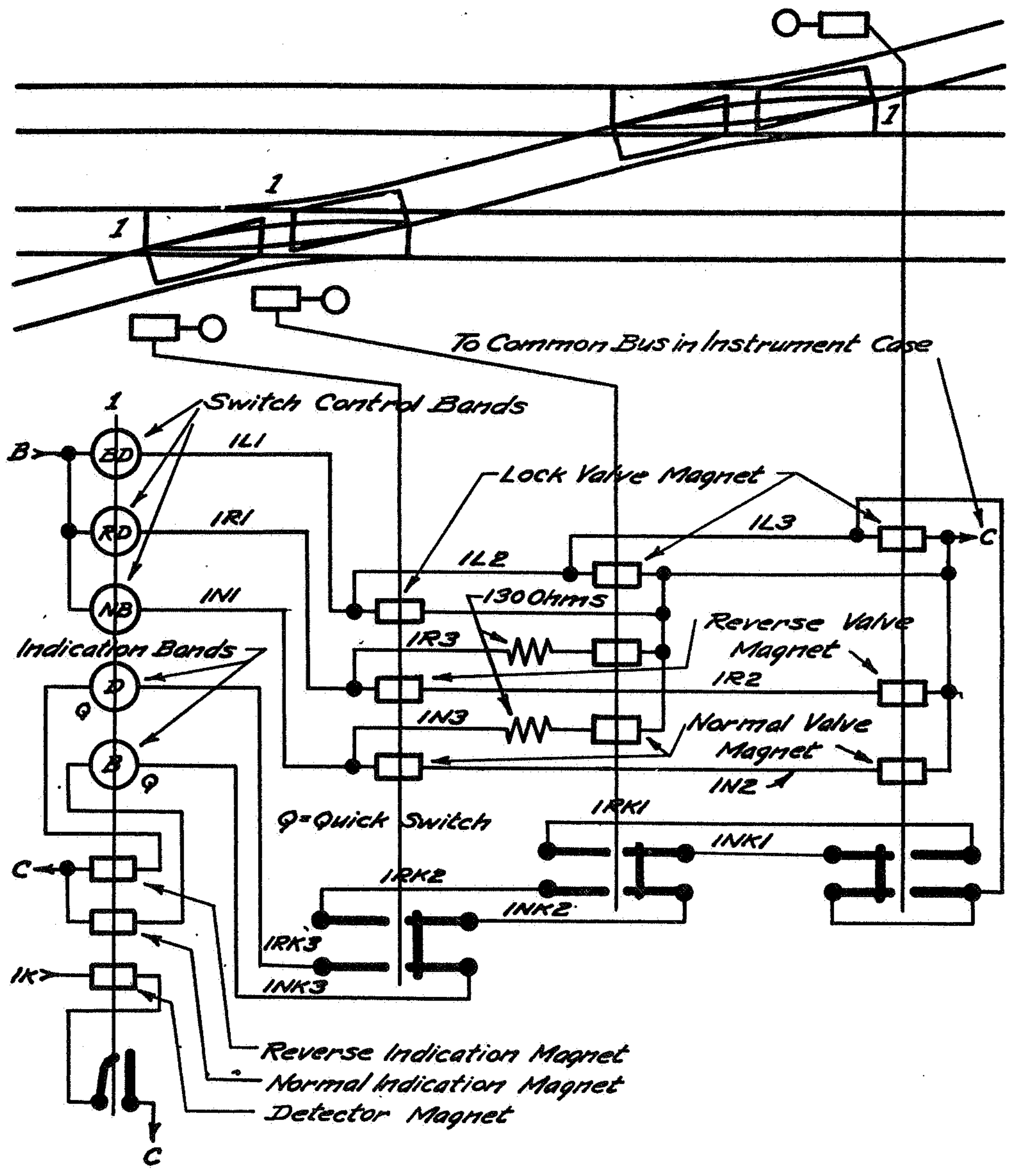


Fig. 16.
Typical Circuit for Double Slip.

In Fig. 16 control valves are shown at the double-slip ends as well as at the movable point frogs. In some installations the valves are located at the movable point frogs only, using a pipe connection to the double-slip end to operate the switch movement, in which case the switch valves are controlled the same as a crossover but with the indication circuit arranged as shown or going through an indication box on the pipe-connected end so it can be assured that all three switches have moved and are properly locked.

The foregoing circuits are based on using what is known as the Model 14 and the motion plate switch-and-lock movements.

There are different arrangements for the control circuits such as having the lock magnets in series instead of in multiple or the control magnets in multiple instead of in series, etc. Ordinarily, however, where there are more than two sets of valves controlled from the same lever, two multiple circuits are used for the control magnets. Figure 16 illustrates three sets of valves in use and in order that they will work promptly no more than two magnets are connected in series. In order to balance the two multiple circuits on the same lever an external resistance is used in one branch which is of the same resistance as a control magnet. Generally the resistance of the lock and control magnets is 130 ohms each. With the non-cut-off type of valve it is desirable for the lock magnets to be connected in multiple in order that they will pick up quickly and unlock the D valve by the time the control magnets are energized.

Switch Layout

Figure 17 illustrates a layout for a single switch, the essential parts of which are the switch-and-lock movement, switch valve and cylinder.

Switch-and-lock movement.

This is the part of the layout that first unlocks the switch points, moves and then locks them in the new position. It consists essentially of a slide bar and switch crank.

The slide bar is made up of two long strips of metal, usually 3/8 inch thick and 2 1/4 inches wide, riveted together at both ends, with a pin and roller between them in about the center of the bar. One end of the bar is connected to the piston of the switch cylinder.

The switch crank is operated by the roller on the center pin in the slide bar but is arranged so that the slide bar travels a certain distance before striking the side of the crank, which moves the switch points from one position to the other, after which the roller passes along a flat surface of the crank.

At one end of the slide bar there are two locking dogs, one riveted to the top and the other to the bottom of the bar. These dogs enter corresponding slots in the lock rod connected to the switch points.

The first movement of the slide bar withdraws the locking dog from slot in the lock rod, unlocking the switch. The next movement engages the switch crank moving the switch to the opposite position and the final movement drives the dog through the slot in the lock rod locking the switch in position.

An indication box is fastened above the slide bar with a contact block fastened to the bar. Contacts in the indication box are arranged so that the contact block will close the contacts on the final movement of the slide bar. Therefore, if there is an obstruction in the switch point, or the switch is out of adjustment so that it does not close to within 1/4 inch of the stock rail, the slot in lock rod will

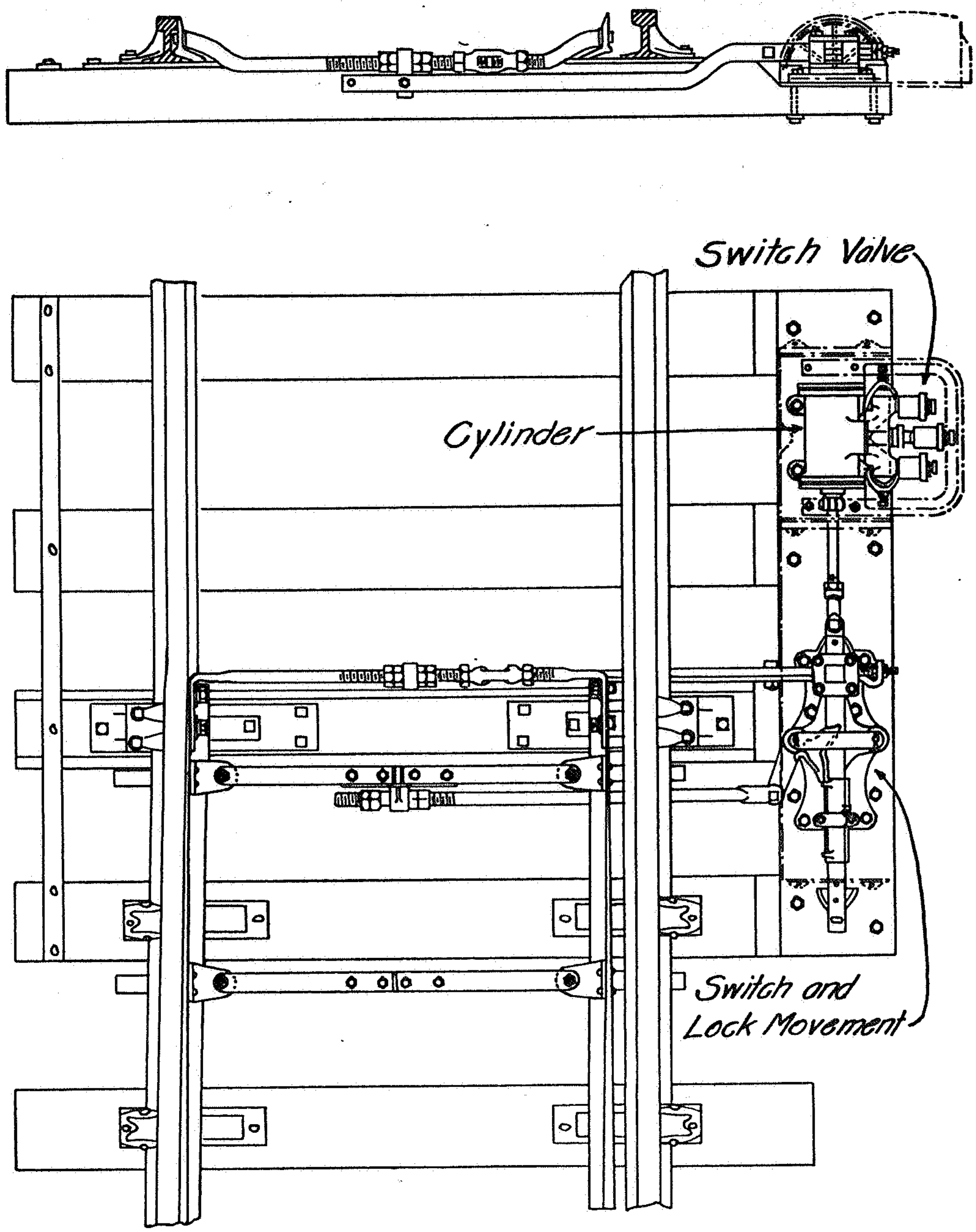


Fig. 17.
Layout for Single Switch.

not line up with locking dog on slide bar preventing it from making its full stroke. This will not permit the contacts in the indication box to close, which in turn will keep the indication circuit open and prevent the completion of the stroke of lever in interlocking machine so that a signal cannot be cleared for any movement over that particular switch. A Model 14 switch-and-lock movement and indication box are illustrated in Fig. 18.

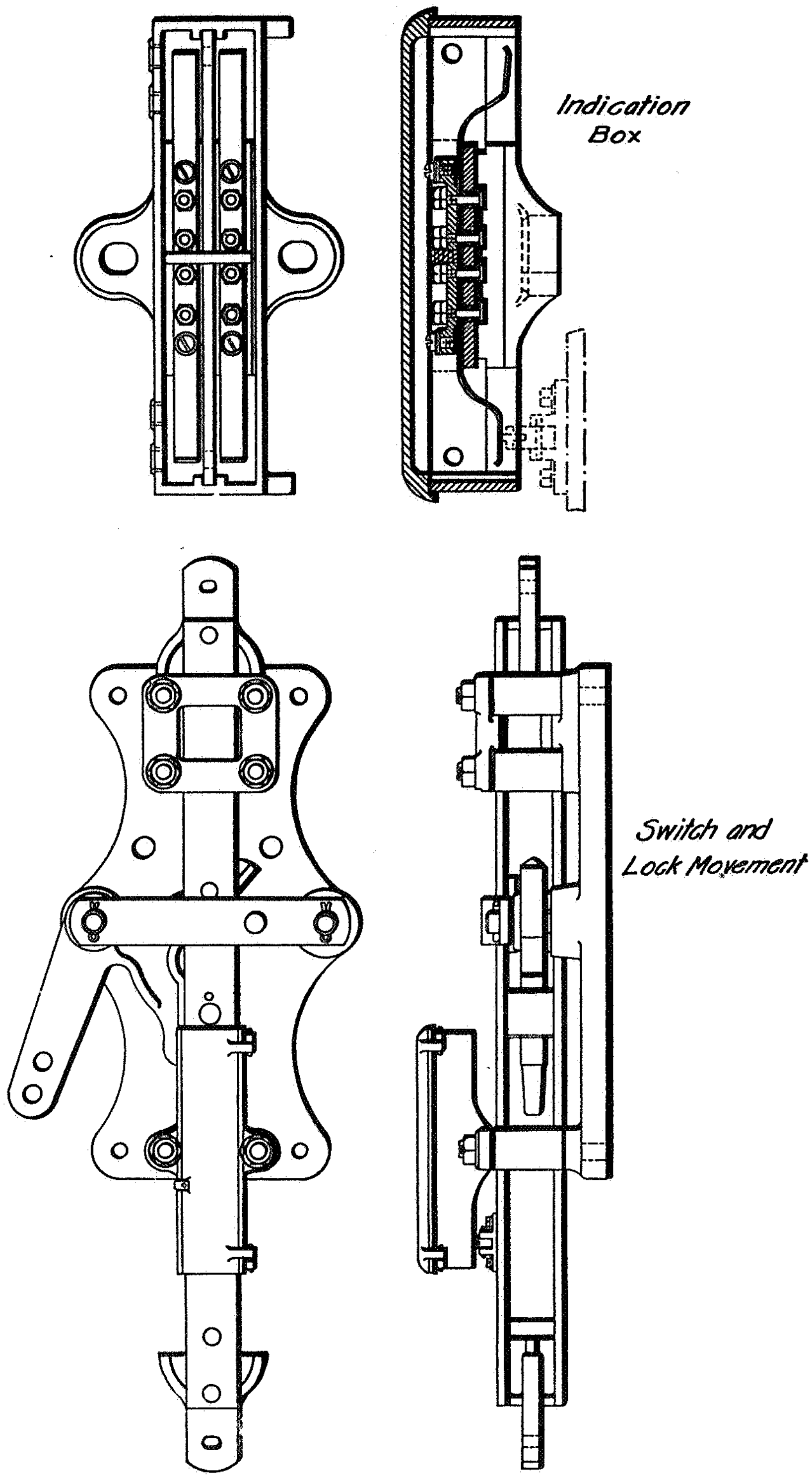


Fig. 18.
Model 14 Switch-and-Lock Movement and Indication Box.

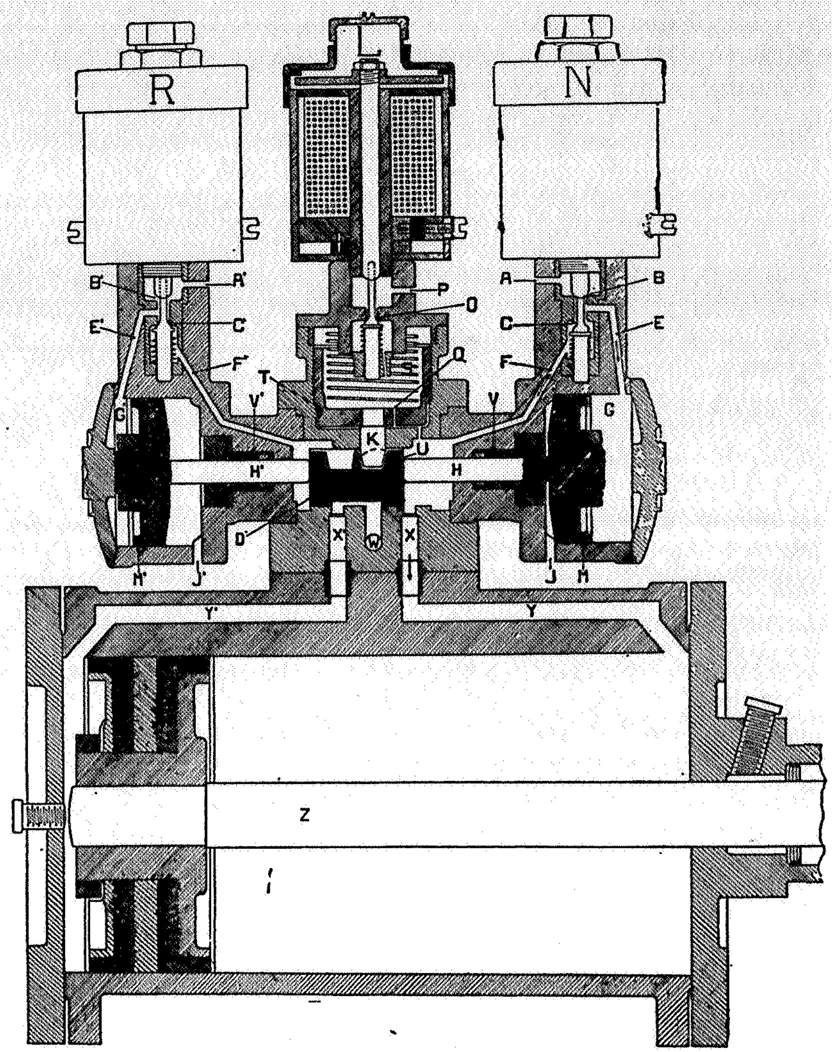


Fig. 19.
Cross-Section of Switch Valve and Cylinder.

Switch valves.

In order that the function of the various air passages and valves as incorporated in the electro-pneumatic switch valve may be more clearly understood, a cross-section of a valve is shown in Fig. 19 and a detailed description of the sequence in which the various parts operate for a complete switch operation are given.

The three control magnets previously mentioned are marked R, L and N, representing the reverse, lock and normal control, respectively.

To move the switch from one position to the other requires considerable force. It is also necessary that the air be supplied in sufficient quantity to operate the switch quickly. The ordinary pin valve in a magnet would not admit enough air to the switch cylinder to operate it very quickly. Therefore, this valve controls what is known as an auxiliary piston, which in turn operates another valve with a considerably larger opening to admit air to the switch cylinder quickly. There is an auxiliary piston for both the normal and reverse magnets as indicated in Fig. 19.

After the switch has been operated to the desired position it is necessary that the mechanism or valves be locked in that position so that there will be no chance of vibration operating any valves, admitting air to the opposite side of the piston, and it is for that purpose the lock magnet is used.

The valve controlling air to the switch cylinder is known as the D valve and is shown by D′. From a study of Fig. 19 it will be seen that there are two notches in the top of the D valve, one of which has the plunger or piston K in it that locks the D valve in that position.

Figure 19 represents a switch valve with switch lever normal and with normal magnet energized, keeping air pressure against normal side of switch piston as follows: from main air line, through opening U into air chamber in valves, through passages X and Y to normal side of switch piston.

To move switch to reverse position it is necessary to remove air pressure from the normal side and apply pressure to the reverse side of piston which is done in the following manner: As lever in machine is moved from normal to reverse position it first energizes lock magnet L. This depresses pin valve O permitting air in upper chamber of T to exhaust to atmosphere. With pressure removed from the inner side of this chamber the air pressure under it will force it to move up, as opening Q is smaller than openings O and P, so that as air leaks through opening Q it will exhaust directly to atmosphere through P quicker than air can be admitted through Q. This withdraws plunger K from D valve which unlocks it.

As the lever continues to move toward the reverse position the band controlling normal magnet N opens, permitting pin valve C to seat, closing opening from air chamber and at the same time opening stem valve at B which permits the air in valve chamber G to exhaust to atmosphere through passage E, openings B and A, removing air pressure from normal auxiliary piston.

As the lever movement continues the reverse band closes, energizing magnet R which closes stem valve opening B′ and opens pin valve opening C′. This closes opening to atmosphere through A′ and permits pressure to come from air chamber through passage F′, pin valve C′, passage E′ to chamber G′. With D valve unlocked and pressure removed from chamber G, the pressure in chamber G′ will force piston H′ against D valve, moving it and piston H to the right. Through the opening in bottom of D valve, passage X will be connected to W, which is atmosphere, which releases the air pressure from the normal side of switch piston through passages Y, X and W to atmosphere. At the same time passage X′ is opened to the main air chamber and pressure is applied to the reverse side of switch piston through passages X′ and Y′, driving piston head to opposite end of cylinder and operating the switch through the switch-and-lock movement as previously explained.

When the switch has moved to the reverse position and is locked, the indication is received in the machine permitting lever to have its stroke completed, which opens the lock band, de-energizing lock magnet L. When this occurs the pin valve seats, closing opening O, shutting off the opening P to atmosphere. Therefore, as air passes through opening Q it fills up this lock cup and the air pressure on either side of the cup quickly equalizes, then spring S forces lock cup down causing plunger K to enter reverse slot of D valve, holding it locked in the reverse position keeping air pressure against the reverse side of switch piston.

The movement of a lever from reverse to normal simply reverses the procedure by energizing lock magnet, permitting D valve to unlock, de-energizing the reverse magnet removing pressure from reverse auxiliary chamber, energizing normal magnet placing pressure in normal valve chamber, forcing D valve to normal position, taking air pressure from reverse side of switch piston and applying pressure to normal side moving the switch to the normal position. Then as lock magnet is de-energized on receiving the normal indication, the D valve is locked in normal position.

While it requires considerable time to explain the operation of the switch valve, the time required for a complete movement is quite short. To assist in quickening this operation openings are shown in the auxiliary valve chambers at J and J′. The purpose of these openings is to permit any air that may leak by the packings to exhaust to atmosphere at once; otherwise this air would act as a cushion materially slowing up the operation of the valves which in turn would retard the operation of the switch.

Cylinder.

Various sized cylinders are used depending on the work intended, the size varying from 5 to 7½ inches in diameter. The smaller sizes are used for operating single switches while the larger sizes are used for operating slips and movable point frogs where, of course, more power is required.

Figure 20 illustrates the complete cylinder while the lower part of Fig. 19 shows a cross-section of same with air passages.

In other layouts the normal position of the piston relative to the cylinder may be reversed with switch in the normal position; this would depend on just how the movement is located with relation to the switch.

Due to the high air pressure, packing is applied to the head of the piston as well as around the piston rod where it passes out of the cylinder, which is called the stuffing box. These features are shown in Fig. 19.

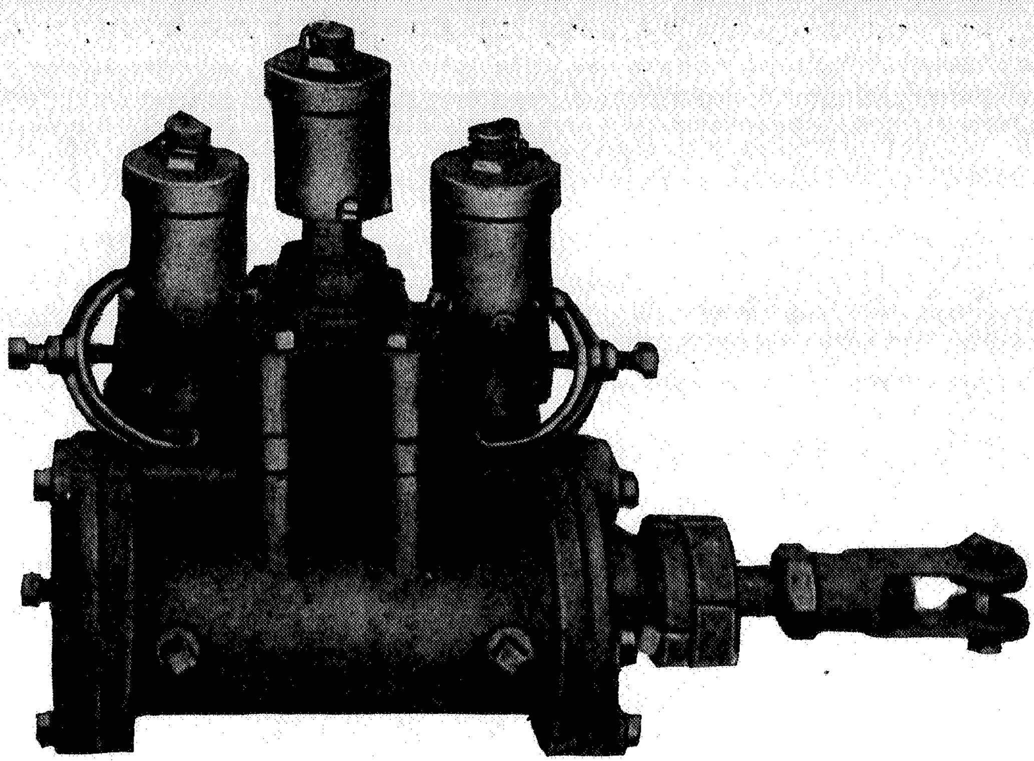


Fig. 20.
Switch Valve and Cylinder.

Separately mounted valves.

In the illustrations so far shown it will be seen that the switch valves are fastened directly to the switch cylinder. Certain modifications have been made permitting the valves to be located on a separate foundation, with hose or pipe connections leading from the normal and reverse air ports of the valves to connections in the cylinder, these connections leading to both sides of the piston head,

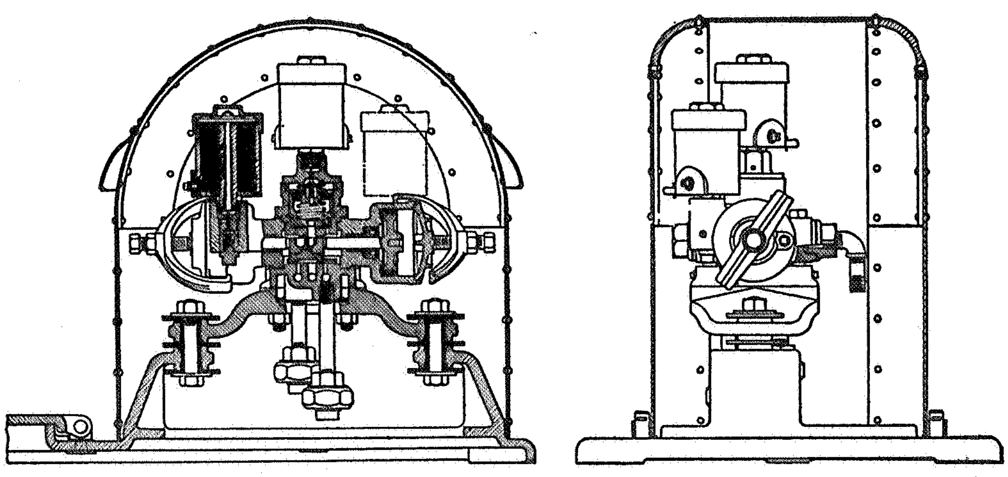


Fig. 21.
Separately Mounted Switch Valve.

permitting switch to operate the same way as previously described. This type of valve is illustrated in Fig. 21.

In later installations various changes have been made, the more noticeable of which are a different type of switch valve and switch-and-lock movement. The switch valve is known as Style C, while the switch-and-lock movement is known as the A1. Both of these were developed primarily to take care of low-pressure operation as it has been found to be more desirable to operate at a comparatively low pressure by using a small compressor starting and stopping automatically with a local air line, rather than use the long runs of main air line and necessary large compressors.

A1 switch-and-lock movement.

The chief difference between the Model 14 and A1 movements is in the fact that the slide bar of the A1 has a travel of 12 inches instead of 8, and the operating arm of the switch crank is adjustable to provide a switch operating rod movement of from 4 to 6 inches. Ordinarily, this arm is adjusted to give ½ inch more throw than the opening of the switch points. Figure 22 illustrates the A1 movement.

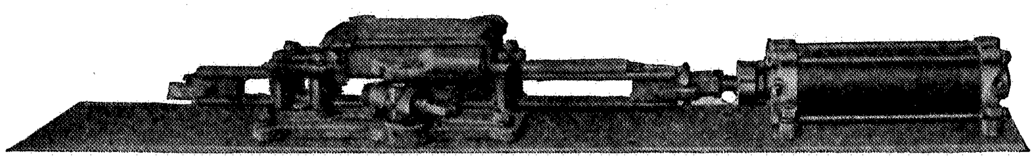


Fig. 22.
A1 Switch-and-Lock Movement.

The indication circuit controller used on this type of movement differs from that used on the Model 14. Instead of there being two sets of two contact springs, there are two sets of three contact springs, one set of which is closed with the switch in the normal position, the other with switch in the reverse position. This type of controller is necessary to permit the use of a polarized indication circuit which further reduces the chance of a false indication by reason of crossed or grounded wires. It also permits a shunt to be applied to the indication relay while switch is moving from one position to the other. Two sets of contacts on each of the contact blocks are used for the indication and shunt circuits, the other set of contacts being used for a restoring circuit where the Style C switch valves are in service. The function of this circuit is explained in Figs. 24 and 25.

Figure 23 illustrates the indication controller, while Figs. 24 and 25 illustrate the arrangement of polarized indication circuits for a single switch and crossover.

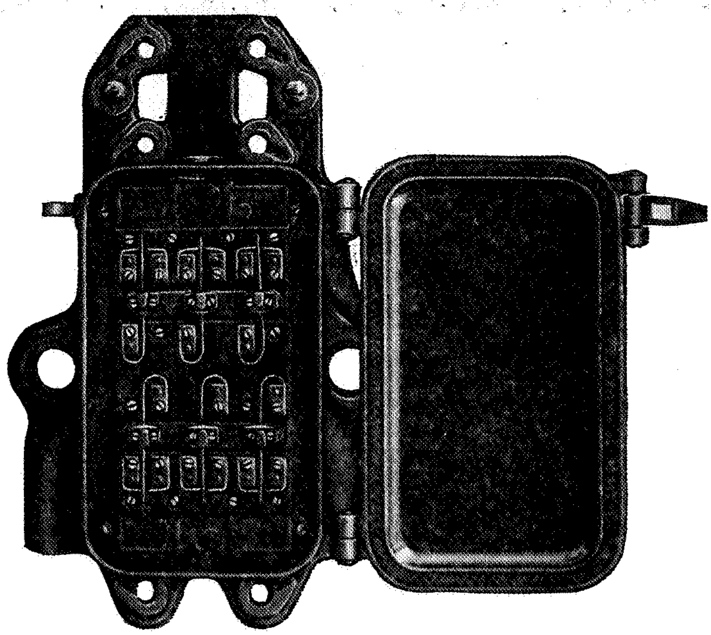


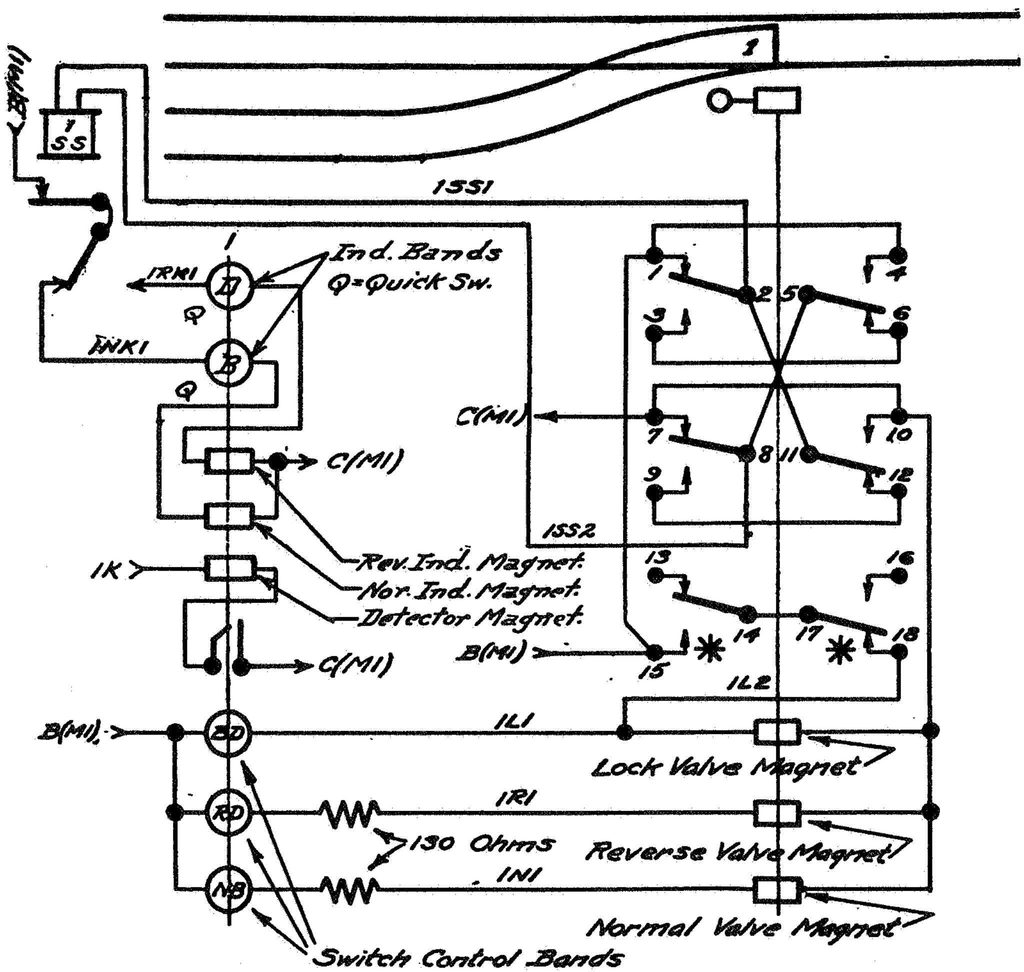
Fig. 23.
Indication Controller.

These circuit diagrams are shown with switch and crossover in the normal position with the normal polar contacts of the indication relay closed, which completes the normal indication circuit, the balance of the circuit being practically the same as the regular switch indication circuit.

When the single switch is moved to the reverse position and is locked, contacts 1, 6, 7 and 12 will open while contacts 3, 4, 9 and 10 will close. By tracing the circuit it will be found to have reversed the flow of current through the indication relay, closing the reverse polar contacts, thus completing the reverse indication circuit. While switch is moving, contacts 3 and 9 are closed and with this in mind when tracing the circuit it will be found that a shunt is applied to the circuit controlling the indication relay from binding post 2, contact 3, contact 6, binding post 5 and jumper to binding post 8.

The indication circuit for a crossover requires four wires between the two ends due to the polarized feature. The reverse indication circuit can be readily traced by assuming the contacts are closed in reverse position as mentioned in the note for Fig. 24.

The switch control circuits are also shown in Figs. 24 and 25, and from the fact that with Style C valves no air pressure is normally applied to the switch cylinder, it is desirable to provide a means of supplying air should the movement back off due to vibration or other causes. One way of accomplishing this is by applying current to the lock magnet wire through contacts 14 and 17, depending on whether the switch is lying normal or reverse. When these contacts close it energizes the lock magnet which admits air to the cylinder driving the slide bar back into place again. This is known as the restoring circuit and it is desirable that the contacts controlling the restoring circuit close before the indication circuit contacts open as otherwise the indication relay would open placing signals in Stop position, as it will be found later that the signal circuits are controlled through contacts on these indication relays. Where the signal control circuits are not controlled through the indication relay, this restoring circuit is sometimes controlled through a back contact on this relay.



Contacts 1 and 7 open and 3 and 9 close before switch is unlocked at start of switch throw. Contacts 4 and 10 close and 6 and 12 open after switch is locked at end of switch throw. Contacts marked thus * shall be adjusted to close just before "SS" contacts open.

Fig. 24.

Polarized Indication Circuit, Single Switch.

Another arrangement used to prevent the movement from backing off is shown in Fig. 26. This consists essentially of a friction lock applied to the switch-and-lock movement slide bar, holding it in place mechanically, but with air pressure applied to the slide bar it operates very readily.

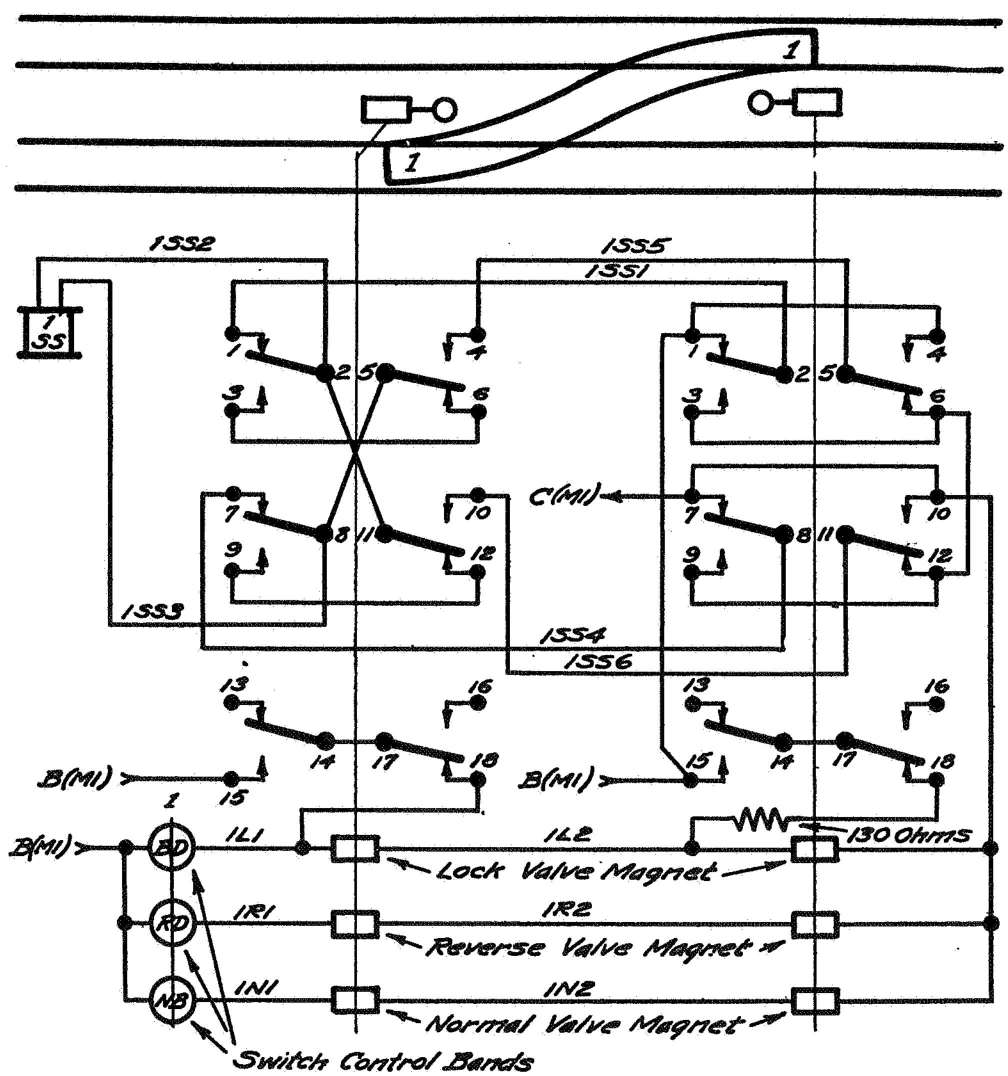


Fig. 25.
Polarized Indication Circuit, Crossover.

Rack and pinion switch-and-lock movement.

The rack and pinion switch-and-lock movement is especially suited to installations where space for the movement is limited. This is peculiarly so in subway installations. The layout is illustrated in

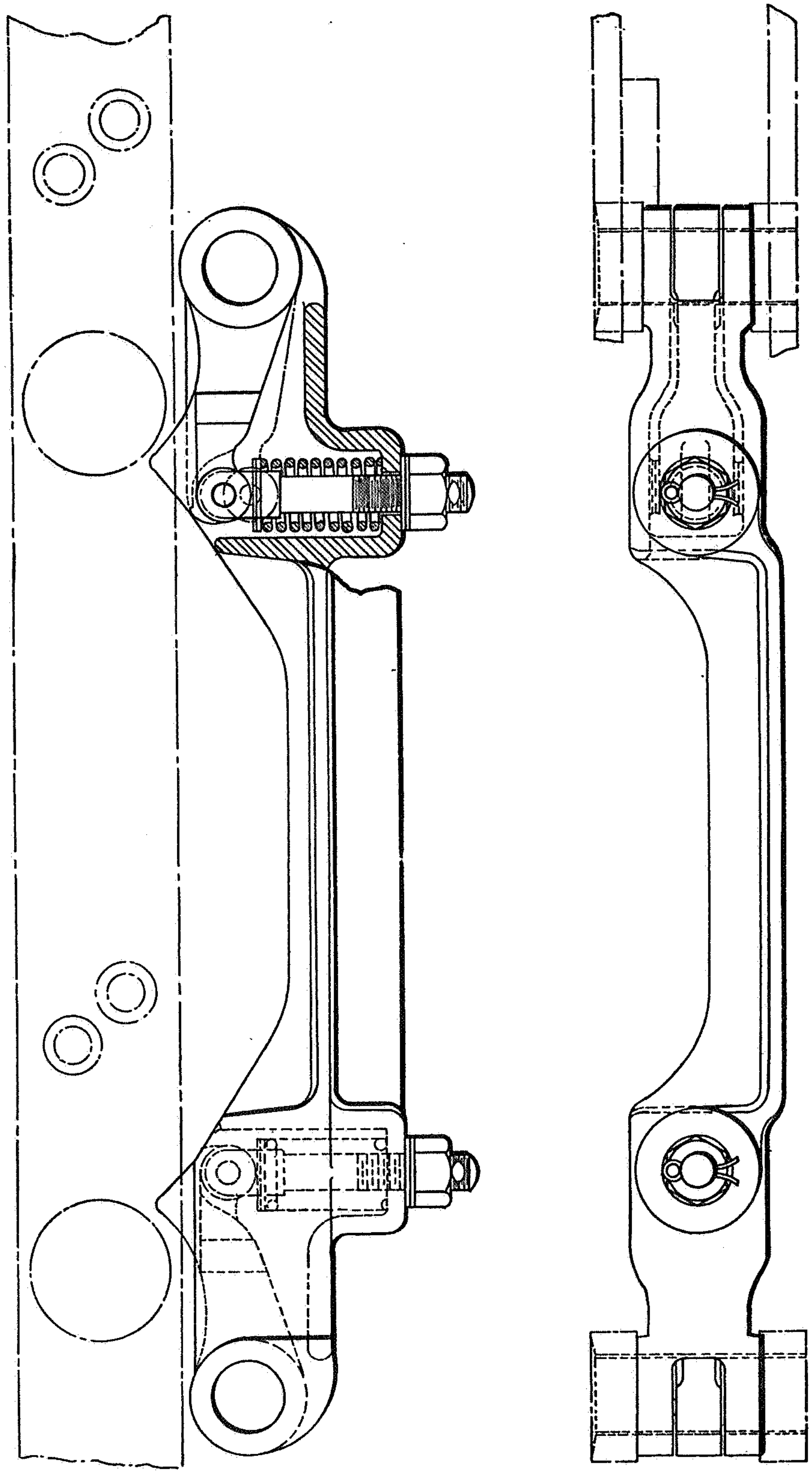


Fig. 26.
Friction Lock.

Fig. 27. It will be noted that this movement is supported by two ties whereas the A1 movement is supported by four. The movement is provided with a means for hand operation which is a feature required where a failure of switch to respond is particularly serious, such as in subway installations, where very close headway of traffic

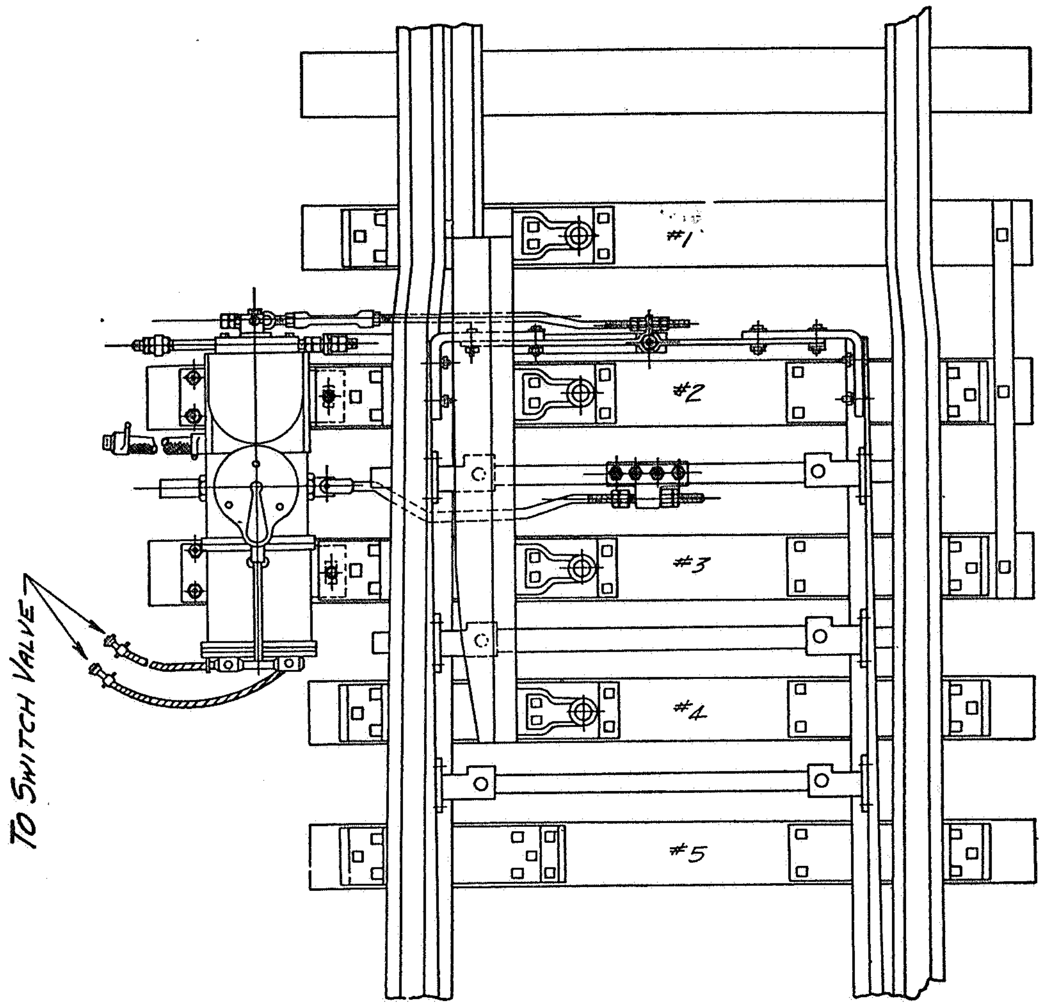


Fig. 27.
Rack and Pinion Switch-and-Lock Movement.

is maintained. The hand-operating feature is so arranged as to positively guarantee that air is cut off from the operating cylinders and that the cylinders are connected to atmosphere before the hand-operating crank can be introduced. Another feature of this movement is that under hand operation, when the manual operation of the switch is initiated, the switch indication circuit is automatically opened on the battery side and the control wires to the indication relay are shunted, thereby making it impossible to display a Proceed signal indication governing movement over the switch. The indication circuit is not restored until the switch movement has been restored to one or the other of its extreme positions, the hand crank removed, and the air again connected to the cylinders.

The movement is provided with a polarized indication circuit controller and can be furnished with either lock rod or point detector attachments or, if desired, both of these features may be incorporated.

The name of the movement "rack and pinion" in itself suggests the general principle of operation. There are two single-acting cylinders, one for the normal and the other for the reverse position of the switch. The pistons in these cylinders are connected to racks which engage with a gear, the gear in turn actuating a cam which produces the operating stroke of the switch. The initial and final movements of the racks which are directly connected to the pistons effect the mechanical unlocking and locking of the switch points, respectively.

The movement may be controlled from any standard independently mounted electro-pneumatic switch valve.

Mid-track switch-and-lock movement.

The mid-track switch-and-lock movement illustrated in Fig. 28, was developed for installations on subway and elevated railroads. The design of this movement is such that when installed no portion of the movement extends above the top of rail. The movement of the points is effected by a motion plate. In the particular application shown, the mid-track movement is applied to a switch with staggered points which is standard on certain lines. Lock rods are not used in this layout in view of the very direct and inflexible type of operating connection between switch-and-lock movement and switch points, although locking dogs are provided on the under side of the motion plate, which engage with the ends of the two point operating rods in the extreme positions of the movement and so prevent motion of the points with the movement in one or the other of its extreme positions. A circuit controller having independent mechanical connections to each of the switch points serves as a point detector.

The motion plate is actuated by a cylinder which may be controlled from any standard independently mounted electro-pneumatic switch valve.

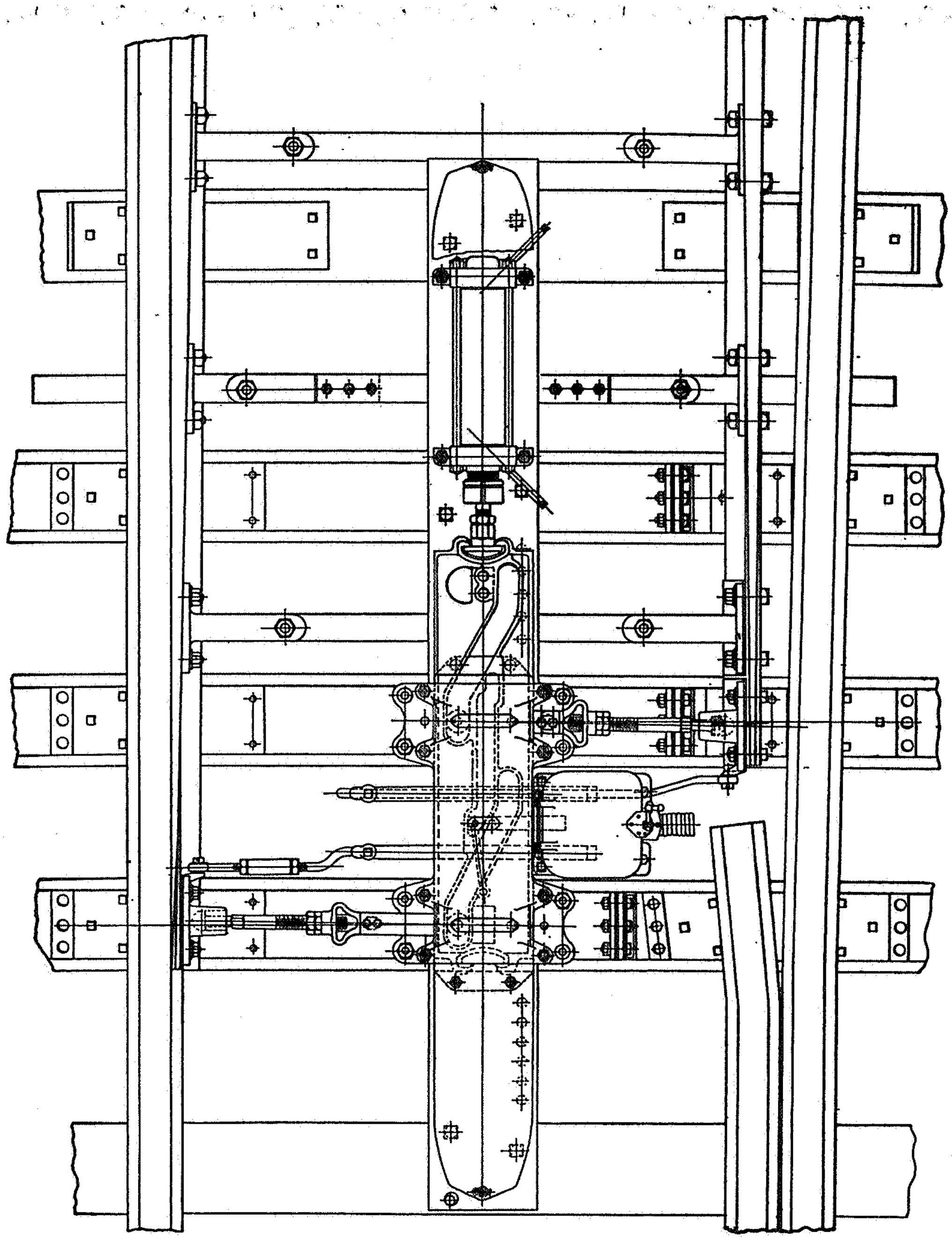
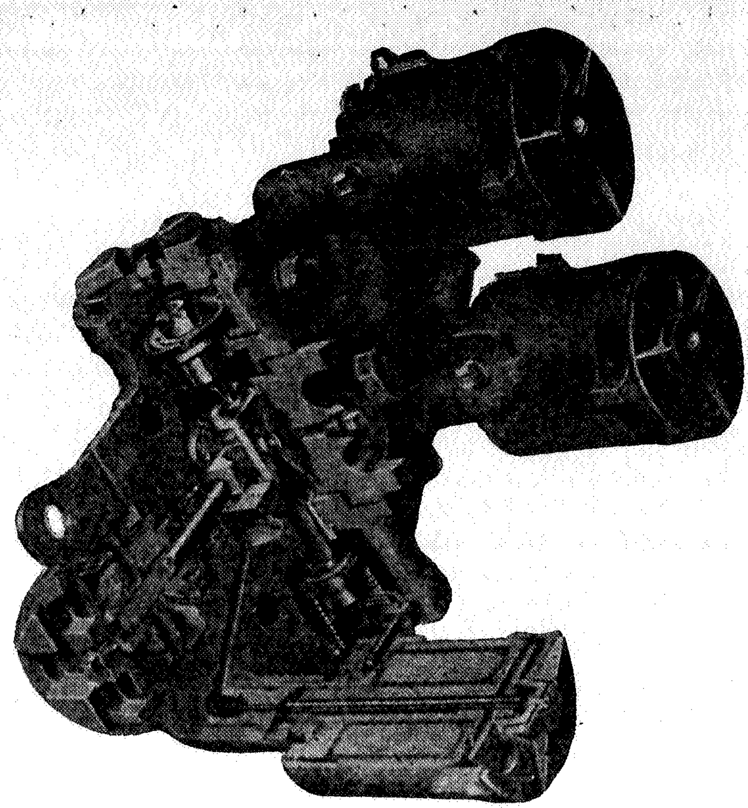


Fig. 28.
Mid-Track Switch-and-Lock Movement.

Style C switch valve.

Figure 29 illustrates this type of valve, from which it will be noted that while there are the three control magnets as before, they are arranged differently, also that the D valve is different.



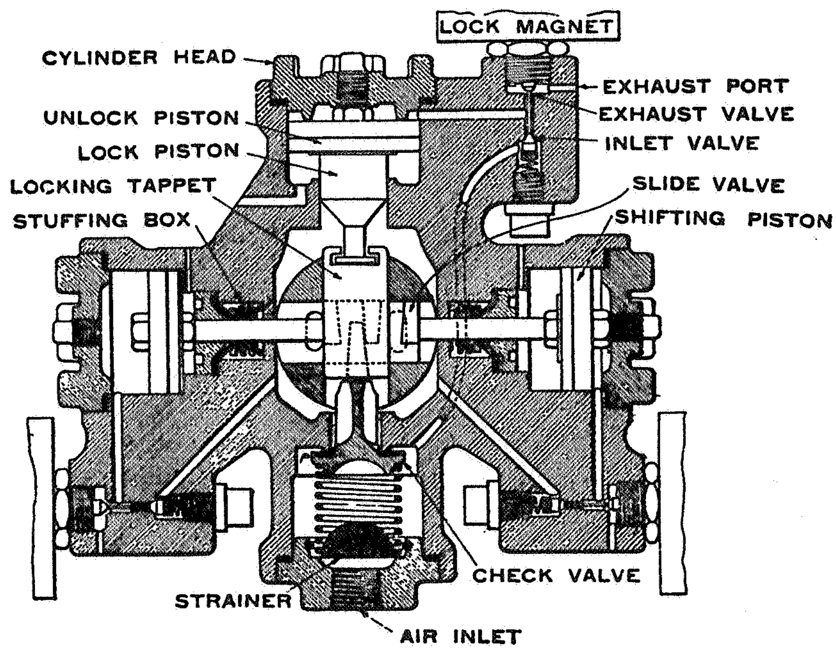


Fig. 29.
Style C Switch Valve.

With the Style C valve, air is admitted to the switch cylinder only when necessary to operate the switch from one position to the other, which permits the use of freely fitting pistons in the switch cylinders without having the leakage which would otherwise occur and does occur to a great extent where pressure is maintained against the switch cylinder piston continuously.

This feature is accomplished by using the lock magnet to not only lock the D valve, but also shut off the air supply from the main air line.

The cross-section view in Fig. 29 shows the various air passages from which it can be seen that air from the main air line is shut off from the movement by the check valve.

In making a movement from the normal to the reverse position the operation of the valves is as follows: As the lock magnet is energized it opens the air passage at the inlet valve, which admits air to the top of the locking piston, which forces this piston down not only unlocking the D or slide valve, but also depressing the check valve permitting air to enter the valve chamber, from where it will follow the air passage through the reverse control pin valve to the auxiliary cylinder, forcing the slide valve to the opposite position, similar to the operation described in detail for the old type of valve. When the switch has moved to the reverse position and is locked, and the indication on the lever is accepted, the lock magnet is de-energized removing pressure from top of unlock piston, then the air pressure within the slide valve chamber forces the lock piston up, which not only locks the slide valve in its new position but also permits the check valve to seat, cutting off air pressure from the main line.

The movement from reverse to normal is simply the opposite to that just described and can be easily followed by tracing the air passages as shown in Fig. 29.

The switch control circuit shown in circuit diagram, Fig. 8, therefore energizes the lock magnet which in turn permits air to enter the slide valve chamber and from there to the switch cylinder forcing the slide bar back to its original position, this operation being completed before the indication contacts have had time to open.

While the polarized indication circuit is shown with the A1 switch-and-lock-movements, provision has also been made for a circuit controller on the old type Model 14 movement so that the polarized indication circuit may be used with this type of movement. Various modifications of the circuits shown are used.

Style CP switch valve.

A more recent type of switch valve has been designed which, while embodying the cut-off feature of the Style C valve differs materially from the latter in that the D or slide valve employed in this and all previous switch valves is eliminated. The stuffing boxes employed in these valves for the pistons of the small cylinders by which the D valve is shifted are also discarded. These two small cylinders are retained in the new valve, however, but employ a plunger type of piston or poppet valve, each acting directly upon a simple inlet valve that controls the air flow to the respective ends of the switch cylinder. Pressure is admitted to and discharged from these small cylinders by individual magnetic pin valves as in the

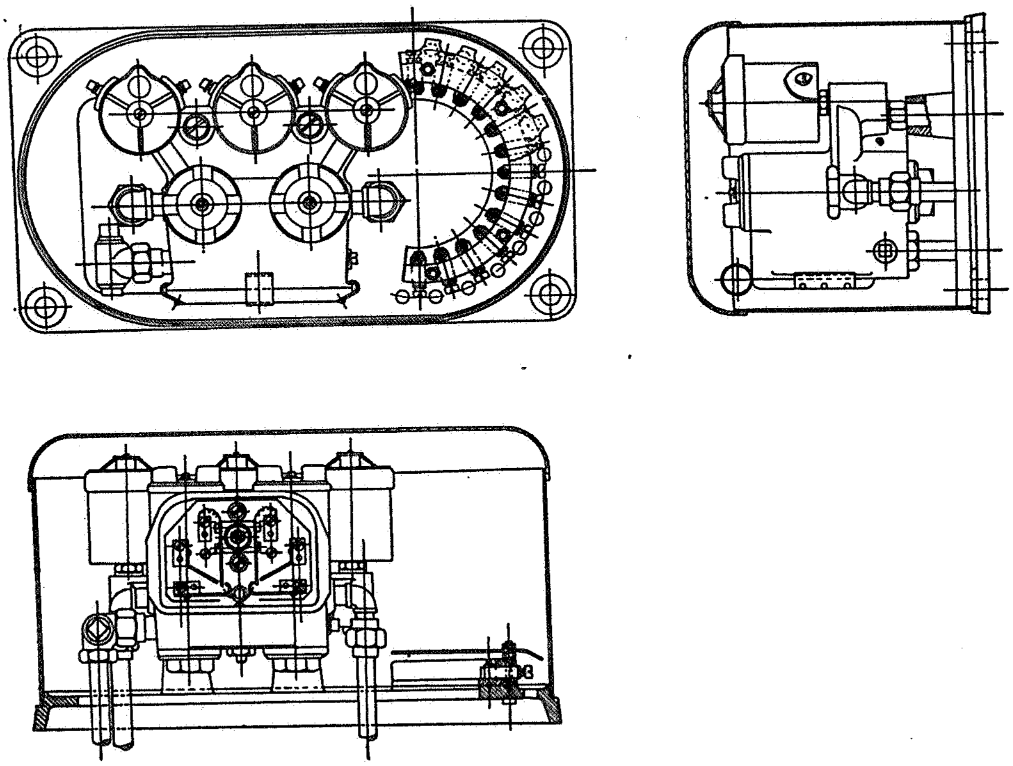


Fig. 30.
Style CP Switch Valve.

previous valves, but the pressure so controlled is also controlled by a similar magnetic pin valve that is interposed between the air main and other pin valves. It is in this third magnetic pin valve that the cut-off feature is located, since until this valve is electrically energized, no pressure reaches the other two, and, hence, none can reach either of the two small cylinders by action of which pressure is admitted direct from the air main to the switch cylinder. To admit pressure to the switch cylinder, therefore, it is necessary to energize this third magnet and one of the two other "selecting" magnets.

When this is done, and the switch in consequence has moved and become locked in a reverse position, the "third" magnet becomes de-energized. De-energization of this magnet not only closes the pressure supply to the other two magnetic valves but, because of this, closes the supply of pressure to the switch cylinder and exhausts from the cylinder the pressure therein that last operated the switch.

In these respects the new valve but duplicates the actions of the Style C valve under normal and abnormal conditions, though through mediums of a somewhat different design and arrangement. The design and arrangement of these parts were adopted primarily to facilitate the incorporation within the valve of a circuit controlling

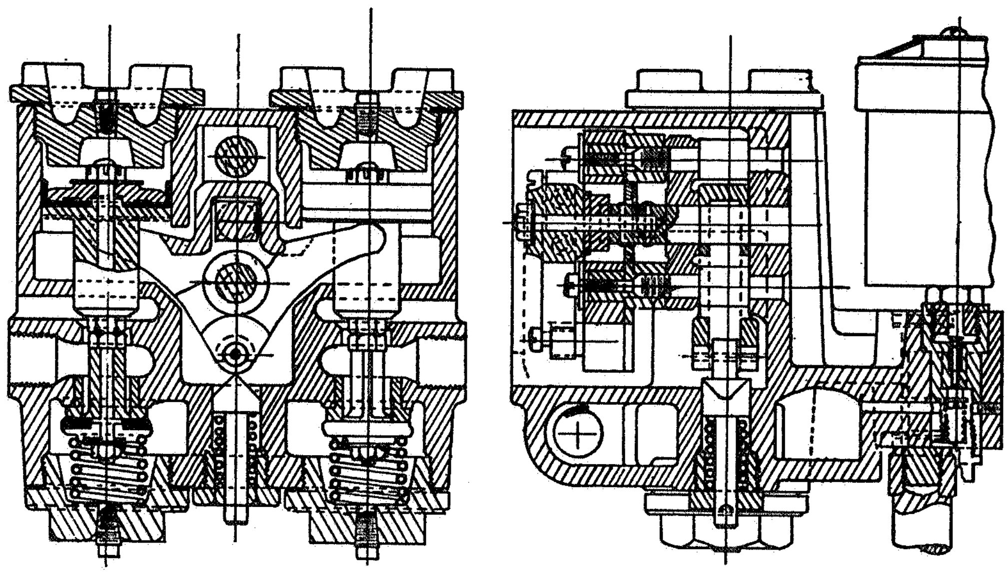


Fig. 31.
Cross-Section of Style CP Switch Valve.

agency whereby the position of the valve becomes a factor in the control of the switch indicating system. By this innovation it has been demonstrated that the "quick switch" heretofore associated with the switch lever, may be eliminated. The circuit controller has been built into the valve in a way that precludes injury to it during repairs and inspection and is immune to weather influence and other conditions.

Figure 30 shows the general appearance of the Style CP valve mounted upon a cast bed plate which also carries a semi-circular terminal board of moulded bakelite to which all external wiring is made and from which connection to the magnets and circuit controller are made by flexible conductors. A shield placed over the terminals prevents shorts or crosses during removal and replacement of the protecting metal covering of the valve. Air supply to the valve and from the valve to the switch cylinder is by ½ inch pipe with all unions arranged above the base plate and easily accessible.

Here too is arranged a globe valve for regulating the rate of flow of the air to the device to suit any desired speed of switch operation, and to stop it entirely for removal, repair, or cleaning of the valve. The exhaust from the valve is carried to the outside of the device through ports in its bed plate. Quick removal and replacement of the valve is conveniently arranged for, but its design precludes mounting it upon the switch cylinder—the separate mounting is considered preferable to the cylinder mounting, because of the improved

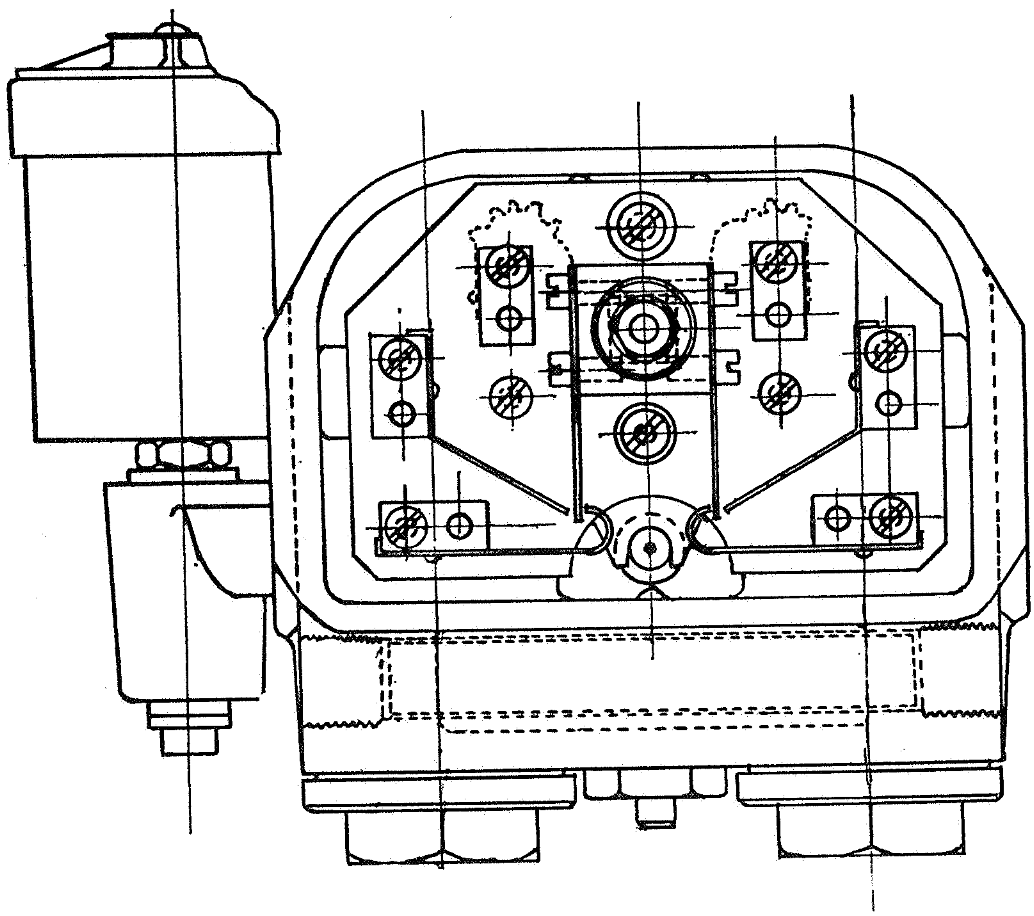


Fig. 32.
Circuit Controller Contacts, Style CP Switch Valve.

accessibility and safety it affords. This valve may be substituted for any former design of valve similarly mounted and retains the same magnets used on former types. A strainer is incorporated in the body of the valve that is easily removed for cleaning without disturbing the piping.

The circuit controller is operated by a walking beam mounted between and actuated by the two pistons of the valve. This walking beam is locked by a spring actuated plunger in either extreme position of the valve so that the contact pressure of the controller springs is maintained securely after each operation and when the pistons are no longer under pressure. This walking beam also renders it impossible for both pistons to be depressed at the same time, for depression of one elevates the other, and thus effectively prevents pressure being admitted to both ends of the switch cylinder at the same time through any unintended or unauthorized manipulation of the valve by hand or otherwise.

The peculiar mounting of the walking beam makes it possible to remove the piston of the valve without disturbing the walking beam or the circuit controller.

The circuit controller, when interposed in the polarized indication circuit, duplicates the effect of the regular indication controller of the switch movement and makes it imperative that the switch, valve and lever must coincide in position before the indication is received and must so remain to give, or to maintain, a Proceed signal indication over the switch.

Figure 31 is a section through the valve pistons and inlet check valves showing the walking beam and means for locking it in its two extreme positions.

Figure 32 shows the circuit controller contacts as actuated by the pivotal shaft of the walking beam.

Figure 33 represents, diagrammatically, the elements of the valve in relation to the switch circuit controller, lever, indicating and control circuits.

Where it is permissible to throttle the supply of air to the switch, it will be noted that this arrangement permits the action of the electromagnetic apparatus to shut off the supply of air, after the switch has completed its movement, before the air in the cylinder has reached full line pressure, under those conditions of free operation which do not necessitate the admission of main-line pressure to complete the stroke of the switch.

At isolated layouts, where air consumption is a matter of some moment, this added economy will be found especially desirable.

Conclusion

The operation of electro-pneumatic signal mechanisms is covered in Chapter XII—Semaphore Signals. Other electro-pneumatic units such as smashboards and train stops are operated on the same principle as already explained, that is, a magnet controlled electrically which in turn operates valves admitting or discharging air to or from cylinders, the pistons of which are connected to the unit to be operated.

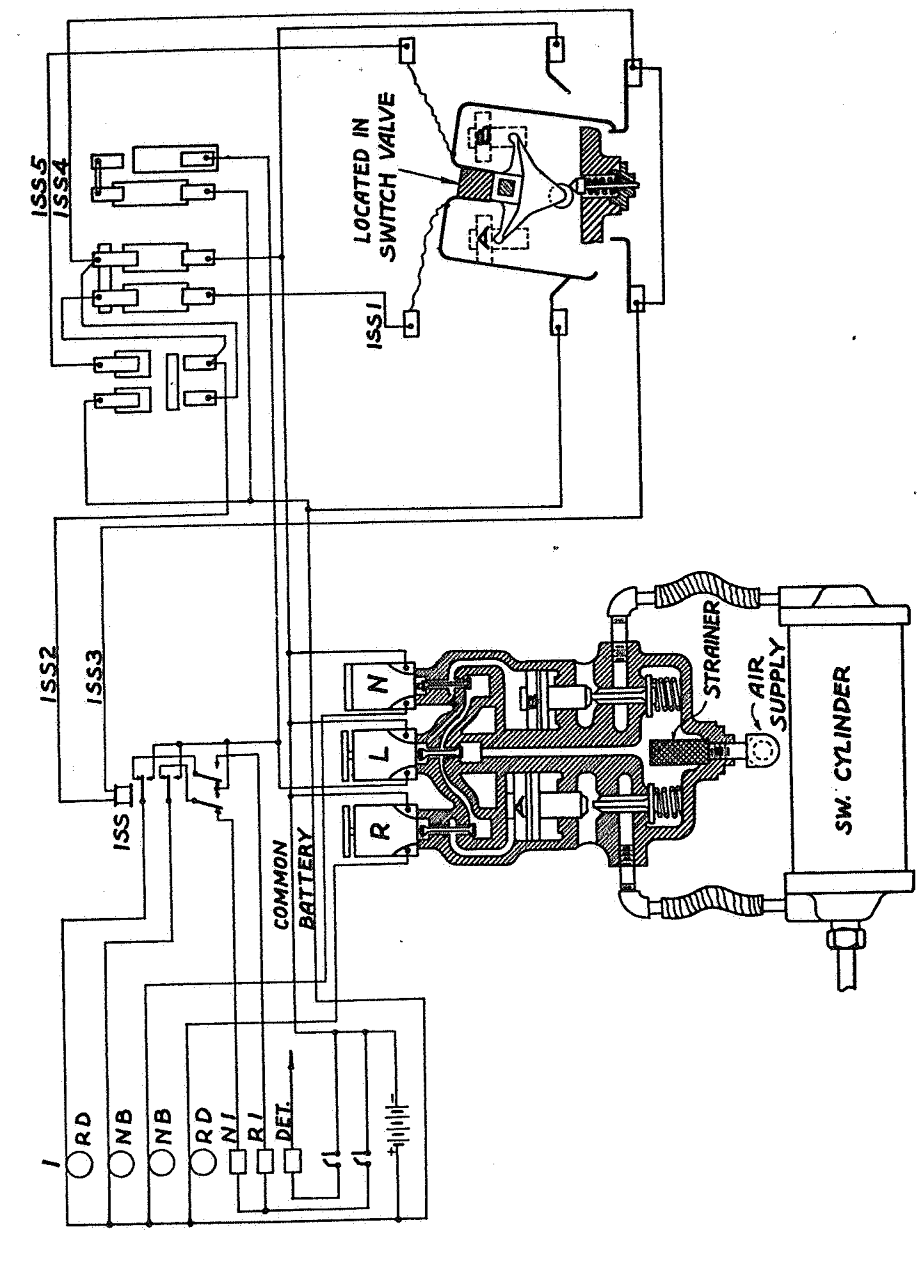


Fig. 33.
Diagrammatic of Style CP Switch Valve in Relation to Circuit Controller Lever, Indicating and Control Circuits.

Instructions

Electro-pneumatic interlocking should be maintained and tested in accordance with the following instructions:

1. Interlocking machine must be kept in good condition, free from excessive lost motion, rust, grease and dirt. 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, that the leverman operates levers from time to time to keep movable parts from freezing, and that sufficient forces are available to keep switches, etc., free from obstruction. Snow and ice must be removed from signal blades, roundels 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 following instructions for testing electric locking:

20. Approach locking must be tested at least quarterly as follows:

(a) When lock is on signal lever. To insure that the lever or latch cannot be restored to the normal position, with the proper route set, signal cleared where necessary, and the approach circuit open, each contact in the approach circuit must be opened separately (multiple circuits to be open) and attempt made to restore lever or latch to normal position.

(b) When combined with switch lever locking. To insure that the lever or latch cannot be moved from normal or reverse position after signal has been cleared and approach circuit open, signal lever must be restored to normal position, each contact in the approach circuit opened separately (multiple circuits to be open) and attempt made to move lever or latch from normal or reverse position.

(c) Multiple circuits must be tested by opening each contact cut around in the approach circuit with the multiple circuit closed and, when lock is on signal lever, restore lever or latch to normal position; when combined with switch lever locking, move lever or latch from normal or reverse position. This test must be made separately for each multiple circuit.

(d) Time interval must be checked and time releases kept within 10 per cent of the time designated. The time for which the release is set must be marked on each release.

21. Time locking must be tested at least quarterly as follows:

(a) When lock is on signal lever. To insure that the lever or latch cannot be restored to the normal position, until the designated time interval has elapsed, lever must be reversed and attempt made to restore lever or latch to normal position while time release is operating.

(b) When combined with switch lever locking. To insure that the lever or latch cannot be moved from normal or reverse position, until time interval has elapsed, attempt must be made to move lever or latch from normal or reverse position while time release is operating.

(c) Multiple circuits must be tested as outlined in Instruction 20-c.

(d) Time releases must be inspected and checked as outlined in Instruction 20-d.

22. Indication locking must be tested:

(a) On signal lever at least quarterly. To insure that the lever or latch cannot be placed in the normal position.

1. For semaphore signals, until the corresponding home signals are within 5 degrees of the Stop position and distant signals are within 5 degrees of the Approach position, signal must be cleared and the lever then restored to indicating position and, holding signal arm by hand, let signal arm gradually resume the normal position, during which time person operating lever should be endeavoring to restore lever or latch to normal position.

2. For light signals, until the corresponding home signals are in the Stop position and distant signals are in the Approach position, signal must be cleared and the lever then restored to indicating position, keeping signal control relay picked up, endeavor to restore lever or latch to normal position.

(b) The operation outlined in Instruction 22-a to be repeated for each signal arm controlled by such lever.

(c) On switch or lock lever at least monthly.

1. When operated, locked and indicated by the same lever. To insure that the lever and switch or switches or other operated units are in the corresponding position and switches locked before lever stroke can be completed and mechanical locking released, lever must be operated to indicating position and each switch or other unit separately prevented from completing stroke, then attempt to complete stroke of lever or latch.

2. When locked and indicated by lock lever. To insure that the operating lever and switch or switches or other operated units are in corresponding position before lock lever can be operated and mechanical locking released, switch or switches or other units must be operated and each switch or other unit separately prevented from completing stroke, then attempt to unlatch lock lever.

23. Switch lever locking must be tested at least weekly as follows:

(a) To insure that the lock will hold the lever or latch, locking circuit must be opened and lever or latch moved against the lock several times while no train is occupying or approaching the section of track affected.

(b) To insure that a lock will not release while the circuit is occupied, each lever must be unlatched or floor push operated (but lever must not be moved) while a train is on the circuit and the lock closely observed to see if it releases. When practicable, this test should be made while light engines are passing over crossovers.

24. Switch lever locking must be tested as follows:

(a) At least monthly. Each track circuit must be shunted at several points with a wire, giving particular attention to crossovers and turnouts and noting that each track and repeating relay opens.

(b) At least quarterly. Each route should be set and the proper relays operated to determine that the route locking is effective.

25. Traffic locking must be tested at least monthly as follows:

(a) To insure that the lock will hold the lever or device for changing the direction of traffic, locking circuit must be opened and the lever or latch moved against the lock several times while no train is occupying or approaching the section of track affected.

(b) To insure that a lock will not release while the section of track protected is occupied, each lever or device for changing direction of traffic should be tried repeatedly (but not operated sufficiently to permit changing direction of traffic) while a train is running over that section and the lock closely observed to see if it releases. When practicable this test should be made with light engines.

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

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

28. 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.

29. 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.

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

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

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

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

34. Wire joints must be made in accordance with A.R.A. Signal Division Specification 11020; they must not be made in insulated wires underground or where they cross tracks.

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

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

37. 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.

38. 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.

39. 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.

40. 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.

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

42. 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.

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

44. Location of air compressor intakes must be kept clean and free from dirt and moisture. Intake must not be close to the ground nor inside of buildings where moisture accumulates. Nothing should be done which might obstruct or increase the resistance of air intakes.

45. Air compressor intake screens and filtering devices must be kept clean.

46. Condensers, tanks, reservoirs, and air distribution lines which may serve the purpose of smoothing out pulsations of compressor units, must not be disconnected or cut out, except for necessary repairs.

47. Condensers, tanks, reservoirs, and air distribution lines must be drained frequently enough to avoid overflow of condensation into branch lines and apparatus.

48. Special attention must be given to drainage of condensation from air systems throughout the period of the year when temperatures are above freezing so as to avoid interruptions during cold weather.

49. Means of draining condensation out of distribution system must be provided and maintained at low points. If settling of ground or other causes changes such conditions, relocation and changes in lines or drains must be made.

50. Valves, fittings and couplings must be tested after assembling in system to determine if there is any leakage. Application of soapsuds to such parts with maximum air pressure is a simple method of disclosing air leakage.

51. Air distribution systems must be maintained so that leakage in any section of the plant will not exceed one pound in 12 minutes at normal pressure with all apparatus connected and at rest.

52. Inside of pipe and fittings must be kept free from iron cuttings, scale, dirt, paints or compounds.

53. Where no air flow meters or similar instruments are in use to disclose the volume of air consumed and condition of air distribution system, a periodical test and record of idle and working time of compressor units must be made.

54. Air strainers used between air distribution system and air apparatus must be cleaned frequently enough to avoid air pressure reduction.

55. Oil used in piping system or internal parts of valves, cylinders and other apparatus, must be of a grade which will not disintegrate nor injure leather and similar packing.

56. Pick-up and release values of valve magnets must be maintained within the limits recommended by manufacturer.

57. Valves and cylinders must be inspected periodically and tested in service by application of air pressure with apparatus at rest. This must be done frequently enough to insure that parts are clean, packing tight, air supply unrestricted and apparatus functioning efficiently.

58. When necessary to clean and adjust switch and signal valves and cylinders they must be removed from service and the work performed in the shop.

American Railway Signaling Principles and Practices

QUESTIONS ON

CHAPTER XVIII

Electro-Pneumatic Interlocking

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ELECTRO-PNEUMATIC INTERLOCKING

General.

1. What general name is given electro-pneumatic interlocking?
2. What are the operating agencies?
3. How are the switches and signals controlled and operated?
4. How does the development of electro-pneumatic interlocking compare with other features of signaling?
5. What essential elements are necessary for the operation of an electro-pneumatic interlocking?
6. What other features are necessary for a complete interlocking?

Compressed Air System

7. How many general methods of supplying air are used?
8. How do the earlier and later methods for supplying air differ?
9. In the earlier arrangement, of what does the main air line consist and between what does it extend?
10. Why are duplicate sets of compressors usually used?
11. How are compressors driven and how are they controlled?
12. Why is the capacity of generators generally greater than that required to take care of the signal system?
13. To how many pounds per square inch is the air usually compressed?
14. What minimum air pressure are compressors required to maintain?
15. How is air supplied to the individual switches and signals at the interlocking?
16. What reduction in the pipes is generally made at the unit to be operated?
17. What arrangement is made so that a section of the main pipe may be shut off and how is it accomplished?
18. Why is a valve provided in each branch line?
19. Of what material should air lines be?
20. How is the expansion and contraction in main air lines taken care of?
21. For how much expansion and contraction for 100 feet of pipe above ground is it customary to provide?
22. What does the expansion joint consist of and for how much travel is it arranged to provide where 2-inch pipe is used?
23. When air line is above ground, what is the maximum distance between expansion joints?
24. What is the maximum distance between expansion joints when the air line is underground?

25. What has been used instead of expansion joints in some installations?

26. At what point is the main air line securely anchored?

27. Why should air lines be kept in good surface and graded?

28. Where should branch air lines be taken from main air lines and how should connection be made and arranged?

29. Where the line is underground, what provision is made so access to expansion joints and valve locations can be had in case of necessity?

30. In later installations, how has the main air line been restricted and how accomplished?

31. What is used with later installations which makes it possible to operate switches at considerably lower pressure and with less air?

32. Of what does the layout ordinarily consist?

33. How do they operate and at what pressure do they cut in and out?

34. How does the arrangement usually provide so if the first compressor does not start at 50 pounds the second will?

35. Upon what may the cut-in and cut-out points vary?

36. In installations of today what is being done generally so that it is only necessary for the compressors to be large enough to take care of the operation of the switches and permits of much smaller compressors than required for the earlier installation?

37. How may the size of compressor needed for a particular layout, where switches only are to be operated, be approximated?

38. How is the manufacturer's rating of compressor based?

39. After it is determined approximately what capacity compressor is required, what one should be selected?

40. What other consideration must be given to compressor capacity?

41. What provision is made so that practically all the condensation will take place before the air reaches the air line?

Electrical Energy

42. How is the electrical energy used for the control of the various units ordinarily furnished, and at what voltage?

43. When alternating current is used for the operation of the various magnets instead of batteries, what voltage is used?

44. Is the current used for each switch excessive?

45. With an installation using storage battery, what is the resistance of magnets?

46. How many magnets, or the equivalent, are used, how are they connected and what is the approximate current consumption for each set of magnets energized simultaneously?

47. How are the valves controlling the supply of compressed air which move the switch, signal or other unit, controlled?

48. How are the electric locks, indicators, relays, etc., controlled?

Interlocking Machine

49. How is an electro-pneumatic machine defined by the Signal Section, American Railway Association?

50. To what extent does air enter into the control of the machine itself?

51. What other type of interlocking may be controlled with the electro-pneumatic machine?

52. How are the levers spaced and arranged?

53. What are the odd-numbered levers used to generally control?

54. What are the normal and reverse positions of the odd-numbered levers?

55. What are the even-numbered levers used to generally control?

56. What is the normal position generally of the even-numbered levers?

57. With the lever in the left or L position, what signal will be cleared?

58. Moving the same lever to the right or R position, what signal will clear?

59. What signals are controlled from the same lever and what is the advantage?

60. Is there anything to prevent the odd-numbered levers being used for signals, etc., and the even-numbered levers for switches, if desired?

61. What must be done when it is desired to use levers for controlling devices other than those for which they were intended?

62. Why is mechanical locking between levers provided?

63. What does each lever operate?

64. What does the driver, which is placed on the forepart of the shaft, operate?

65. What does the beveled gear drive, near the center of the shaft, operate?

66. What does the vertical shaft operate and what is the purpose?

67. How does the travel of the lever compare with the travel of the vertical shaft?

68. How is the increased travel of the vertical shaft accomplished?

69. What is the object in having the shafts travel 120 degrees?

70. Was the vertical roller used with the earlier types of machine?

71. Where were the bands mounted when the vertical roller was not used?

72. When shaft was connected direct to lever and moved through an arc of only 60 degrees, what effect did it have on certain contacts?

73. What was done to assist in the adjustment of contacts?

74. What is the part of machine just mentioned called?

75. With what is the rear portion of the shaft equipped?

76. What is the purpose of the segments?

Switch lever.

77. What is actuated by lever handle or knob?

78. Why is the quadrant notched?

79. What is done to further insure the quadrant taking the strain?

80. How are the contacts, below the front part of the lever, operated?

81. How is the cam, which operates the contacts, operated?

82. When are the contacts open and when do they close?

83. Where is the quick switch located?

84. Of what is the quick switch a section, and how is it operated?

85. How is the switch restrained from following the lever during the first part of the movement?

86. What movement of the lever operates the switch and to what position does the switch travel?

Signal lever.

87. How does the general arrangement of the signal lever compare to the switch lever?

88. How do the mechanical locking driver and bevel gear on the switch and signal compare?

89. How many segments and magnets has the signal lever and how does the circuit controller compare with that on the switch lever?

90. How is the circuit controller operated?

91. What prevents the operation of the push button when lever is in the normal position?

92. In what position must lever be so push button may be operated to close contact connected thereto?

93. When contacts are closed, what position must the lever be placed in to open them, and how is it accomplished?

94. What is this push button generally known as and what is its function?

Operation of switch lever.

95. In how many movements is a switch lever moved from the normal to the reverse position?

96. What does the first movement of the lever operate?

97. When may the lever be moved to its extreme reverse position?

98. By what is the releasing of the lever to make the second movement known?

99. While the first movement of the lever is accomplished in one operation, how many separate actions take place?

100. When the lever has moved from the N position approximately 22 degrees or to the B position, what circuit is closed and what does it do?

101. As the lever moves through the next few degrees (slightly beyond the B position) what band is opened?

102. As the lever continues to move through the next 10 degrees, what band closes and in what position does this leave the lever?

103. With the lever in the D position it is how many degrees within its complete stroke?

104. With the lock circuit closed, normal control open and reverse control closed, what causes the switch to be moved to its reverse position?

105. When is the reverse indicating circuit completed?

106. How does the indicating circuit function?

107. On this final movement of the lever, in what position is the lock band opened and how far is this from the extreme reverse position?

108. In what position does this lock the switch mechanism?

109. What effect does the movement have on the quick switch and what contacts are effected?

110. What conditions apply when lever is moved from the reverse to the normal position?

111. Ordinarily, on what does the arrangement of the lock control band depend, and why?

112. How does the lock circuit flow?
   (a) Explain the normal control.
   (b) Explain the reverse control.

113. What is the tooth projecting from the bottom of both normal and reverse magnet segments called?

114. What is the purpose of the safety tooth?

115. How is the false switch indication prevented?

116. What bands must not close until after the safety tooth is passed?

117. If the circuit bands should close before the safety tooth is passed and the lever is moved only far enough to close them, what could happen to the switch?

118. With the safety tooth not passed, what would be the effect?

119. Why must the adjustment of bands be checked quite frequently on levers equipped with 60 degree rollers?

120. Why is the adjustment more easily maintained with the 120 degree rollers?

121. How can it be determined that the control bands close only at the proper time?

122. In moving the lever from the normal to the reverse position and after reaching the indicating point, why is it necessary to wait?

123. When the switch has responded, what takes place which will permit the further movement of lever?

124. In restoring the lever from the reverse to the normal position, what action takes place?

Quick switch.

125. When a switch lever is moved from its normal position towards its reverse position, or vice versa, why is it necessary to complete the stroke before it can be returned to its original position?

126. Before the lever stroke can be completed, what action must be taken by the switch?

127. In the electro-pneumatic system of interlocking, how is the switch moved?

128. What does the set of valves govern?

129. Does the indication circuit check the position of the control valve or the position of the switch points?

130. Why is it assured that the switch valves have responded to the control lever?

131. What other feature is accomplished by the quick switch?

132. What recent development eliminates the necessity for a quick switch?

Operation of signal lever.

133. What is usually the normal position of the signal lever and how is it moved to clear a signal?

134. In moving the lever from the center to the right or left, is there an interruption in the movement?

135. In returning the lever to the normal position, is the movement continuous?

136. If the lever is to the right or R position, how far can it be moved toward the center or normal position before it is stopped?

137. What releases the lever after it is stopped and how is it accomplished?

138. What is the releasing circuit known as?

139. In addition to separating the R and L circuits, what is accomplished by the LB and RD bands when lever is in the center or normal position?

140. When is the only time the indication magnet is energized?

141. What is the main purpose of the signal indication lock circuit?

Electric switch locking.

142. With what were detector bars, which were used quite generally in the early stage of eletcro-pneumatic interlocking, replaced?

143. What other condition made the elimination of detector bars necessary?

144. What effect does electric switch lever locking have on the lever?

145. How many general schemes are used in electric switch lever locking and how do they compare?

146. How do the indication magnets prevent the manipulation of switch levers when magnets are de-energized?

147. How does the de-energized track relay prevent either indication magnet from being energized?

148. When the track relay is energized, how can the switch lever be moved from one position to the other?

149. In what position of the lever is the latch contact in the circuit, and what is its purpose?

150. How are the indication and electric locking circuits to the indication magnets controlled?

151. By what circuit and in what position is the lever when the normal indication magnet is energized?

152. In what position is the lever when the normal indication circuit is closed?

153. What is used for switch lever locking by another arrangement when the indication magnets are reserved for their original purpose?

154. How does the latter scheme compare with the circuit shown in Fig. 10?

155. In the earlier machines of this type, where was the magnet located and controlled?

156. From a study of Figs. 11 and 12, why is it the switch lock could not pick up until the track relay was energized?

157. What name has this type of lock been given?

158. Where has the lock been placed in the later machines of this type?

SS protection.

159. Before clearing a signal for a train to proceed over a switch, what is it essential to know with reference to the switch and its controlling lever?

160. What circuit is used to assure that a switch will remain in the position desired?

161. How many general types of SS circuits are there and what are they called?

162. Which type of SS circuit was used in the earlier installations, and to what extent is the polarized type now used?

163. How does the SS circuit compare with the indication circuit from the contacts in the indication box to the machine?

164. Explain the circuit for the SS neutral type.

165. In order for the SS relay to remain energized, how must the switch be with relation to the lever?

166. What prevents a signal that governs a movement over the switch from clearing unless the positions of the switch and lever correspond?

167. What is the one main feature of the SS circuit?

168. Why are bands sometimes arranged as NB and RB bands or similar combination?

169. What circuit is sometimes energized through the back contacts of the SS relay making it undesirable for the SS relay to open should the switch lever be moved as far as the locking would permit?

Crossovers, slips and movable point frogs.

170. What apparatus besides switches must be taken care of in the arrangement of circuits?

171. In the electro-pneumatic layout, is it possible to operate more than a single switch or set of valves from one lever?

172. Where valves are located at the movable point frogs only, how is the switch movement at the double-slip end operated?

173. When valves are located at the movable point frogs only, how are the switch valves controlled?

174. How is the indication circuit arranged, and why?

175. Are there different arrangements for the control circuits, and how are they arranged?

176. What circuits are usually used for the control magnets where there are more than two sets of valves controlled from the same lever?

177. How are the two mutliple circuits, on the same lever, balanced?

178. What is the resistance of the lock and control magnets generally?

179. With the non-cut-off type of valve, why is it desirable for the lock magnets to be connected?

Switch Layout

180. What are the essential parts of a switch layout?

Switch-and-lock movement.

181. What part of the layout is the switch-and-lock movement and of what does it consist essentially?

182. How is the slide bar made up and how is it connected?

183. How is the switch crank operated and how is it arranged to handle the slide bar and move the switch points?

184. Where are the locking dogs located and how do they function?

185. What does the first movement of the slide bar accomplish?

186. What does the next movement do?

187. What does the final movement do?

188. Where is the indication box located?

189. On what movement of the slide bar do the indication contacts close?

190. If there is an obstruction in the switch point, or the switch is out of adjustment so that it does not close within ¼ inch of the stock rail, what will be the result?

Switch valves.

191. How many control magnets are used, and how are they designated?

192. Why is the auxiliary piston used and what is its purpose?

193. Why must the switch mechanism or valves be locked after the switch has been moved to the desired position?

194. What is the D valve?

195. Is air pressure constantly applied to hold the switch in normal position?

196. How is a reversal of the switch accomplished?

197. What occurs when the switch has been moved to the reverse position and is locked in that position?

198. What sequence of operation takes place after the stroke of the lever has been completed?

199. What sequence of operation takes place when the lever is moved from reverse to normal position?

200. Is much time required for the operation of a switch movement?

201. What is done to assist in quickening the operation?

Cylinder.

202. What are the sizes of cylinders used?

203. What determines the size of the cylinder required?

204. May the normal position of the piston relative to the cylinder be reversed with the switch in normal position?

205. What is the stuffing box?

Separately mounted valves.

206. Must switch valves be fastened directly to the switch cylinder or may they be separately mounted?

207. In later installations what type of switch valve and switch-and-lock movement has been used?

208. What was the primary object in developing these devices?

A1 switch-and-lock movement.

209. What is the chief difference between the Model 14 and A1 movements?

210. How is the operating arm of the switch crank ordinarily adjusted?

211. How does the indication circuit controller differ from that used on the Model 14?

212. Why is this type of circuit controller necessary?

213. What advantages has it?

214. How are the contacts used?

215. Describe the operation of contacts when a switch is moved from normal to reverse position and is locked?

216. How many wires are required for the indication circuit between switches of a crossover, and why?

217. Describe one way of supplying air to the switch mechanism in case the switch opens from vibration or other cause.

218. What is the circuit controlling this feature called?

219. Why must the contacts controlling this circuit close before the indication contacts open?

220. Where the signal control circuits are not controlled through the indication relay, may the restoring circuit be controlled through it?

221. What other arrangement is used to prevent the switch from opening without an application of air to close it?

Rack and pinion switch-and-lock movement.

222. Where is the rack and pinion type of switch-and-lock movement especialy suited for use?

223. By how many ties is it supported?

224. Can it be operated by hand?

225. How is the hand-operating feature arranged?

226. What other feature of this movement makes it impossible to display a Proceed signal indication while the switch is being operated by hand?

227. Can either a lock rod or a point detector be used with this movement?

228. Describe the operation of the movement.

229. What type of switch valve is necessary to control it?

Mid-track switch-and-lock movement.

230. For what type of installation was this movement developed?

231. How is it designed?

232. How is the movement of the points effected?

233. Why are lock rods not used?

234. How are locking dogs applied?

235. What serves as a point detector?

236. How is the motion plate actuated?

Style C switch valve.

237. How does this valve differ from others?

238. When is air admitted to the switch cylinder?

239. What does the lock magnet do?

240. How is air from the main air line shut off from the movement?

241. In making a movement from normal to reverse, how do the valves operate?

242. In making a movement from reverse to normal, how do the valves operate?

243. May the polarized indication circuit be used with this movement?

Style CP switch valve.

244. How does this differ from the Style C valve?
245. Describe its operation.
246. What was the purpose in the design and arrangement of its parts?
247. What is substituted for the quick switch in this movement?
248. How are wires connected to the magnets and circuit controller?
249. Why is a shield used?
250. How is air supplied?
251. What is the purpose of the globe valve?
252. Where is the exhaust carried?
253. Why is separate mounting of the valve preferred?
254. May this valve be substituted for other designs where similarly mounted?
255. Is a strainer used?
256. How is the circuit controller operated?
257. How is the walking beam locked?
258. How is pressure prevented from being admitted to both ends of the switch cylinder at the same time?
259. Can the piston be removed without disturbing the beam or circuit controller?
260. What makes it imperative that the valve and lever coincide in position before indication is received?
261. Where it is permissible to throttle the supply of air to the switch, what does this arrangement permit in the way of economy of operation?
262. At what points is this economy especially desirable?

Conclusion

263. How are other electro-pneumatic units such as signals, smashboards and train stops operated?

Instructions

264. How must interlocking machine be kept?
265. What instructions and advice must be given levermen when necessary?
266. What special attention must be given interlocking plants during snow and sleet storms?
267. By whom must levers and other operating appliances be operated?
268. For what purpose must periodic inspection and test be made?

269. Is it permissible to change or remove the locking of an interlocking machine?

270. If locking is disarranged, what must be done?

271. How must seals and locks be maintained and handled?

272. What practices, which may result in train delays, must be avoided?

273. Is it permissible to turn relays over or bridge the contacts?

274. What clearances must be maintained?

275. How must foundations be kept?

276. How often must paint be applied and what attention must be given its application?

277. What attention must be given threads and bearings of movable parts?

278. Where must cotter pins be used and how must they be kept?

279. Where must gaskets for relay boxes and other housings be kept?

280. When must moving parts be replaced?

281. How should signals be maintained and tested?

282. How should relays be inspected and tested?

283. How should electric locking be tested?

284. How often must locking be tested, and how is the test made:

(a) When lock is on signal lever?
(b) When combined with switch lever locking?
(c) When locks are on multiple circuits?
(d) When time releases are used?

285. How often must time locking be tested, and how is the test made:

(a) When lock is on signal lever?
(b) When combined with switch lever locking?
(c) When locks are on multiple circuits?
(d) When time releases are used?

286. Must indication locking be tested?

(a) How often must it be tested, and how is test made when lock is for:

1. Semaphore signal?
2. Light signal?

(b) Must test be repeated for each signal arm controlled by the lever?

(c) How often must it be tested and how is test made:

1. When operated, locked and indicated by same lever?
2. When locked and indicated by lock lever?

287. How often and in what manner must switch lever locking be tested:

(a) To insure that the lock will hold the lever?
(b) To insure that the lock will not release while the circuit is occupied?

288. How often and in what manner must test be made of:
  (a) Track circuits?
  (b) Route locking?

289. How often and in what manner must traffic locking be tested:
  (a) To insure that the lock will hold the lever or device for changing the direction of traffic?
  (b) To insure that the lock will not release with the track occupied?

290. How should rectifiers be maintained and operated?

291. How should batteries be maintained?

292. How must lock rod be adjusted and locking edges kept?

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

294. How must fouling circuits be maintained?

295. How must wires be supported?

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

297. Must insulated wire be protected from mechanical injury?

298. How must wire joints be made?

299. How must lightning arresters be connected and grounds maintained?

300. How must bootlegs and conduits be maintained?

301. What attention must be given to fibre insulations?

302. What must be done before removing rails, frogs or switch points?

303. What understanding must be had between maintainers and section foremen as to location and care of electric circuits?

304. When and how must a maintainer give an operator an "out of service" notice?

305. How must line wires be supported? Must broken insulators be replaced?

306. What inspection must be made of pole line supporting signal wires?

307. What attention must be given to air compressor intakes?

308. How must intake screens and filtering devices be kept?

309. Is it permissible to cut out condensers, tanks or other equipment from the air distribution lines?

310. How often must condensers, tanks and reservoirs in air supply lines be drained?

311. At what periods of the year must drainage of condensation from air system be attended to?

312. What drainage facilities must be provided in a distribution system?

313. How must valves, fittings and couplings be tested for leaks after assembly?

314. How must the air distribution system be maintained with respect to leakage?

315. How must inside of pipes and fittings be kept?

316. Where no air flow meters or similar instruments are used, what records must be kept?

317. How often must air strainers be cleaned?

318. What kind of oil must be used in piping system or internal parts of valves, cylinders and other apparatus?

319. Within what limits must pick-up and release values of valve magnets be maintained?

320. How often and in what manner must valves and cylinders be tested and inspected?

321. When necessary to clean and adjust switch and signal valves or cylinders, where must the work be performed?