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American Railway Signaling Principles and Practices

CHAPTER VI

Direct Current Relays

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DIRECT CURRENT RELAYS

In practically every branch of the electrical field, relays play a very prominent part. Their principal function is to repeat in other circuits the effects of an electric current. As an illustration: In a telegraphic line circuit the relay is energized by a comparatively weak current. This attracts an armature electromagnetically. Suitable contacts, which close other circuits, are connected to the armature.

In railway signaling there is no apparatus that is more essential to the successful operation of the system than the relay. In a track circuit the relay is arranged to close its contacts on the passage of a comparatively weak current in the rails and coils. The closing of these contacts in turn completes a circuit in which a current flows to operate the signal or other apparatus as desired. The same principle applies, if necessary, to operate apparatus located at some distance from the controlling point. The relay, located at the outlying point, is energized by a comparatively weak current transmitted over wires from the controlling point. When the control circuit is closed it energizes the relay, closing its contacts, completing a circuit to the apparatus to be operated.

Relays are of various types of construction, depending on the service in which used. This chapter will deal exclusively with relays used in signal work, operated by direct current. The arrangement of circuits controlling relays, circuits controlled by them and relays operated by alternating current, are described in other chapters.

Theory of an electromagnet as applied to the operation of direct current relays.

The following general principles of the operation of an electromagnet should be borne in mind throughout the study of this chapter.

As an electric current is transmitted through or along a wire it gives out magnetic lines of force in the form of circumferences of circles about the axis of the wire. Any magnetic substance brought within the influence of these magnetic lines of force will collect them and become a magnet. As soon as the current stops flowing the lines of force collapse and the magnetic substance becomes demagnetized.

If wire is formed into a coil of many turns the magnetic lines of force passing through the center of this coil become quite strong and, with a given amount of current flowing in the circuit, the magnetizing force increases in proportion to the number of turns of wire. For example, a coil of 100 turns of wire with 0.1 ampere of current flowing through it will have ten times the magnetizing force of a coil of 10 turns with the same current flowing through it. Likewise, any increase in current through a coil will increase the magnetizing force in proportion to the increase in current. Therefore, a coil of 10 turns of wire with 1 ampere of current flowing will have the same magnetizing force as a coil of 100 turns with 0.1 ampere of current flowing.

The magnetizing force is determined by multiplying the number of turns of wire by the current flow in amperes and is known as ampere turns. This magnetizing force produces magnetic flux or lines of force.

An iron or steel core inserted in this coil will collect these magnetic lines of force as it offers a low-resistance path, but the amount is limited by the saturation of the magnetic circuits. This amount varies with quality of material, its cross-section and the air gaps. The quantity of magnetism or magnetic flux, as it is called, is the total number of magnetic lines of force passing through the magnetic circuit.

Wire wound around a core in one direction and with current flowing through the wire in a given direction will produce a north magnetic pole at one end and a south magnetic pole at the other end of the core. By reversing the flow of current or the direction of winding around the core, the magnetic poles will be reversed.

The core used in the coils is of a specially selected iron or steel, very susceptible to magnetism, but just as easily demagnetized; otherwise, the core would become a permanent magnet. It is desired that the core become a magnet only when under the influence of an electric current. Such a core with its coil is called an electromagnet.

The most common form of electromagnet used in direct current relays is the U-shaped electromagnet consisting of two cores over which are placed the magnetizing coils, one or more bars or plates of iron or steel (yoke, sometimes referred to as the back strap) secured across the top of the cores, and a strap or piece of iron or steel (armature) suspended beneath the cores. The yoke and armature material must also be specially selected for the same characteristics as the cores. The armature is the movable part of the electromagnet completing the magnetic circuit from one core to the other. It is necessary that the current in one coil should flow around its core in a direction opposite to that in the other coil; otherwise, the magnetic flux produced in the two cores would oppose each other and form like poles at the corresponding ends with the result that the magnetic attraction becomes extremely low.

For a complete theory of magnetism, consult standard text-books on electricity and magnetism.

General

Direct current relays are divided into two general groups, neutral and polarized. Under each group there are several classifications, such as track, line, ordinary acting, slow acting, quick acting, retained neutral, etc. They are furnished in shelf and wall types. A track relay has coils of low resistance and receives its operating energy through conductors of which the track rails are the essential part, while a line relay has comparatively high-resistance coils and receives its operating energy through local or line circuits. There is no essential difference in the construction of the track and line relays; therefore, in describing the construction and method of their operation no distinction will be made between them.

Neutral Relays

The Signal Section, Association of American Railroads, defines Neutral Relay as: A relay which operates in response to a predetermined change of the current in the controlling circuit, irrespective of the direction of the current.

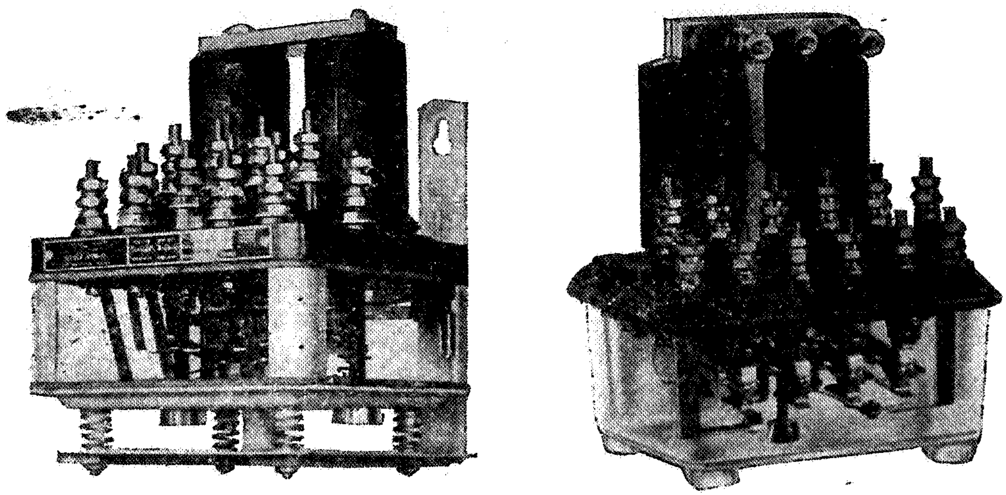


Fig. 1.
Types of Neutral Relays—4 Front and 4 Back Contacts.

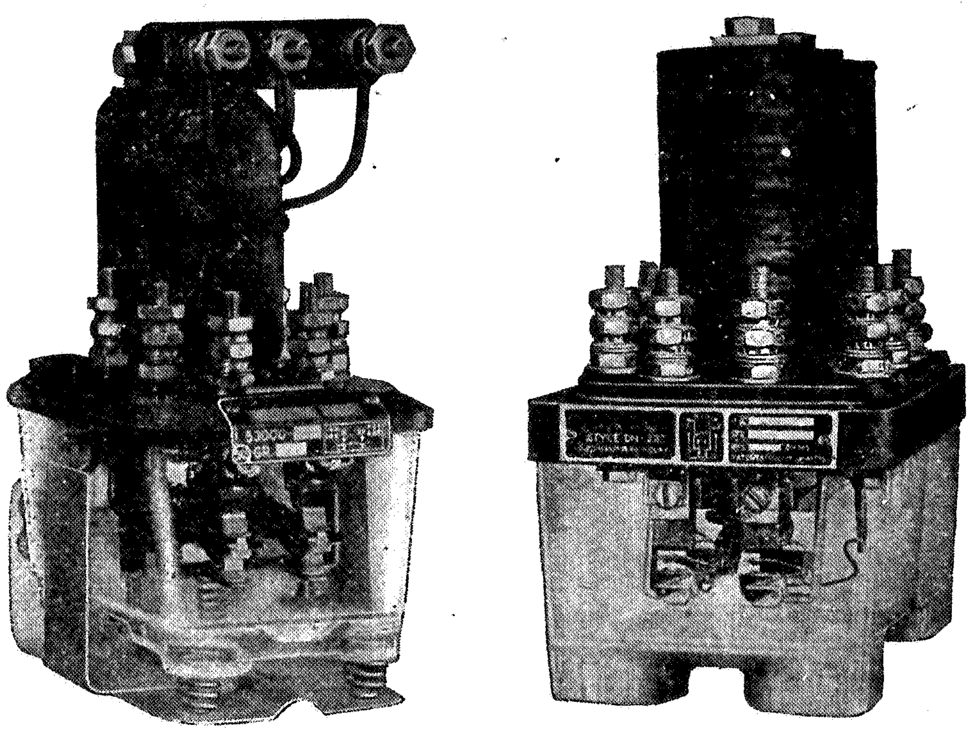


Fig. 2.
Types of Neutral Relays—2 Front and 2 Back Contacts.

Generally speaking, all moving parts are enclosed in a sealed dust-proof case, the sides of which are of glass of such transparency that the parts within the case are visible and can be readily inspected. The principal parts are coils, cores, armature, contacts and binding posts with the necessary supports.

Coils.

Each relay usually has two coils with a hollow center to accommodate a core. The coils are made up of a large number of turns of small gage, soft-drawn copper wire, the size and number of turns depending on the resistance of the relay. For example, a 4-ohm relay coil will have approximately 1000 turns of No. 17 gage wire while a 1000-ohm relay coil will have approximately 13,000 turns of No. 30 gage wire. The insulation on the wire is enamel or like insulation so that the coils will not be of an excessive size. The coils are generally connected in series, the ends of the wires terminating on binding posts to which the control wires may be attached. Each coil, therefore, contains one-half the specified resistance of the relay; that is, in a 4-ohm relay each coil has a resistance of 2 ohms, while in a 1000-ohm relay each coil has a resistance of 500 ohms. In some cases the coils are connected in parallel and the resistance, then, of each coil is double the specified resistance of the relay; that is, in a 1-ohm relay each coil has a resistance of 2 ohms.

Each coil is so constructed that it may be removed and replaced, in kind, without changing the magnetic or mechanical adjustment of the relay, and securely fastened in place to prevent any movement by vibration. They are impregnated or otherwise treated so as to satisfactorily protect the wire from moisture under all service conditions and are protected in a suitable manner from mechanical injury.

Cores.

Each coil is placed around a core which is a piece of specially selected iron or steel very susceptible to magnetism, but just as easily demagnetized. The cores extend beyond the top and bottom of each coil. At the top of the two cores is a specially selected iron or steel yoke, or yokes, known as the back strap, or straps, securely fastened to each core by a bolt or screw. The bottom of each core is equipped with a specially selected large iron or steel block known as the pole piece or face.

From the study that has previously been made of magnetism, it will be seen that with this arrangement there are three sides of a magnetic circuit as the winding on the coils is so arranged that when current flows through the wire it will produce a north magnetic pole in one pole piece and a south magnetic pole in the other pole piece. To complete this magnetic circuit, across the bottom of the pole pieces is the movable part of the relay, the armature.

Armature.

The armature is a flat piece of specially selected iron or steel, very susceptible to magnetism and just as easily demagnetized, supported by a bracket which is securely fastened to the pole pieces or to the top plate of the relay. This bracket is so constructed that it cannot exert pressure on the armature, but leaves it free to be moved when under the influence of the magnetic circuit. As the circuit through the coils of a relay is closed, it sets up a magnetic circuit from one core to the other through the yoke and armature. As the armature is free to move, it will be attracted to the pole pieces and remain there as long as the circuit through the coils is closed. When the circuit is opened, the magnetic flux collapses and the armature will drop away by gravity from the pole pieces to a stop provided for that purpose.

Air gap.

In order that a predetermined minimum air gap between the armature and pole pieces may be maintained, relays are provided with non-magnetic stop pins imbedded either in the pole face or in the armature. In addition, there is generally an independent adjustable armature stop located midway between the pole pieces toward the front of the armature and supported by the top plate or the extension of the armature bracket; this stop, after being properly adjusted to secure the requisite working air gap, is sealed or otherwise secured in place.

It is essential to maintain the established air gaps to prevent low values of magnetism from keeping the armature attracted or "picked up." Without these stop pins the armature could come in direct contact with the pole faces and a small amount of magnetism would be sufficient to hold up the armature. The amount of opening to be maintained in this magnetic air gap is dependent on the calibration characteristics desired, the dimensions of and the kind of material in the magnetic circuit, the weight of the armature, etc., but is not less, however, than a minimum value established for mechanical clearances.

Contacts.

Securely fastened to the armature, but thoroughly insulated therefrom, are metallic springs or fingers, the front ends of which are equipped with contacting surfaces. These contacting surfaces are metal, carbon, or similar composition, depending on the type of relay and service in which they are to be used. Relay contacts are designed for first and second voltage ranges.

Contacts are so arranged that circuits may be completed with the relay energized or de-energized. Those contacts arranged to close a circuit when the relay is energized are called "independent front contacts"; when the relay is de-energized, "independent back contacts," while those arranged to complete a circuit in either position are called "dependent front and back contacts." Figure 3 illustrates these contact arrangements for a neutral relay.

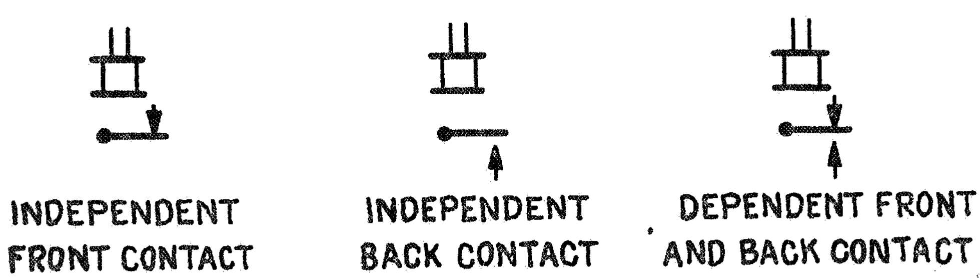


Fig. 3.
Contact Arrangement of Neutral Relay.

The contact finger is joined by a flexible connector to a binding post projecting through the top of the relay. This flexible connector or conductor is formed and attached so that it will not affect the torque of the armature.

Neutral relays are available in various sizes, with a maximum number of contact fingers of 2, 4, 6, 8 or 10, with front or back contacts as desired.

Binding posts.

Binding posts are made of brass, or copper or nickel base alloys, and so constructed that they cannot be turned in the frame to which they are attached. Binding posts supporting the fixed parts of front and back contacts are fastened in their supports so that adjustments of any kind cannot be made without first breaking the seal of the relay. The end of the binding post that makes contact with the contact springs connected to the armature is of metal, carbon or similar composition, while the other end is a terminal to which the outside wires or circuits are fastened by terminal nuts.

Circuits are controlled through these relays by attaching wires to the proper binding posts; the circuit is opened or closed when the armature is picked up or dropped away, as the case may be. These circuits are easily traced through the relay by following from the binding post to contact spring, to flexible connector, to binding post. The relays are constructed to accommodate different combinations of contacts and the arrangement of contacts and binding posts is usually indicated by a diagram on the name plate.

Relay supports.

Relays, either wall or shelf type, are generally resiliently supported to nullify the effects of vibration.

Polarized Relays

The Signal Section, A.A.R., defines Polarized Relay as: A neutral relay equipped with polar armatures and contacts.

The same general construction is followed in the polarized relay, Fig. 5, as in the neutral relay with the following additions: A permanent magnet similar in shape and appearance to the core of the neutral relay is installed in the rear or in front of the two relay coils. One end of this permanent magnet is in contact with the yoke; the other end is equipped with a polar armature so placed as to operate alternately against the two neutral pole pieces. This permanent magnet and polar armature has the appearance of an inverted "T," the head being one pole and the bottom of the stem the other pole. The polar armature is suitably supported and is free to move toward either neutral pole piece. Contacts are connected to either end of this polar armature, which in turn connect to binding posts, closing or opening circuits, depending on the position of the polar armature. Figure 4 illustrates the contact arrangement of a polarized relay. The polar contacts shift their position whenever the polarity of the circuit through the coils is reversed.

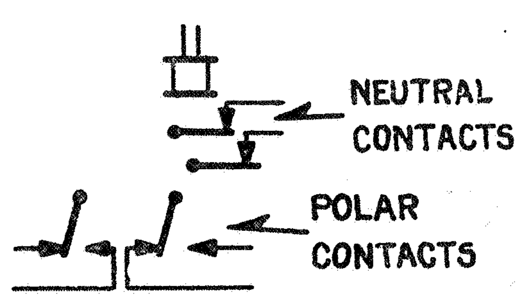


Fig. 4.
Contact Arrangement of Polarized Relay.

As mentioned under neutral relays, current flowing through the coils of the relay made one of the pole pieces a south and the other a north magnetic pole. The polar armature being part of the permanent polar magnet does not change its magnetic pole; therefore, the top of the permanent magnet remains one pole and the bottom the opposite pole. According to the law of magnetism, like poles repel and unlike poles attract; therefore, the polar armature will be repelled by the like neutral pole piece and attracted by the unlike neutral pole piece. This polar armature being pivoted in the center will cause the polar contacts to move and make contact with one set of binding posts keeping the contacts on the opposite side open.

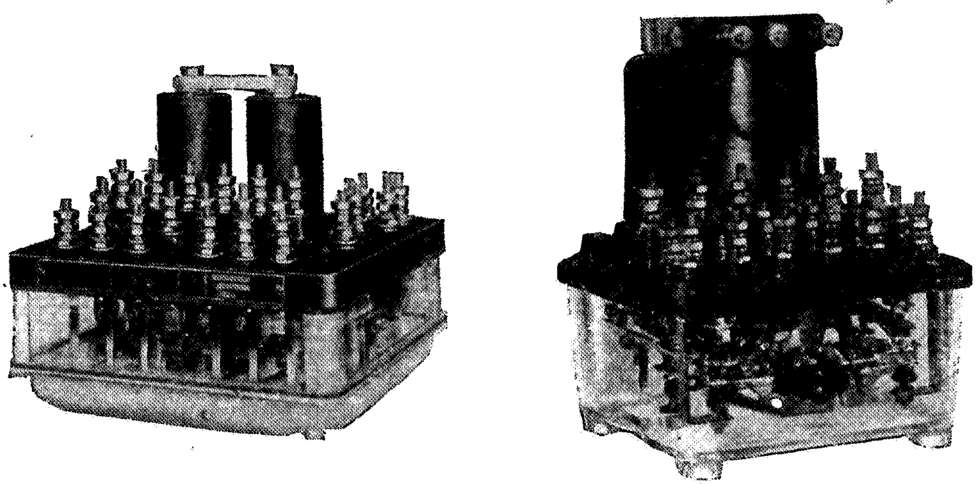


Fig. 5.
Polarized Relays.

By reversing the flow of current through the coils of the relay, the neutral pole pieces will change to the opposite magnetic poles. During this action the neutral contacts will open and again close. As the polar armature still retains the same pole there will be attraction where previously there was repulsion and repulsion where there was attraction, causing the polar contacts to move in the opposite direction closing the polar contacts that were opened and opening those that were closed.

Some polarized relays have a special feature in which there exists a positive check that the polar armature agrees in position with the polarity of energy on the main coils before it is possible for the neutral armature to pick up.

Polarized retained neutral relays.

The Signal Section, A.A.R., defines Polarized Retained Neutral Relay as: A relay equipped with an auxiliary magnet which retains the neutral armature in the energized position during the reversal of current in the control coils.

These relays have a special feature whereby the neutral armature is not released during the period of pole changing, thus eliminating the necessity of additional relays of the slow drop-away type. This is accomplished by the addition of a pair of coils (called retaining coils) and an auxiliary armature which is carried on an extension arm attached to the main armature.

The two retaining coils are connected with secondary windings on the main relay coils. The changes in flux caused by the dying out and building up of the current in the primary winding of the main coils induce a voltage in the secondary winding which causes a current to flow in the circuit including the retaining coils, thus producing a flux which tends to retain the auxiliary armature. Types of this relay are shown in Fig. 6.

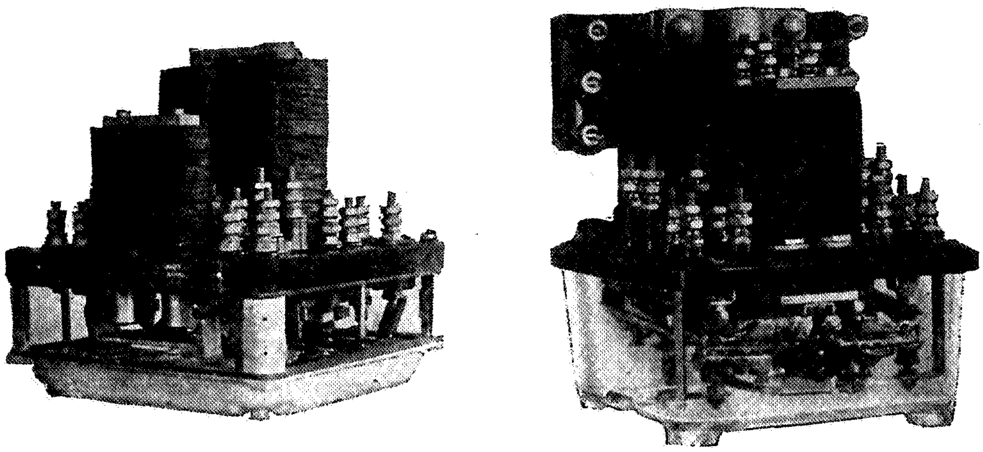


Fig. 6.
Polarized Retained Neutral Relays.

Quick Drop-Away Relays

The Signal Section, A.A.R., defines Quick Drop-Away Relay as: A relay which, when the controlling circuit is opened or completely shunted, will release quicker than an ordinary relay.

For certain conditions it is desirable to use a relay that will release more quickly than the regular type of direct current relay and for this purpose certain modifications are made in the relays previously described.

The quick drop-away relay is practically the same in all mechanical features as the ordinary relay except that the yoke is insulated magnetically from the cores by means of copper ferrules and very thin washers. These washers, by introducing an additional air gap in the magnetic circuit, increase the pick-up and drop-away values approximately 50 and 60 per cent, respectively. Other special means are sometimes employed to give a quick drop-away, depending upon the type of relay involved and the conditions to be met.

Slow Drop-Away Relays

The Signal Section, A.A.R., defines Slow Drop-Away Relay as: A relay which, when the controlling circuit is opened or completely shunted, will release slower than an ordinary relay.

For certain conditions it is desirable to use relays that will not release as quickly as the ordinary relay and for this purpose slow drop-away relays are used. These relays likewise have the same general mechanical characteristics as the ordinary relays, except that the coils are wound over a heavy section copper tubing, or a portion of the winding is replaced by copper washers to provide an inductive means to retard the decreasing flux in the magnetic circuit. The air gap between the armature and the pole pieces is also materially reduced where excessive delay is required, the idea being to decrease the reluctance of the magnetic circuit and provide sufficient flux for retardation purposes. The main purpose of this relay is to permit of a circuit being controlled through its contacts during the open-circuit period of the relay control circuits. This retardation period is the time interval from the opening of the relay circuit to the opening of the front contacts and is approximately 25 times longer than with the ordinary relay.

The resistance of these slow drop-away relays is generally about one-half that of the ordinary relay for a given voltage operation in order that twice the amount of current will flow through the coils thereby increasing the flux in the magnetic circuit to more nearly the saturation point and also on account of the limited winding space on the coils due to the use of copper tubing. To obtain proper retardation it is essential that the working voltage be maintained at normal or above, as a slight decrease in voltage causes a material reduction in the retarding effect of the relay. Figure 7 illustrates

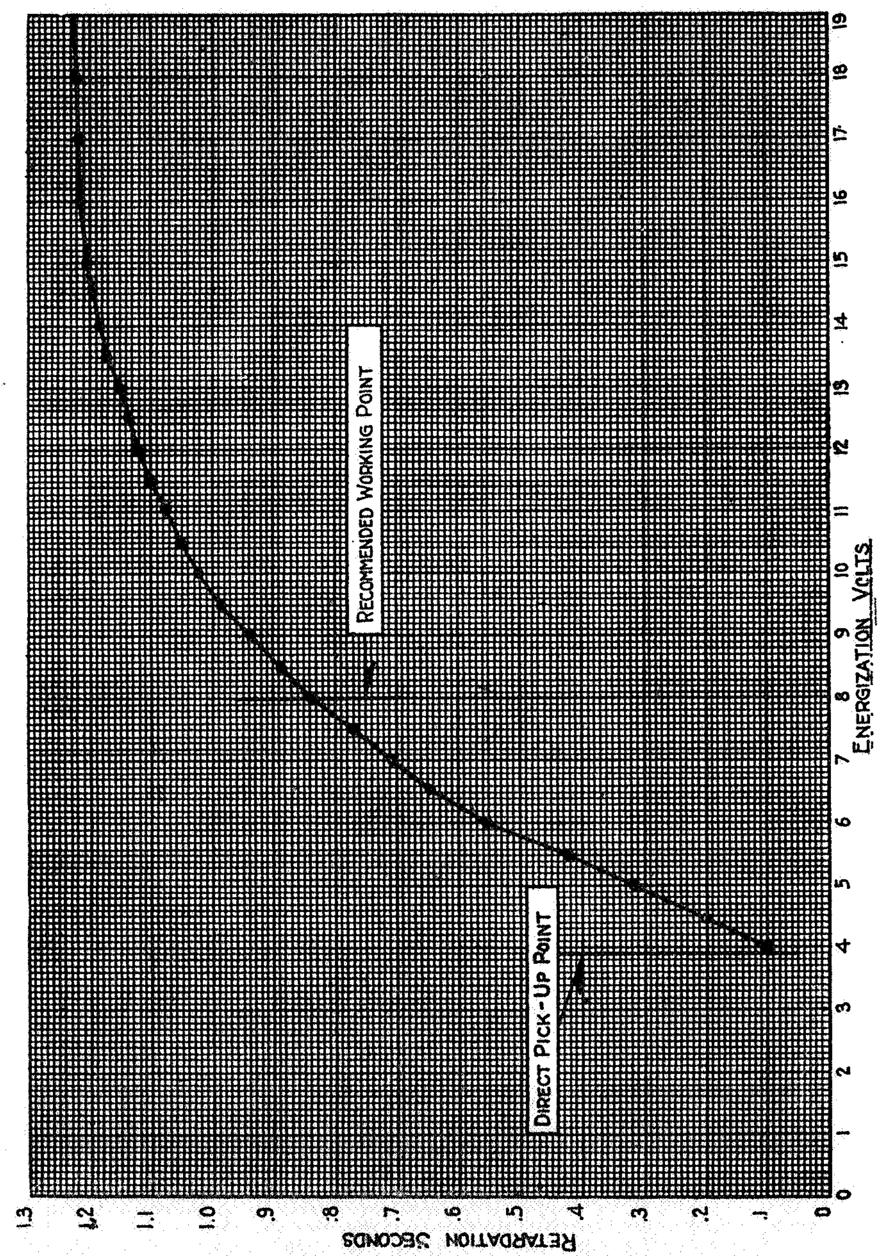


Fig. 7.

Typical Curve Showing Relationship Between Retardation and Energization of a Slow Drop-Away Relay.

by a typical curve the variables in retardation when operated at indicated voltages.

To further increase the retardation of these relays or to provide a small amount of retardation in ordinary relays, the coils are sometimes short circuited through the back contact of the controlling relay, or through a special rectifier connected across the coils.

Slow Pick-Up Relays

The Signal Section, A.A.R., defines Slow Pick-Up Relay as: A relay which, when energy is applied, will pick up slower than an ordinary relay.

For certain conditions it is desirable to use a relay that will not pick up as quickly as the ordinary relay and for this purpose slow pick-up relays are used.

These relays have the same general mechanical characteristics as the ordinary relay, except that steel shunts are placed across the cores immediately above the top plate to shunt part of the magnetic flux from the armature; in addition, part of the winding is replaced by copper washers or the equivalent, to retard the building up of the flux in the magnetic circuit. Normally, these relays will have a slow pick-up time of approximately 1½ seconds.

Time Element Relays

The Signal Section, A.A.R., defines Time Element Relay as: A relay which will not close its front contacts or open its back contacts, or both, until the elapse of a definite time interval.

There are two general types, electromagnetic and thermal. Thermal type relays cannot be used where an accurate time delay is required since they employ bimetal requiring heating to operate contacts. The time of their operation depends on the cooling time between operations, whereas those of the electromagnetic type will duplicate the same time delay no matter how frequent their periods of operation.

Electromagnetic type.

A time element relay of the electromagnetic type is shown in Fig. 8.

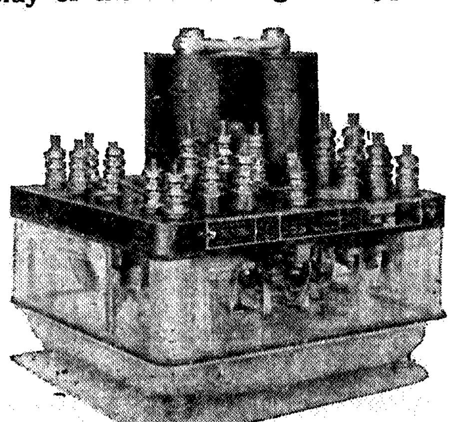


Fig. 8.
Direct Current Time Element Relay.

Operation of relay.

The time element relay illustrated in Fig. 8 has two operating coils and two small auxiliary coils, and is available with four different time ranges covering all requirements from 10 seconds to 24 minutes. The time interval is obtained by the oscillating motion of the oscillating armature, which is converted to a rotary motion by means of a ratchet wheel and pawl which drive a set of planetary gears. The planetary gears are so arranged that when power is applied to the relay a part of the main flux is used to operate a clutch armature which engages the stationary gear of the planetary system. The operation of the clutch armature permits the remainder of the planetary system to rotate about the stationary gear until it closes a contact which energizes the auxiliary coils and permits the neutral armature to pick up. When the pick-up of the neutral armature occurs, auxiliary contacts are opened, stopping the action of the oscillating armature.

The planetary gear is so arranged that when energy is taken off the relay the clutch armature holding the stationary gear releases and allows the gear train to drop to the normal position. A check contact closed when gear train is normal provides a means of indicating that the relay is in proper condition for the next operation. Due to the fact that the check contact opens slowly it is not to be used for controlling high-voltage circuits, and in case of low-voltage circuits it should not be used to open circuits carrying more than 0.05 ampere. A description of the operation of this relay, making reference to diagram Figs. 9 to 13, inclusive, follows:

Figure 9 shows a top view arrangement of the coils and relative positions of the neutral, clutch and oscillating armatures.

Figure 10 shows a schematic view of the magnetic circuits which will be of assistance when considering the following description.

Figure 11 illustrates time adjustment (operated by key and normally sealed and locked). Figure 12 shows the key.

Figure 13 shows internal wiring and time element feature.

Upon energization of the control wires, Fig. 13, current flows through the low-resistance coils of magnet A through back contacts E1 and E2, to contact E3 operated by the oscillating armature, then to negative battery. The operating coil of magnet B is shunted by the circuit through contacts E, E2 and E3. The oscillating armature is then pulled up against the pole face of magnet A, whereupon contact E3 is opened and E5 is closed, thus shunting the operating coil of magnet A and removing the shunt from the operating coil of magnet B. This sets the oscillating armature in motion to operate the pawl acting on the planetary gear combination. Upon energy being supplied to the operating coils of the relay, the clutch armature is pulled up against its pole faces and an arm on it comes in contact with the stationary gear member of the planetary gear, thus allowing the ratchet operated by the oscillating armature to move the timing contact around step by step until ultimately contact E4 is closed.

The main neutral armature, during the foregoing operation, is held down by the magnetic flux which flows in the pole pieces projecting underneath it. When contact E4 is closed after the expiration of the time element, current flows from positive battery through contact E4, neutralizing coils C1 and C, contacts E2 and E3, to negative battery. This energizes coils C and C1, causing them to introduce a flux which neutralizes that holding

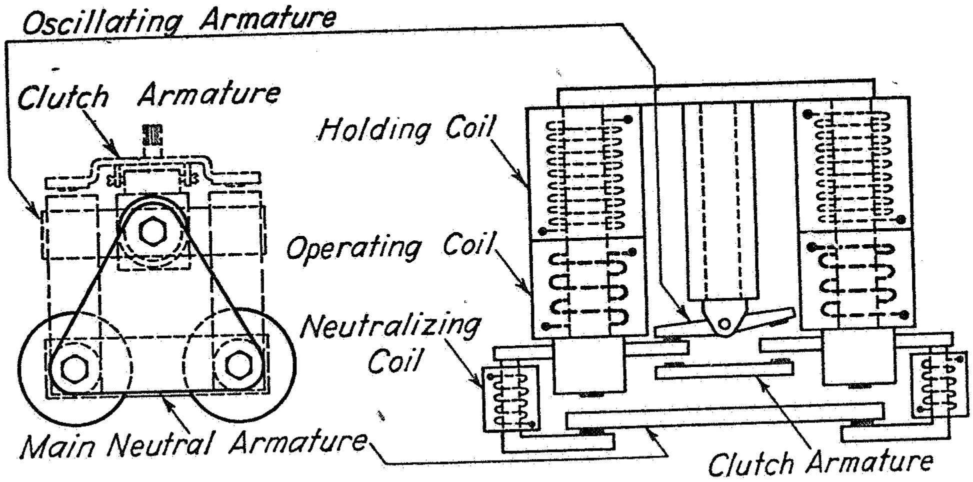


Fig. 9

Fig. 10

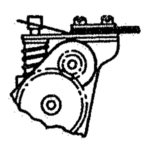


Fig. 11

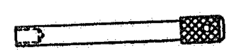


Fig. 12

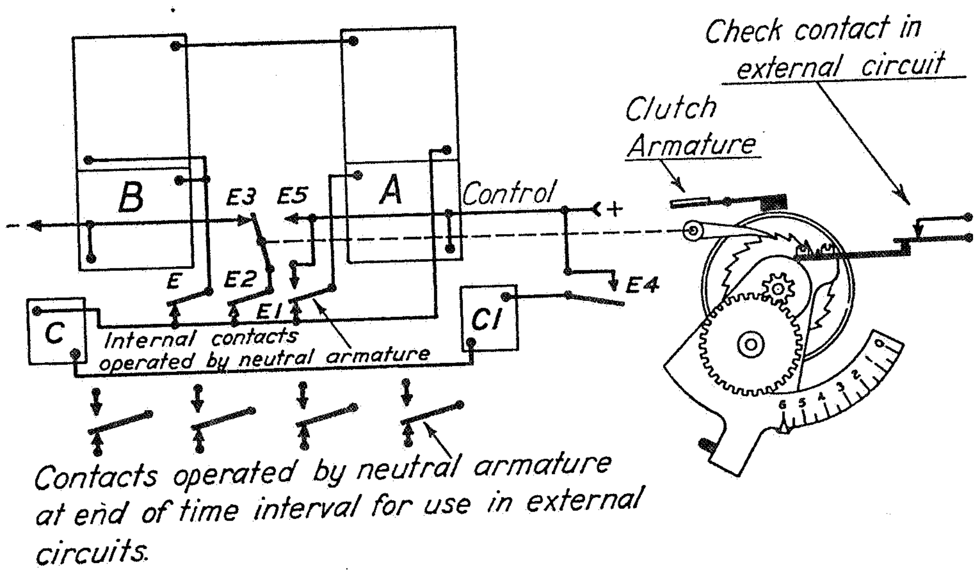


Fig. 13

the neutral armature down, and permits the main flux through the top pole face of magnets A and B to attract the neutral armature, thus opening contacts E, E1 and E2, and closing the front contact of E1 to short circuit the operating coil of magnet A. The neutral armature is thus picked up, the shunt on the high-resistance holding coils of magnets A and B is removed by the opening of back contacts E and E1, and the holding circuit is as follows: Positive battery through contact E4, coils C1 and C, holding coils on magnets A and B, operating coil on magnet B, to negative battery.

Upon energy being taken away from the relay coils, the clutch and neutral armatures both release, and the contacts and planetary gear combination return to the normal position shown in Fig. 13. A slow release is provided for by short circuiting the operating coil of magnet A through the front contact of E1.

The time element relay shown in Fig. 14 is available with four different time ranges covering all requirements from 2 seconds to 8 minutes.

The time period covered by each time range can be predetermined and set by adjusting the pick-up contact from the outside of the relay.

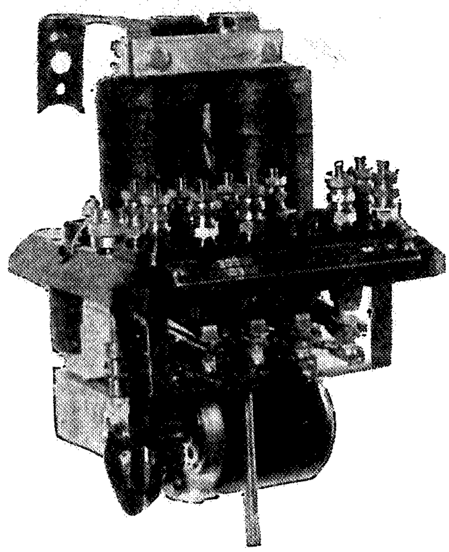


Fig. 14.
Motor-Operated Time Element Relay.

A check contact is provided for whatever checking is desirable. The check contact is in series with an internal contact which checks correct operation.

The relay is equipped with rectifier when partial slow release is required. The relay can be arranged to operate on a single source of energy or can be controlled by line energy while the motor is operated on local source of energy.

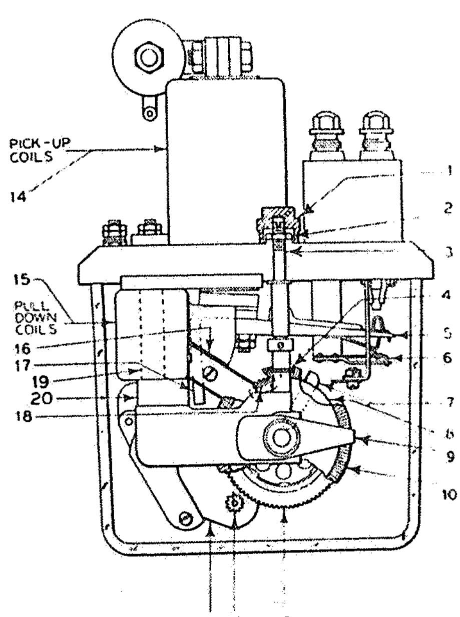


Fig. 15.

The basis of the magnetic structure, Fig. 15, is an ordinary 4-way relay modified by extending the cores downward (19). These extension cores are provided with core faces (20) and coils (15). The neutral armature is provided with extensions (17) which are attracted to the extension core faces when the lower coils are energized. The balance of iron structure, air gaps and coil turns is such that the neutral armature will be picked up only when the upper coils (14) are energized and the extension armature will be attracted only when the lower coils (15) are energized.

Mounted on the neutral armature and moving with it is a gear (13). A driving arm, fastened to this gear engages a pick-up contact (7). The gear is rotated by a pinion (12) of a constant speed motor. On the alternating current relay, this motor is a synchronous motor which will not vary in operation with a variation in voltage. In the direct current relay, the motor is of novel design and will not vary in speed over any range of voltage that may be encountered in service. Thus the timing of the relay is very accurate under all service conditions.

When the relay is first energized, only the lower coils receive energy through a back contact of the operating finger. This attracts the extension armatures and moves the neutral armatures downward, compressing the springs of the back contacts (6). The downward movement of the neutral armature brings the gear into mesh with the motor pinion. Since the motor circuit has been closed through the back contact, the motor now rotates the gear until, at the expiration of the predetermined time, the driving arm closes the pick-up contact. This contact supplies energy to the upper coils which creates a flux in the magnetic structure in the opposite direction to the flux created by the lower coils. This overcomes the holding-down effect of the lower coils and allows the relay to pick up like an ordinary neutral relay. The neutral armature is held up through the front contact of the operating finger until all energy is removed from the relay.

At the instant the neutral armature picks up, the gear is lifted out of mesh with the motor pinion and is returned to its normal position by an enclosed spiral spring.

Thermal type.

The Signal Section, A.A.R., defines Thermal Relay as: A relay whose contacts are actuated by the heating effect of current flowing through its controlling element.

A time element relay of the thermal type is shown in Fig. 16. The principle of operation of this relay consists of the heating of the main contact finger, which is bimetallic, by current passing through a special heater coil on this finger, causing it to change its shape and thereby close a contact.

Relays of this type are made adjustable and non-adjustable. The time of operation of the adjusted relay can be varied within certain limits by means of an outside adjustment. In the relay illustrated in Fig. 16, this variation is accomplished by altering the front contact opening. In other types it is accomplished by an adjustable resistor in series with the heater coil.

Thermal relays may be operated from direct or alternating current of

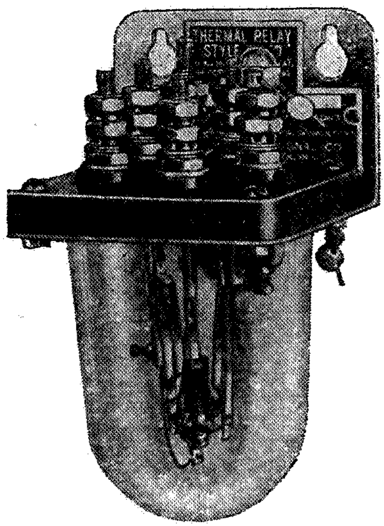


Fig. 16.
Time Element Relay, Thermal Type.

suitable voltage. The power consumed by the heater coil is approximately 10 watts.

Thermal relays are adapted for use where power consumption is of no concern, and where extreme accuracy in duplication of definite time intervals is not required.

Flasher Relays

The Signal Section, A.A.R., defines Flasher Relay as: A relay so designed that, when energized, its contacts open and close at predetermined intervals.

They are generally used for operation of flashing light type highway crossing signals, and are designed to give approximately 40 operations per minute. One type of flasher relay is shown in Fig. 17. Figure 18 illustrates the operation of this relay and shows the arrangement of the various parts. Note that the armature is so mounted that it may rock from side to side.

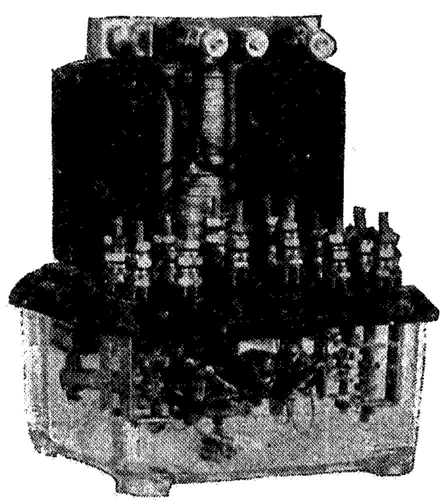


Fig. 17.
Flasher Relay.

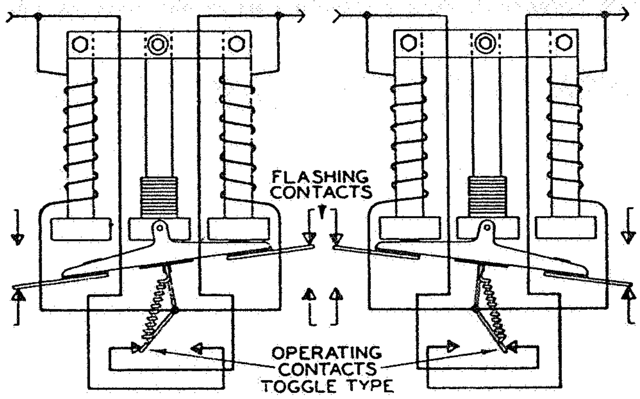


Fig. 18.

When the relay is de-energized, the armature remains in its last energized position as shown in Fig. 18. At the instant voltage is applied to the relay one coil is energized and the armature moves to the opposite side. As it moves to the opposite side, the operating contact shunts one coil which causes the other coil to pull the armature over. The toggle of the operating contact is operated just before completion of stroke and the action is reversed as follows: Toggle contacts now shunt coil which has just caused operation, resulting in slow release, at the same time energizing the other coil causing operation in the opposite direction as soon as slow release effect has been overcome.

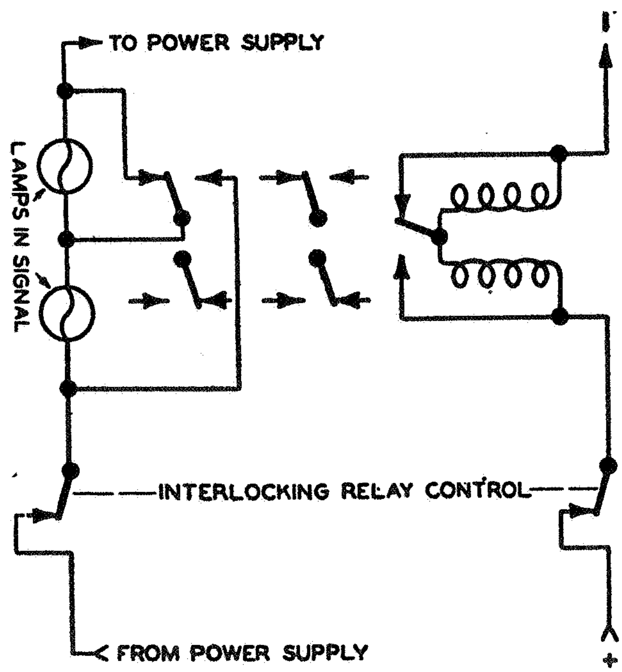


Fig. 19.

Contact Arrangement and Connections for Flasher Relay Shown in Fig. 17.

The contact arrangement in the flasher relay shown in Fig. 17 and typical control circuit are shown in Fig. 19. Arcing and burning of the control contacts is lessened by the shunting action of the control contacts. Radio interference is suppressed by a condenser across the coil operating contacts.

Another type of flasher relay, Fig. 20, functions essentially the same as the type just described.

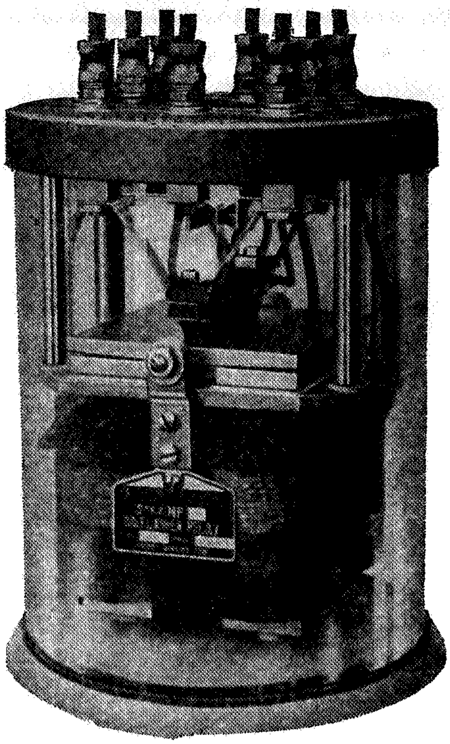


Fig. 20.
Flasher Relay.

The lamp control contacts are so arranged that they open only in each extreme position of the armature. The open pair of contacts closes during the stroke of the armature, before it reaches its center position; thus, an overlap of the two pairs of lamp control contacts is obtained. For this reason at least one pair of lamps in the crossing signal will be lighted at all times. As a matter of fact, the armature assumes such a position when the coils are de-energized that all lamp contacts are closed, thus providing maximum protection at the crossing should there be a failure in the flasher

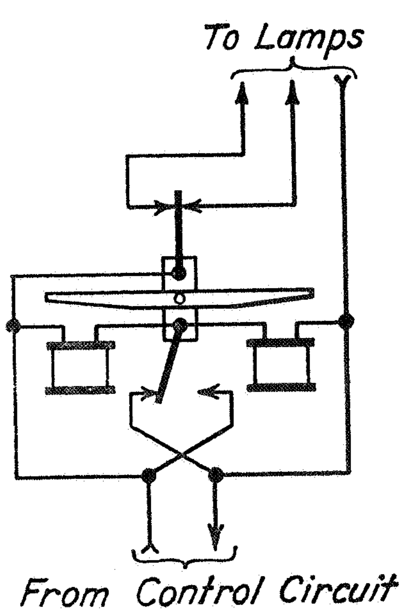


Fig. 21.
Contact Arrangement and Connections for Flasher Relay Shown in Fig. 20.

control circuit. Figure 21 illustrates the arrangement of the contacts of this type of relay.

The flasher relay shown in Fig. 22 functions essentially the same as the two types just described.

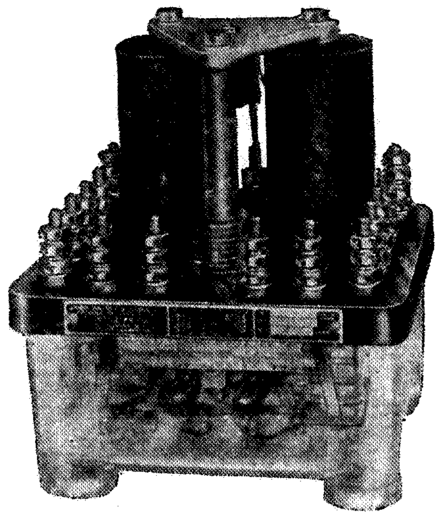


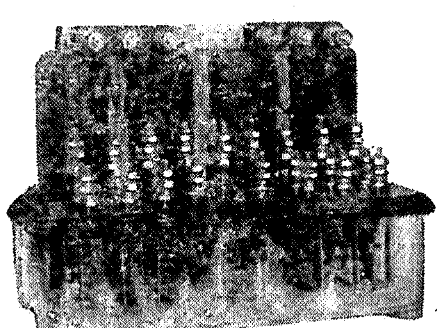
Fig. 22.
Flasher Relay.

The contact arrangement is such that one-half the contacts are closed in either extreme position of the armature, which permits of shunt or close-and-open control of lamps. The armature is biased by a counter-weight to close only one-half the contacts when relay is de-energized. Radio interference is suppressed by a special rectifier assembled to the relay across the coil operating contacts.

Interlocking Relays

The Signal Section, A.A.R., defines Interlocking Relay as: A relay having two independent magnetic circuits with their respective armatures so arranged that the dropping away of either armature prevents the other armature from dropping away to its full stroke.

In the case of an interlocking relay, Fig. 23, it is the same as two neutral relays enclosed in the same case or base with an interlocking device between the two sets of contacts so arranged that when one set of coils is de-energized it will lock the other set of contacts away from the back



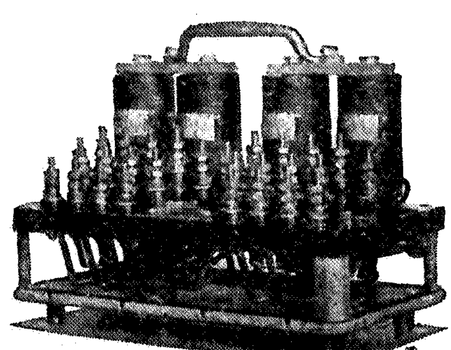


Fig. 23.
Interlocking Relays.

contacts. These relays are used on single track for the control of highway grade crossing signals; also on double, three or more tracks when the crossing signals are controlled in both directions on such tracks.

Two Rate Charge Control Relay

This relay is intended for use in connection with lead storage cells. The voltage of these cells, when fully charged, increases with rise in charge rate and falls with rise in temperature.

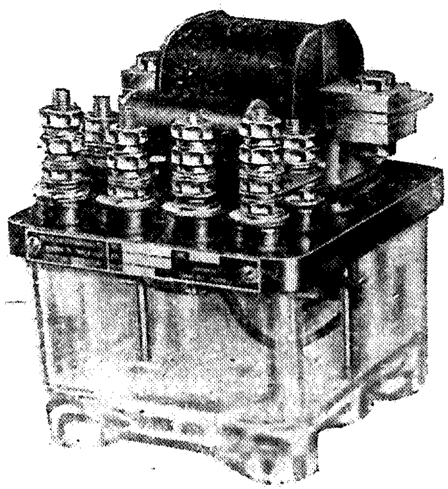


Fig. 24.
Two Rate Charge Control Relay.

To meet these two conditions this relay has been provided with proper temperature compensation and means for adjusting its operating voltages to suit charge rate.

The relay is equipped with one back contact, and the contact pressure is maintained by providing the armature with a considerable stroke before the contact load is picked up, so that when the contact starts to open there is sufficient magnetic pull to cause armature to pick up to core pin.

The relay is made as immune from vibration as possible by balancing the armature about the pivot and mounting it in a vertical plane so that neither horizontal nor vertical shocks produce a rotating effect which would tend to make the relay pick up below the intended value. The weight of the armature is supported by the pivot on a jeweled trunnion screw, which reduces friction to a minimum.

It is necessary that the pick-up voltage of the relay be adjusted to suit the battery charging means and load conditions at each location. To take care of this adjustment, a slider has been placed in the magnetic circuit between the yoke and core; this changes the pick-up by varying the amount of iron and brass in the magnetic circuit as shown in Fig. 24. The arrangement is accessible without opening the relay and provides for tightening so that handling will not alter the adjustment.

Power Transfer Relay

The Signal Section, A.A.R., defines Power Transfer Relay as: A relay so connected to the normal source of power supply that the failure of such source of power supply causes the load to be transferred to another source of power supply.

The power transfer relay shown in Fig. 25 is a direct current relay having a copper-oxide rectifier mounted on top of relay and connected as shown in Fig. 26.

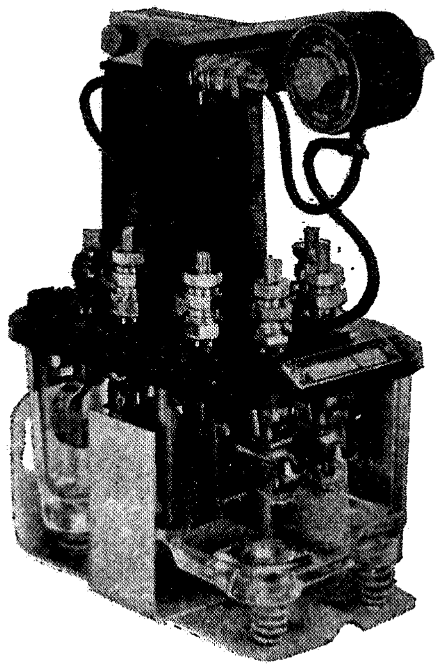


Fig. 25.
Power Transfer Relay.

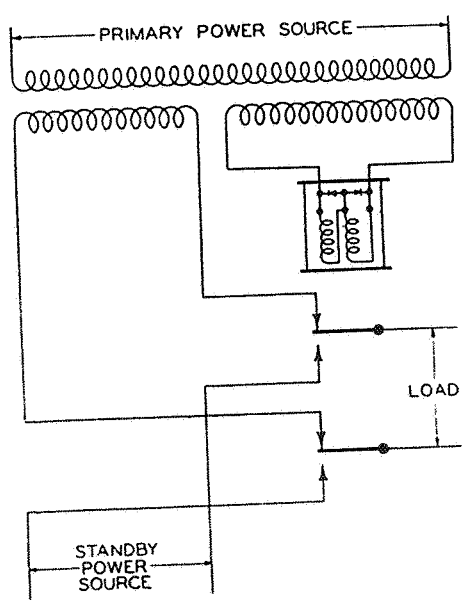


Fig. 26.
Contact Arrangement and Connections for Power Transfer Relay Shown in Fig. 25.

During one-half of each cycle, current flows through one relay coil and that leg of rectifier in parallel with the second relay coil and that leg of the rectifier in parallel with the first relay coil.

Although the current through each coil pulsates, the vector sum of the currents in both coils is practically constant. This means that the electromagnetic flux or force acting upon the armature is practically constant also; therefore, there is no tendency for the armature to vibrate.

Quick Detachable or Plug-In Type Relay

This relay is primarily for use where quick and easy replacement of relays is desirable without disturbing the wire connections.

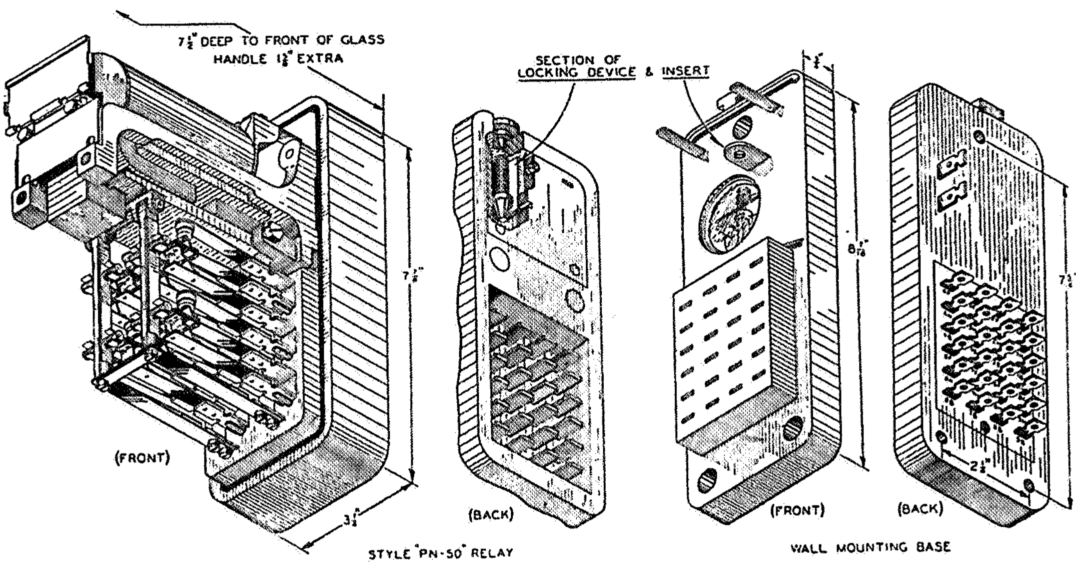


Fig. 27.
Quick Detachable or Plug-In Type Relay.

The relay shown in Fig. 27 is made in one standard size with 8 front and 8 back dependent contacts, and is always wall mounted. It requires only about one-fourth the space as would be necessary for a conventional relay having the same contact capacity.

As shown in Fig. 27, a separate base containing receptacles for plug connection is mounted permanently on a vertical rack or framework, and wire connections are soldered to the receptacle terminals.

The relay has plug connections at the rear which fit into matching receptacles in the fixed base, so that the relay is pulled out horizontally directly away from the rack in order to remove it.

The coil connections are made in similar manner, except that the two plugs extend outward from the mounting base and function as guides for proper register of the other connectors. Each connector plug slips between two springs in a receptacle in the mounting base. The connections are designed to give high contact pressure with low friction, so that it is easy to connect or disconnect the relay.

The plug receptacles in mounting base, Fig. 27, project through the back so as to provide lugs for soldering the wire connections.

A special latch automatically locks the relay in position (see sectioned view, Fig. 27). This latch lock is controlled by a special tool used when installing or removing the relay.

A convenient arrangement, Fig. 28, is provided for circuit checking without disturbing the wire connections.

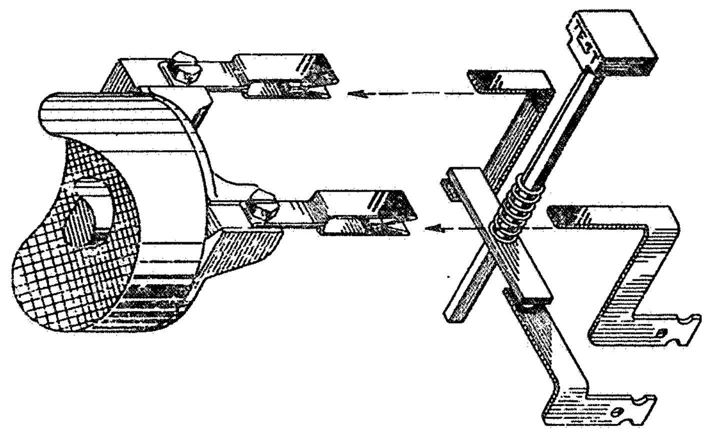


Fig. 28.

The relay is so designed that the coil or contact springs may be changed without disturbing the magnetic air gap adjustment.

A permanent magnet is provided, Fig. 29, at the lower front edge of the armature which exerts extra downward pull on the armature when in the de-enerized position, thus providing high back contact pressure and eliminating any need for shock absorbers. Because of this permanent magnet, the relay will operate only with one polarity of energizing current.

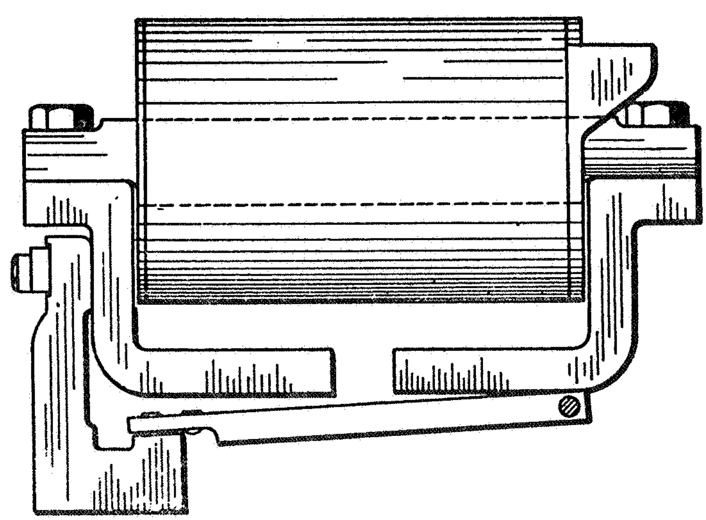


Fig. 29.

The cover of this relay, Fig. 30, is of a one piece molded glass construction, arranged to fit over the relay including the coil, and by the use of gaskets and sealing all openings, the relay is made as air-tight and dust-proof as possible.

The handle at the front of the relay also serves as a holder for a tag upon which the circuit identification of the relay may be marked.

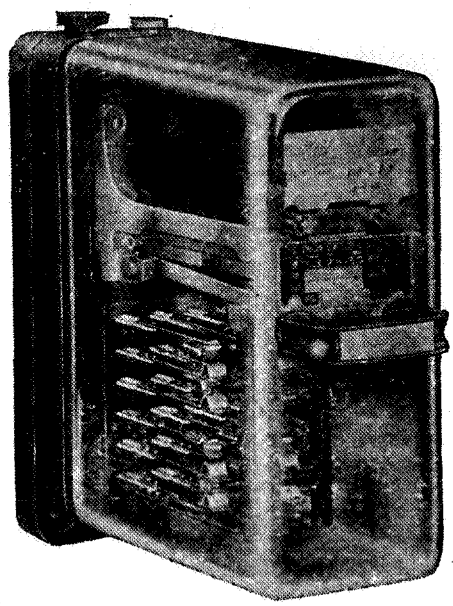


Fig. 30.
Quick Detachable or Plug-In Type Relay.

Another type of quick detachable or plug-in type relay is shown in Fig. 31. This relay is made in two sizes: Size 1, neutral and thermal type (Class TG and TJ), and Size 2, neutral, neutral polarized, retained neutral polarized and motor-driven time element type. Two Size 1 relays take the space required by one Size 2 relay.

The Size 1 neutral type has an 18 contact spring capacity or three vertical rows of 6 springs each; the Size 2 neutral type has a 36 contact spring capacity or six vertical rows of 6 springs each. The rows of contact springs may be arranged in practically any combination of dependent or independent contact groups: for instance, a row of 6 springs may be arranged to give:

1. Two dependent front and back contacts.
2. Three independent front contacts.
3. Three independent back contacts.
4. Two independent front contacts and one independent back contact.
5. One independent front contact and two independent back contacts.

Table I shows the contact combinations that are available for a Size 1 neutral relay, while Table II shows the contact combinations that are available for a Size 2 neutral relay. Note the maximum capacity of this relay is 12 dependent contacts (12 front and 12 back contacts).

Tables III and IV show the contact combinations that are available in the neutral polar and retained neutral polarized (Size 2) relays, respectively.

The thermal type relay (Size 1) is provided with one normal closed independent and one normal open independent contact.

The motor-driven time element relay (Size 2) is provided with an independent check contact and an independent timing contact.

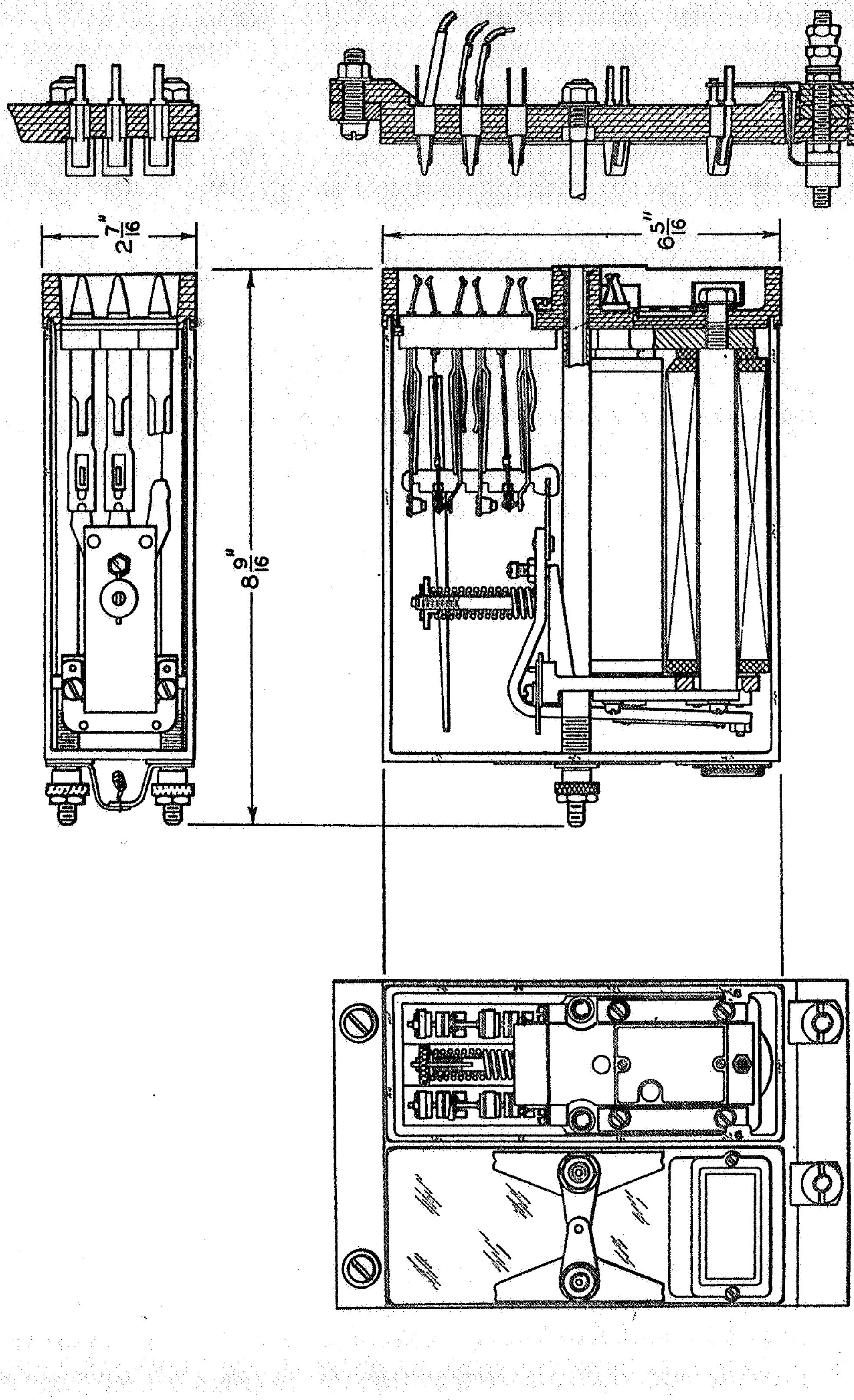


Fig. 31.
Quick Detachable or Plug-In Type Relay.

TABLE I

FB	F	B	CO
2			
4			
6			
	3		
	9		
4	3		
2	1	2	
2	1	5	
2	2	4	
2	4	2	
4	2	1	
	4	2	
	4	5	
	5	4	
	6	3	
	7	2	
	8	1	
1	2	4	1
3		3	1

TABLE II

FB	F	B
12		
8	6	
6	9	
6	7	2
4	8	4
4	4	8
	8	7

TABLE III

FB	F	B	NR
4			4
4			8
6			4
8			4
4	3		4
4	6		4
4	4	2	4
2	3		4
2	1	2	4
2	4	5	4
2	3	3	4
	3	3	4
	5	1	4

TABLE IV

FB	F	B	NR
4			4
2	2	1	4

FB—dependent front-back contacts
F —independent front contacts
B —independent back contacts
CO—dependent front-back contacts with the "close-before-open" feature
NR—dependent normal-reverse polar contacts

Relay Coil Combinations

These relay coils are arranged for one or two independent windings, or three dependent windings, *i.e.*, windings connected to the same common. (This does not apply to the thermal or motor-driven time element relays.)

With various combinations of short-circuited windings, rectifier and resistor shunts, copper washers and magnetic shunts, a number of different relay characteristics may be obtained, such as:

1. Normal pick-up and drop-away.
2. Quick pick-up and slow drop-away.
3. Slow pick-up and partial slow drop-away.
4. Slow pick-up and slow drop-away.

Figure 32 shows the various coil combinations for Size 1 relays.

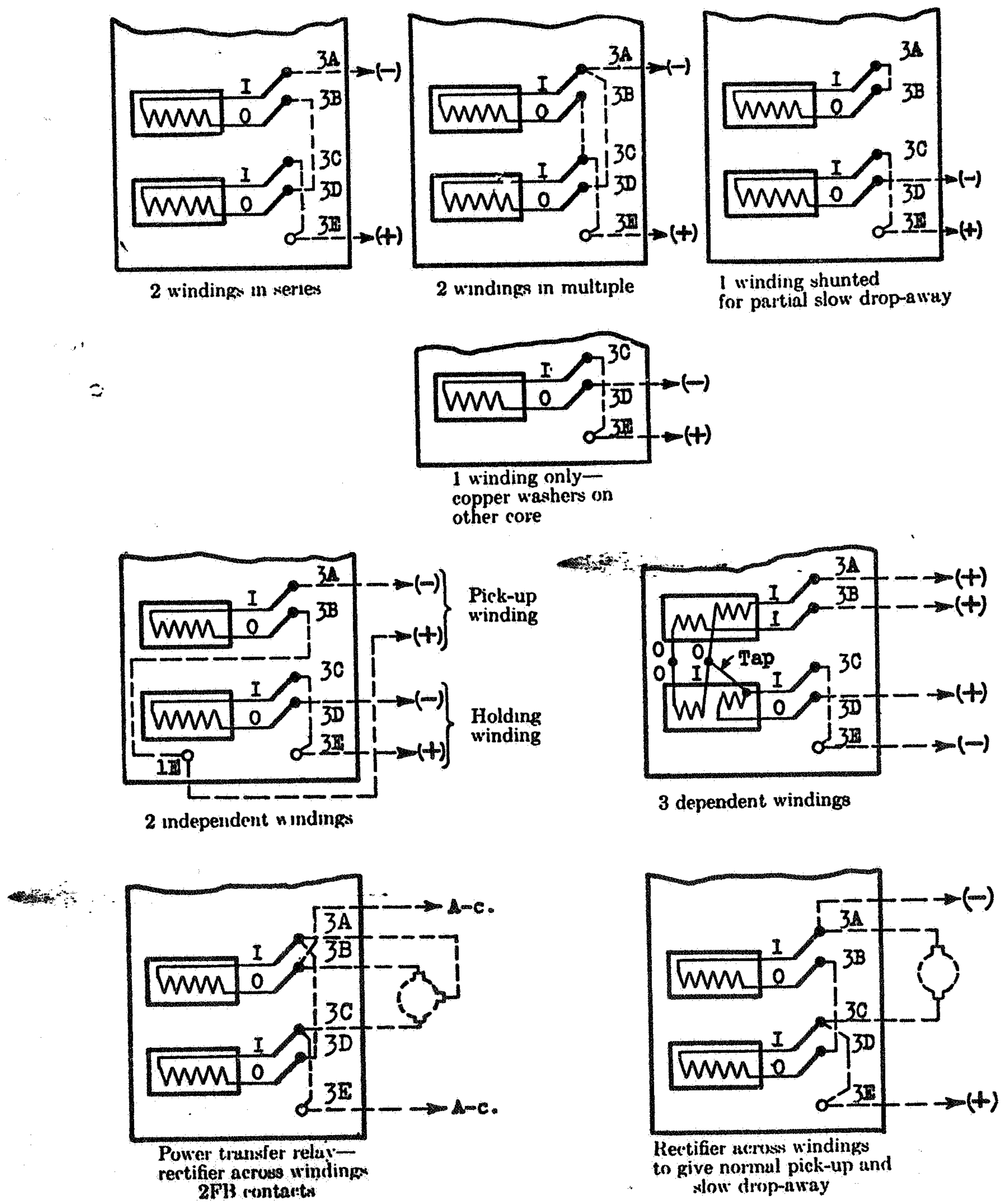
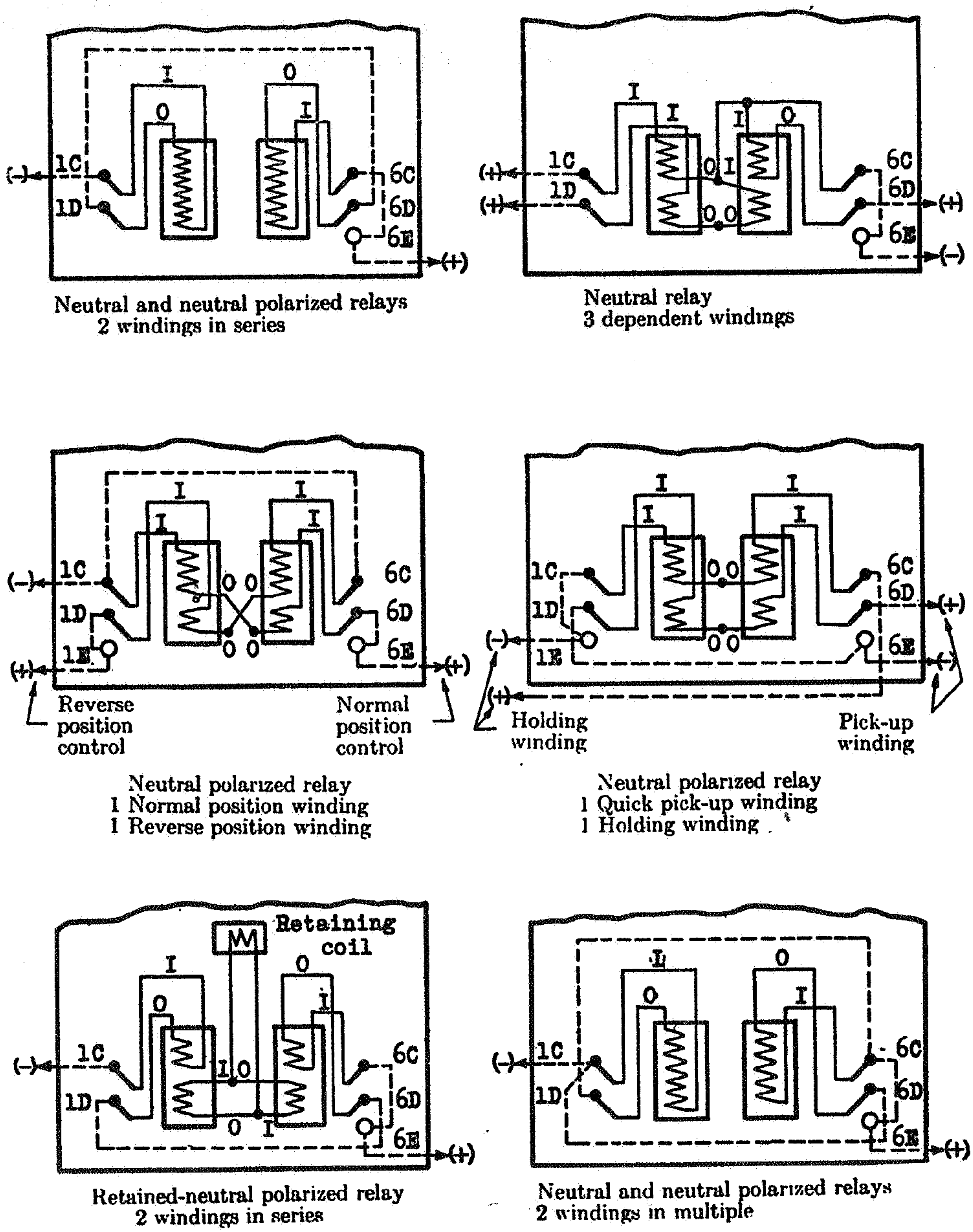


Fig. 32.
Type B, Size 1, Direct Current Relay Winding Combinations.

Figure 33 shows the various coil combinations for Size 2 neutral, neutral polarized, and retained neutral polarized relays. Figure 34 shows the wiring diagrams of the Class TG and TJ thermal type relays (Size 1).

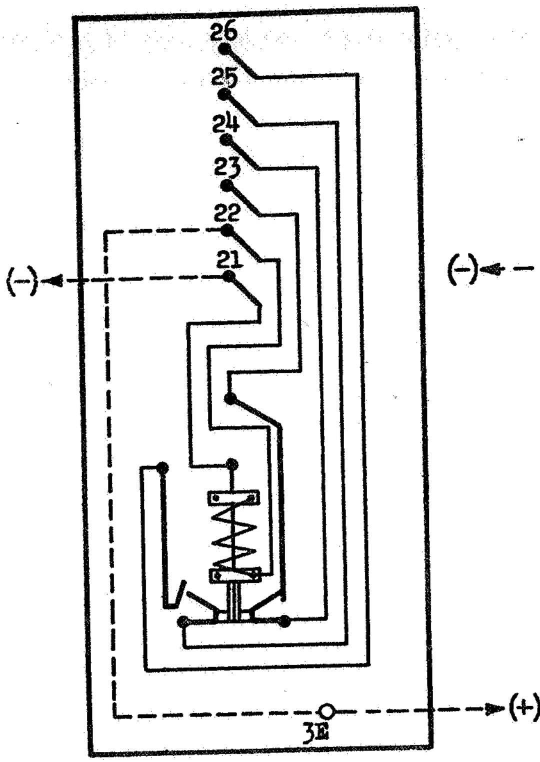
Figure 35 shows the wiring diagram of motor-driven time element relays.



Polar contacts on polarized relays assume normal position (lower right-hand and upper left-hand contacts closed) when windings are energized with polarity as shown

Fig. 33.

Type B, Size 2, Direct Current Relay Winding Combinations.



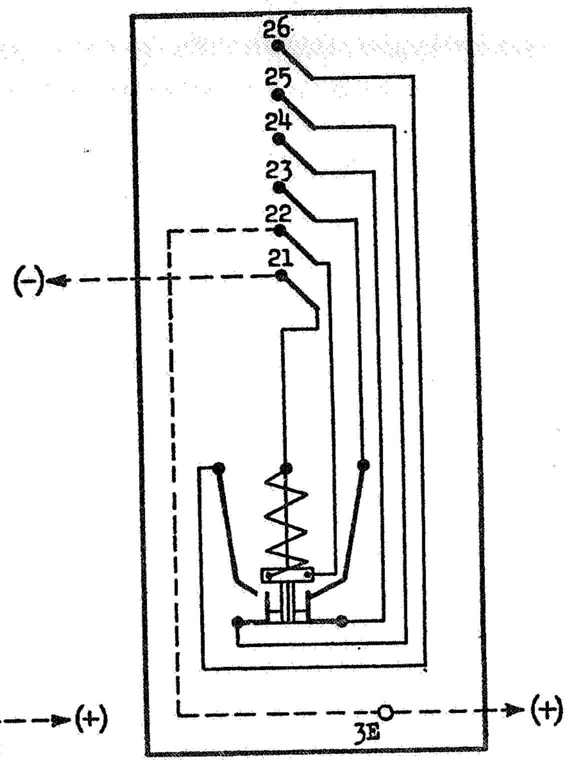
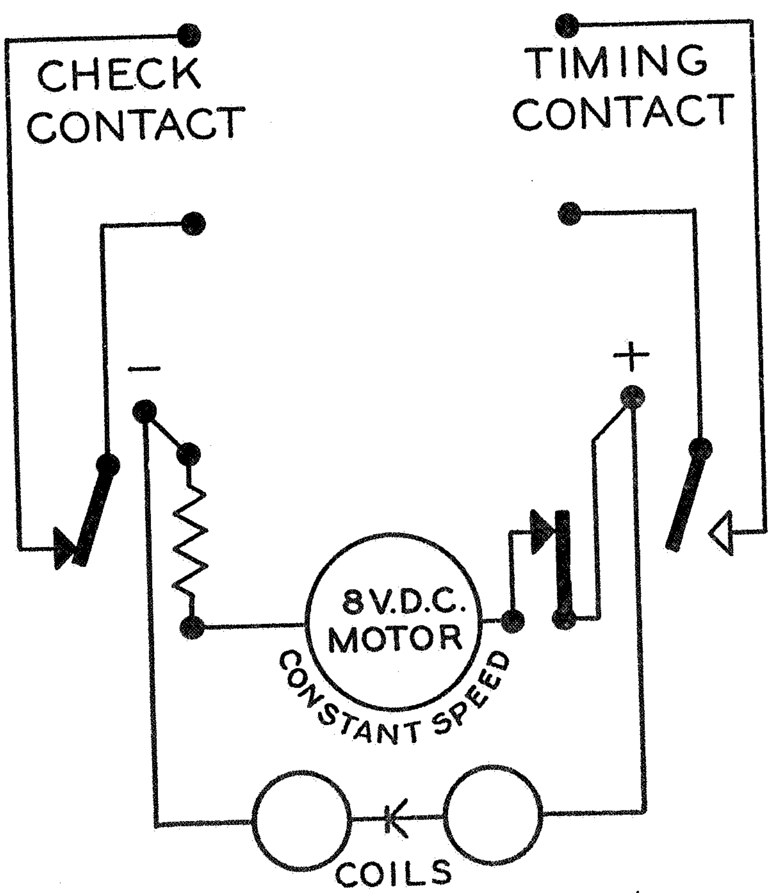


Fig. 34.

Wiring Diagram of Class TG Thermal Relay.

Wiring Diagram of Class TJ Thermal Relay.



Fixed resistor shown in motor circuit used to limit operating voltage to 8 volts at motor terminals.

Rectifier shown between coils provided to prevent operation in event of wrong polarity being applied.

Fig. 35.
Wiring Diagram of Motor-Driven Time Element Relay.

Figure 36 shows the electrical connection between the permanent plugboard (mounted on relay rack) and the contact block in base of relay. All external wire connections are made to the plugboard terminals by a soldered connection on the back of the plugboard. The plugboards are provided with guide rods to assure proper alignment of the relay prongs and the plug portion of the terminals protruding from the plugboard. These guide rods may be installed after the plugboard is assembled in the relay rack. The relays are held in proper position by knurled retaining nuts.

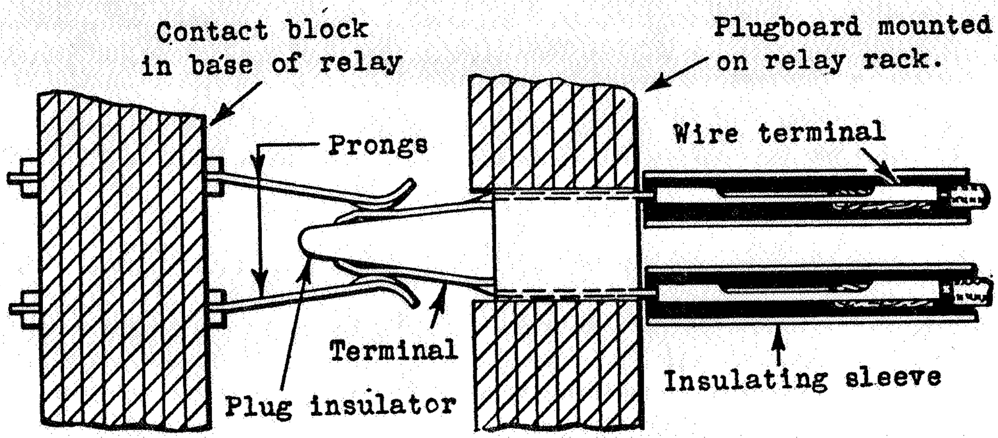


Fig. 36.
Detail of Plug Connection.

A molded transparent plastic cover, which is very tough and difficult to break, protects the working parts of the relay.

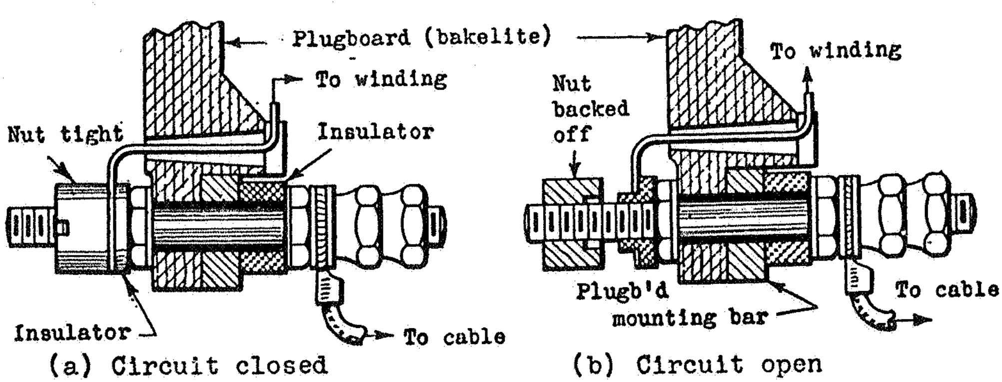


Fig. 37.
Test Terminal for Opening Winding.

These relays are provided with test terminals, mounted on the plugboards and directly underneath their respective relays, to permit opening the circuit to the relay coil to see that it drops away or picks up properly, or for determining the relay's operating value. One or two test terminals are provided each relay, depending on whether the relay has one or more independent coils. Their location in the circuit is indicated in Figs. 32 and 33 by the terminals numbered "1E," "3E," and "6E." These test terminals, comprised of in part by the round slotted nut shown in Fig. 37, open or close the circuit, dependent on whether the slotted nut is backed off or screwed up tight. A special tool, Fig. 38, is provided for this purpose.

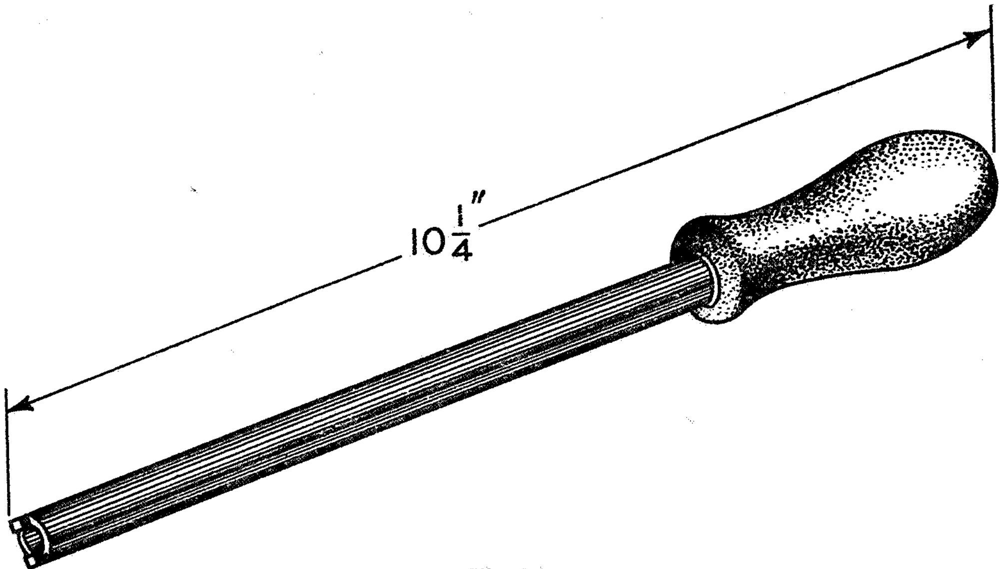


Fig. 38.
Tool for Test Terminal Nut.

C.T.C. Type Neutral Relay

This relay is used only for non-vital circuits in centralized traffic control systems, etc. The relay may be either ordinary, quick or slow drop-away. Relays A, B, C and D, Fig. 39, are ordinary drop-away, relay E is quick drop-away, while relays F, G, H and J are slow drop-away.

The contact arrangements are variable, both as to number and kind. Dependent or independent front and back contacts, or dependent close-before-open (continuity) contacts are available.

This type of relay is housed in glass enclosed dust-proof cases individually or in groups as required.

Miscellaneous

Other special types of relays are in service to accommodate some special or local requirement, but the method of operation is practically the same as mentioned in this chapter.

Instructions.

Relays should be inspected, tested and maintained in accordance with the instructions issued by the railroads, which usually include reference to Signal Section, A.A.R. Instructions for Direct Current Relays, and manufacturers' service data.

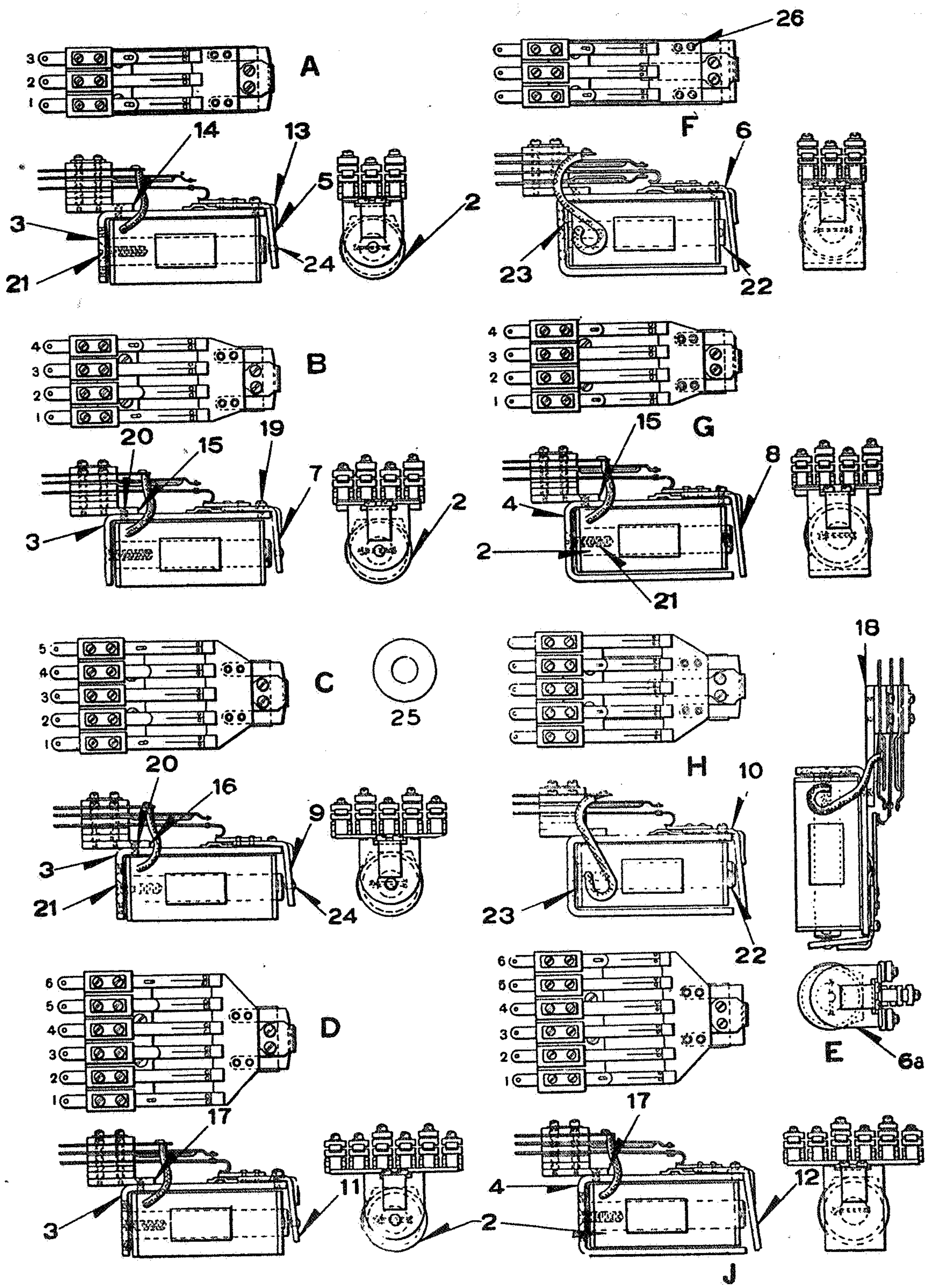


Fig. 89.

O.T.C. Type Neutral Relay.