

**RELAYS  
AND  
APPARATUS COMMON TO MANUAL  
AND  
DIAL CENTRAL OFFICES  
PAMPHLET No. 36**

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## INTRODUCTION

The apparatus described in this pamphlet may be divided into four major groups, covering switching, indicating, transmission and protective devices.

The most commonly used electrically operated switching device is the relay. A great many different types of relays are necessary in order to best meet the various operating and maintenance conditions. It is seldom that a relay designed for one purpose will be entirely adaptable to another. For example, some relays are required to operate on direct current and others on alternating current. Some relays have a large number of springs, while others have only a very few springs. The great variety of circuit requirements necessitates the use of quick-acting highly sensitive relays, slow acting and slow releasing relays, polarized relays, high and low impedance relays and many other variations and combinations of these features. Examples of manually operated switching apparatus are keys, plugs and jacks. A detailed description is given for only those most commonly used.

Indicating devices may be of either the visual or audible type and include drops, signals, ringers, buzzers, switchboard lamps, registers and clocks. With the exception of switchboard lamps, these are electro-magnetic devices similar in theory and construction to relays.

Among the apparatus used for transmission purposes and described herein are the various types of telephone transformers, such as repeating coils, induction coils and input and output transformers. Also belonging to this group are retardation coils and condensers. Although there are a great many different kinds of transmission apparatus, only the mechanical and constructional details of representative types have been discussed.

Apparatus used for the protection of telephone circuits includes protectors, varistors and fuses. Resistances may also be included in this classification, since they are frequently used to protect apparatus in a circuit against an abnormal current flow.

## PREFACE

This pamphlet is issued for the information of the Western Electric Installation Field forces to familiarize the installer with the general, physical and operating characteristics of relays and apparatus common to manual and dial offices.

The contents are of a purely descriptive nature and do not prescribe methods or give engineering information for the installation of central office equipment. At the end of each section a number of questions are given, to be of assistance in connection with training classes.

While particular types of apparatus are discussed, the pamphlet will not be reissued to keep it up to date with changes in equipment. When changes in equipment occur which are of general interest, a new pamphlet will be written.

The contents of this pamphlet are based on information issued by the American Telephone and Telegraph Company and the Bell Telephone Laboratories. Most of the information of Section 1 was taken from a pamphlet previously issued, entitled "Western Electric Company Relays".

In the second, third and fourth editions of this pamphlet, information on newly coded relays and other apparatus has been added. Descriptive matter relating to obsolete equipment has been omitted and other minor changes have been made to bring the pamphlet up-to-date.

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## SECTION 1

### RELAYS

#### SECTION 1-A GENERAL THEORY OF RELAY OPERATION AND DESIGN

In the discussion which follows it is assumed that the student has a general idea of the fundamentals of electricity and magnetism. For those who do not have this knowledge, it is recommended that either of the following references be studied: "The Application of Electricity and Magnetism to Transmission in the Telephone Plant", Section 1; "Principals of Electricity Applied to Telephone and Telegraph Work", Chapters I to IX. (See Job Clerical Handbook).

#### MECHANICAL AND ELECTRICAL FEATURES OF RELAYS

##### General

A relay is fundamentally an electrically operated switch. It consists of an electromagnet (core and winding), an armature, and contacts. These parts are arranged in such a way that when the core becomes magnetized by an electric current through the winding, the armature is attracted by the core and moves sufficiently to open or close the contacts.

When the circuit through the relay winding is closed, the core becomes magnetized and sets up magnetic flux in the magnetic circuit. One end of the magnetized core becomes a north pole and the other a south pole; and if the direction of current through the winding is changed, the poles are reversed. When the current is in such a direction as to make the end of the core nearest the air gap a north pole, the lines of force or flux go out of the core, across the gap and into the armature, thence through the return pole piece to the other end of the core, thus completing the magnetic circuit. With the end of the core nearest the air gap a north pole, the end of the armature facing it becomes a south pole, because it is the other end of a magnet. Since unlike poles attract each other, the armature will be drawn toward the core if the flux produced by the current through the winding is great enough.

##### Core and Armature

The material which is generally used for the manufacture of relay cores and armatures is Magnetic Iron, a soft grade of iron. Another material, Silicon Steel, is used mainly for relays required to operate on a small energy input, such as supervisory relays (B type) and for alternating current relays. Another material, a special nickel steel alloy called Permalloy developed by the Bell Telephone Laboratories, is principally used for highly sensitive relays, such as the 209, 239 and 267 types, and for certain codes of general purpose relays requiring fast operate and release characteristics. To prevent rust, relay cores and armatures are given a protective finish of either zinc, nickel or chromium.

The design of the magnetic structure of a relay - that is, the core and armature is based mainly upon the pull the armature must exert in order to move a certain load a certain distance. The flux necessary to produce this pull is dependent upon certain fundamental constants of design which are the leakage flux, the flux density of the core and the flux density of the pole face. Results obtained from tests conducted on a number of different designs and at various loads indicate that the leakage flux depends almost entirely upon the armature air gap reluctance and the ratio of the core length to the core diameter.

The flux density of the core and that of the pole face depend, of course, largely upon the requirements of the relay, but are chosen with respect to first cost and efficiency of operation. The most efficient core design is obtained by using a core flux density corresponding to the maximum permeability of the core iron. Where a relay is required to operate only on short intervals of time, resulting in low annual power charges, efficiency of operation may, however, be sacrificed in order to obtain a low first cost. In this case a core of small cross section is used, which in turn requires a high core flux density and pole face density in order to obtain the necessary pull. The same consideration applies to relays carrying a very large mechanical load, where the size of the core would have to be made unreasonably large in order to obtain a high efficiency. A core of comparatively small cross section is, therefore, also used for relays of this type. However, in the case of relays carrying a very light load - for example, five grams - the size of the core may have to be increased considerably more than is needed magnetically in order to give the required mechanical strength for winding and mounting. This results in the use of a core flux density much less than its most efficient point on the magnetization curve. In general, where small forces are involved, a high efficiency of operation is desirable, whereas in designs for the heavier forces more consideration is given to a low first cost.

The best flux density and area for the pole face with respect to electro-mechanical efficiency is obtained by making the reluctance of the air gap equal to the reluctance of the remainder of the magnetic circuit. This, however, is not always practical, as it may lead to very small armature movements and, consequently, low pole flux densities are generally chosen.

From the above consideration it follows that for relays carrying the heavier loads, magnetic irons capable of high flux densities are desirable, as the high densities

permit of a small core section and consequently a small and low cost magnet. Magnetic iron is, therefore, used for the core and armature of most types of relays. Relays controlling light loads are best constructed from magnetic materials which have a high permeability and low coercive force. A high permeability reduces the energy required to saturate the core and a low coercive force is necessary to prevent the armature from sticking to the core. The magnetic materials used in this case are Silicon Steel and Permalloy, the latter having the better characteristics of the two materials.

### Windings

There may be from one to four windings on a relay. For purposes of differentiation, windings are classified as Primary, Secondary, Tertiary, or Quarternary. At least one winding on every relay must be an inductive winding. An inductive winding is wound in such a manner that the current will always flow around the core in the same direction and thus cause the core to become magnetized. A non-inductive winding is wound so that the current will flow around the core in one direction through half of the winding and in the opposite direction through the other half of the winding, thus neutralizing the inductive effect. The term "differential relay" is sometimes used and refers to a relay having two inductive windings of the same number of turns and resistance, connected so that the inductive effect of one winding neutralizes that of the other. Thus, relays equipped with differential windings may be operated by energizing one winding and then released by energizing the other winding. Figure 1 shows the most common symbols used on circuit drawings for relay windings.

Annealed copper wire, ranging in size from No. 20 to No. 40 B & S gauge and having, as insulation, a covering either of black enamel, one or two layers of silk, or a combination of enamel and silk, is used for the inductive windings. The material ordinarily used for non-inductive windings is enamel or silk covered nickel-silver wire, as the high resistance saves winding space.

Relay spools are generally insulated to withstand a test of 500 volts, 60 cycles, applied between the winding and the core. The material used as a covering for the core and between windings is generally cellulose acetate sheet which is also effective in preventing deterioration of the smaller sizes of copper wire from corrosion. This corrosion is usually an electrolytic action between different windings and winding and core, caused by moisture in the winding and the potential on the winding and the core. In addition to this insulation on apparatus using multiple-wound (or filled) coils, such as U and Y type relays, a thin piece of cellulose acetate sheet is used between each layer of winding. Multiple-wound coils are made by winding a number of coils of the same kind on a single arbor with slight separations between adjacent windings so

that the coils may be cut apart when completed. Where this method is used, the insulation of the wire is generally extra thin enamel.

To prevent abrasion, the coil is provided with a covering of bleached muslin impregnated with a resin compound and faced on both sides with cellulose acetate. This covering, greenish in color, is known as vincelatate muslin.

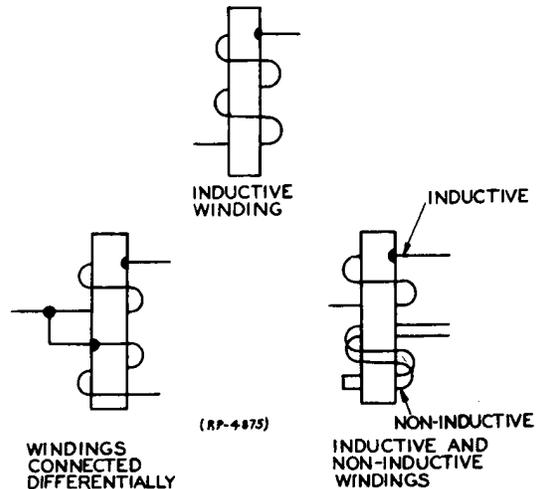


FIG. 1 RELAY WINDINGS

Spoolheads are generally constructed of phenol fibre although sometimes a metallic spoolhead is used for mechanical reasons; for example, on the 206 type relay. The lead-out wires of the winding are insulated and separated from each other by means of end washers of either varnished red rope paper or cellulose acetate sheet, and are brought out to terminals in the spring pile-up, or terminals fastened to the rear spoolhead.

The design of a suitable winding depends, of course, largely upon the force or ampere turns required for operating the particular arrangements of contacts involved. This force is usually expressed in ampere turns which is the product of the number of turns in the winding and the current passing through it. Thus a force of 100 ampere turns required to operate the armature of a given relay structure may be obtained by using either 1000 turns and .100 amperes or 10,000 turns and .010 amperes. A number of different factors must be considered, however, in determining the proper winding and spool dimensions, which are briefly covered in the following paragraphs.

The maximum number of ampere turns that can be safely applied to a relay winding is determined by the maximum permissible temperature rise in the winding. This rise in temperature is dependent upon the circuit conditions and upon the heat dissipating capabilities of the winding and relay structure. For the proper dimensions of the spool, first cost and efficiency of operation are the deciding factors. The

volume of wire used in the spool determines its first cost, while a variation in the length of the coil, which changes its leakage flux, determines the efficiency of the coil. In general, a short thick spool is the most efficient but is high in cost, while a long thin spool is cheap in first cost but not as efficient. For the accurate determination of the number of turns of wire that may be wound on a spool, winding formulae have been developed. These winding formulae are used in connection with winding constants, which have been determined for various sizes of wire and kinds of insulation, and take into account all the variables involved in actual winding practice.

### Contacts

The selection of the proper contact material is important, as in most cases the useful life of a relay is determined by the life of its contacts. The contact material used must be practically free from corrosion, as corrosion acts like a high resistance film on the contact surface. Contacts must also be able to withstand the electrical wear caused by arcing, and must be sufficiently hard to limit the wearing away to a minimum.

Relay contacts are made from No. 1 contact metal (an alloy of platinum, gold, and silver), No. 2 contact metal (palladium), platinum, tungsten or from special contact materials in instances of severe operating conditions such as are encountered with 209 type relays. In general, the "U", "Y" and multi-contact relays for the crossbar system employ twin contacts of silver, except in talking circuits where no current is made or broken. In these cases twin contacts of palladium are used. The size and shape of contacts depends largely upon the mechanical wear to which they are subjected and upon the energy to be controlled. The size is also made sufficient to take care of manufacturing variations in the location and alignment of the contacts. This is accomplished by mating a point contact with a disc contact or by two contact bars meeting at right angles. In the case of point and disc contacts, the point is required to make within the circumference of the disc whereas for bar type contacts the amount of permissible variation in alignment depends upon the length of the bars. Because of the greater economy in the use of precious metal, bar type contacts are used on most of the general purpose relays, such as the E, R, U and Y types.

The sizes and shapes of relay contacts most widely used are shown in Figure 2. Contacts are usually attached by spot welding to the contact members, except in the case of contact screws where they are tightly fitted.

In order to prolong the life of contacts, contact protection circuits are used in a number of instances. They are for the purpose of limiting the arcing of the con-

tacts and consist in most cases of either a non-inductive shunt across the winding, or a non-inductive resistance in series with capacity across the winding or contacts. Another arrangement consisting of non-inductive resistance in series with capacity and the capacity again shunted by a non-inductive resistance is used for conditions such as are encountered by the contacts of the 209 type relay in telegraph circuits.

### RELAY REQUIREMENTS

Relays are adjusted to certain mechanical and electrical requirements to insure their operation in the circuit for a reasonable period of time. Although a relay may apparently function satisfactorily in a circuit when it meets its electrical requirements, there is no assurance that its adjustment is permanent unless certain mechanical conditions are met. Since a relay may be considered an electrically operated switch, it is obvious that its switching arrangement, that is, the contacts must function properly. Contact alignment and a minimum contact separation are, therefore, necessary. This, however, is not sufficient, as a certain contact pressure is essential to prevent fluttering between the contacts. Spring tension, contact follow and stud gap are the requirements which in conjunction with the electrical requirements insure satisfactory contact closure. In addition, there are a number of other mechanical requirements depending upon the type of relay, such as armature travel, tightness of assembly, clearance between parts, straightness of springs, mounting, etc., which are necessary to insure satisfactory operation.

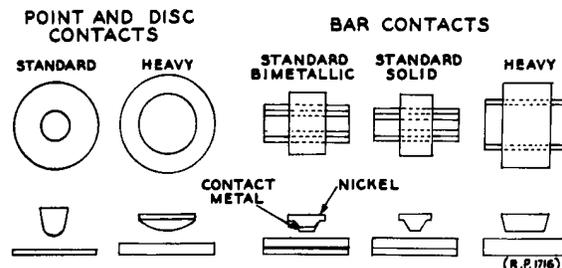


FIG. 2 RELAY CONTACTS

The electrical requirements cover operate, non-operate, release, and hold conditions and are in the form of current, voltage, or non-inductive resistance values. A soak current value is also sometimes specified in conjunction with other electrical current values. The purpose of this soak is to set up a maximum amount of residual magnetism which would either aid or oppose the operation of the relay. In the majority of cases the electrical requirements for a relay consist of an operate and a non-operate value. The non-operate value is mainly for the purpose of insuring back contact pressure and sometimes to meet a non-operating circuit con-

dition. Most E, R and U type relays have only an operate value, the non-operate having been replaced by minimum spring tension requirements on the armature or traveling springs, thus insuring a more uniform back contact pressure adjustment. An operate and a release value are usually required for relays associated with external circuits, such as trunk, line, and supervisory relays, in order to effect the release of the particular relay against a current due to leakage in the circuit. A hold value is sometimes specified to insure that the relay does not release when the current through the relay winding is decreased to less than its operate value. Hold and release values are also specified to insure meeting the required release times of slow acting relays. One or more of the aforementioned values may be specified for a relay, depending upon the circuit conditions.

In the majority of cases relays are adjusted on a direct current flow basis. Where a relay cannot be conveniently isolated, voltage values are sometimes applied, as this eliminates the necessity of opening the circuit in order to isolate the relay for current flow purposes. The D.C. Adjusting Set, ITE-4040, is provided for the application of direct current flow and voltage requirements. This set consists essentially of a variable resistance in series with a meter and such keys and switches as are necessary for the proper application of the requirements. Figure 3 shows the panel layout of the set.

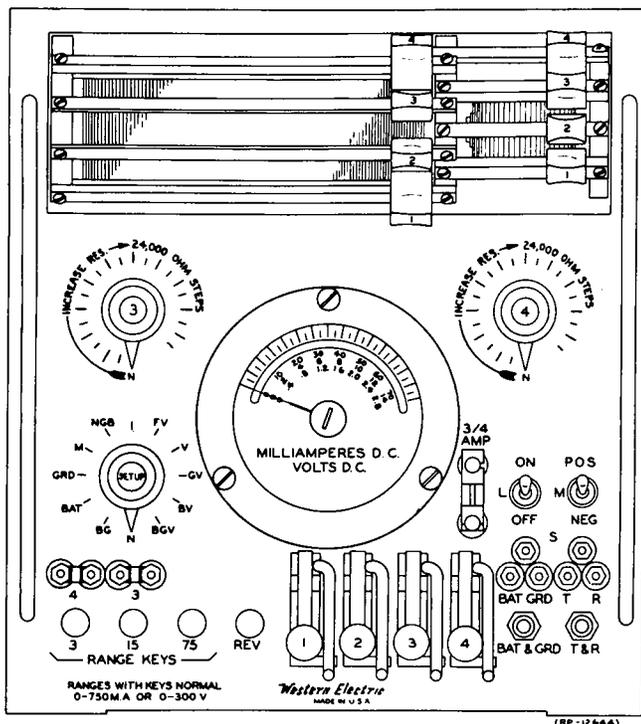


FIG.3 D.C. ADJUSTING SET

Relays operating on alternating current are usually adjusted on alternating current by means of non-inductive resistance in series with the relay or by means of the low shunt method. For the application of non-inductive resistance requirements, the variable resistances of the D.C. Adjusting Set may be used. Instructions for obtaining the desired resistance values are contained in the associated method of operation sheets. For the low shunt method of adjusting, the Telephone Company's maintenance test equipment, such as the A-C Relay and Signaling Test Set (J68602-AJ) is generally available. A panel layout of this set is shown in Figure 4.

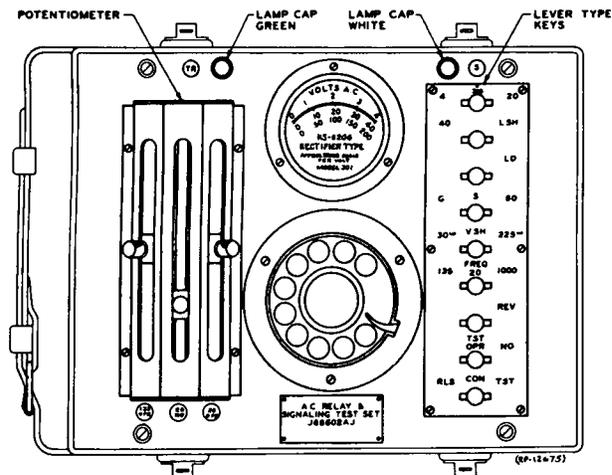


FIG.4 A-C RELAY AND SIGNALING TEST SET (J68602-AJ)

The low shunt method of applying alternating current tests to alternating current relays utilizes an arrangement whereby a resistance of relatively low value is bridged across the circuit. The function of this resistance is to lower the impedance to such a degree that the effect of other impedances normally shunting the relay is materially reduced. The normal shunts encountered are the DC supervisory relay in the case of cord circuits, and the repeating coil in the case of line circuits. The impedance of these shunts varies from 500 ohms to infinity and in conjunction with the relay alone causes a wide variation in combined impedances. However, when the low shunt is added, it dominates the circuit and variations in other impedances in parallel have little or no effect on the total impedance. Therefore, when a definite current flow is established through the circuit by means of a meter, it results in a definite voltage across the circuit regardless of the impedance normally shunting the relay. Consequently, the low shunt method of checking relays insures a very uniform and reliable test without resorting to troublesome circuit preparation.

Trip relays in subscriber's ringing systems are sometimes adjusted by means of non-inductive resistance in series with the relay. The Telephone Company's trip relay adjusting set is generally available for this purpose.

RELAY DESIGNATIONS

The various types of relays are known by either a letter or a number, such as E type and 114 type. The individual relays are designated (or coded) by adding a number or letter to the type designation mark,

such as E-156 and 114-KA relays. This code designation thus distinguishes a relay of a certain type, having definite windings and contact spring arrangements. The code designation usually appears on the front spoolhead or some other part in front of the relay where it can be readily seen.

QUESTIONS

1. Why are there so many different types of relays?
2. What materials are generally used in the manufacture of relay cores and armatures?
3. What determines the size and shape of relay contacts?
4. What is meant by a differentially wound relay?
5. What is the theory of a non-inductive winding?
6. What types of protective circuits are used to lengthen the life of contacts?
7. Why is an operate value only generally specified for E, R, and U type relays?
8. What is the purpose of a soak value?
9. What is the low shunt method of adjusting relays?
10. What adjusting set is used for the application of direct current flow requirements?

## SECTION 1-B

DETAILED DESCRIPTION OF RELAYS

In general, relays may be divided into two groups: relays operating on direct current, and relays operating on alternating current. Each of these groups may be subdivided according to the type, purpose, or characteristics of the relays. In the following sections the various relays have been grouped in this manner and their characteristics described in detail.

DIRECT CURRENT RELAYSA, AB, E, EA, F, H, R and T Type Relays  
(Flat Type Relays)

These relays are known as "Flat Type Relays" because the major parts of the relay, that is the core, armature and contact springs are punched out from flat stock. See Figures 5 to 9. This arrangement facilitates the interchangeability and replacement of these parts. The punched design has also made possible a reduction in the size of the relay, so that more flat type relays than relays of the old types can be mounted in a given space. Except on the F and T types of relays (which have a loosely hinged armature), a soft iron reed riveted to the ends of the armature and clamped under the spring pileups completes the magnetic return path over the two sides of the armature. In order to reduce the reluctance of the magnetic circuit, thereby increasing the operating capability of the relay, the armature and core have a large pole face area. Magnetic iron is used for the core and armature of most flat type relays. E and R type relays using code numbers beginning with 6000 have permalloy cores and armatures. The contact springs of flat type relays are made of nickel-silver.

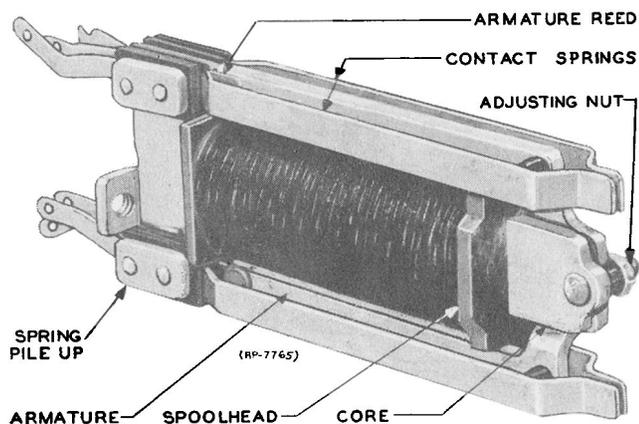


FIG. 5 "A" TYPE RELAY

The A type relay, the armature and core of which are made from a thinner stock of iron than that used for other flat types, is used mainly for line and cut-off relays on manual installations. This relay is largely superseded by the AB type relay described in one of the following paragraphs.

The E type relay is a general purpose relay and replaces practically all the old barrel type relays of the 122 and similar types. There may be as many as 14 springs (7 in each pileup) used on an E type relay, while not more than three sets, or 9 springs, can be conveniently placed on the old spring or barrel type relays (125 type for example). The contact springs are actuated by insulating studs attached to the armature and which pass through holes in the stationary springs. The available 59 different spring combinations permit the selection of a great many circuit arrangements. Stop pins, or non-freezing discs, are welded to the armature of most E type relays to prevent the armature from sticking as a result of residual magnetism.

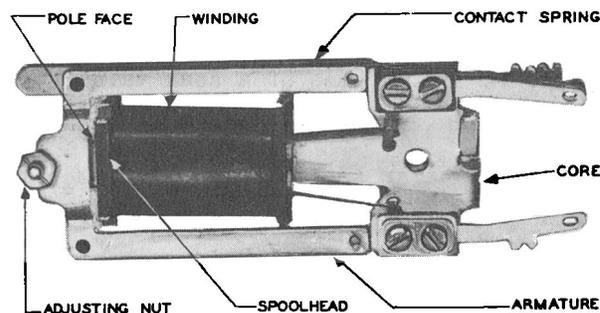


FIG. 6 EA TYPE RELAY

The EA type relay is essentially an E type relay modified to permit the use of multiple wound (or filled) coils. The width of the pole face is smaller than that of the E type relay, so that the finished coil may be slipped over the core before the front spoolhead is attached. Some EA type relays, such as the EA2 shown in Figure 6, are equipped with a short coil, since this construction is more advantageous from a manufacturing standpoint. EA type relays are extensively used as line relays in dial equipment.

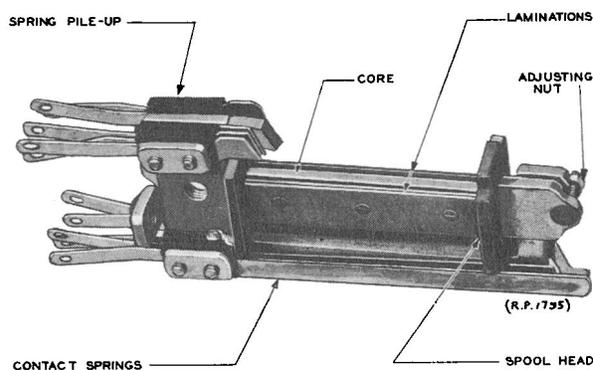


FIG. 7 CORE OF "H" TYPE RELAY

The H type relay is practically identical with the E type relay, the only difference being the provision of iron laminations (see Figure 7) riveted to either side of the core. These laminations give the H type relay a higher impedance at talking current frequencies than the E type possesses.

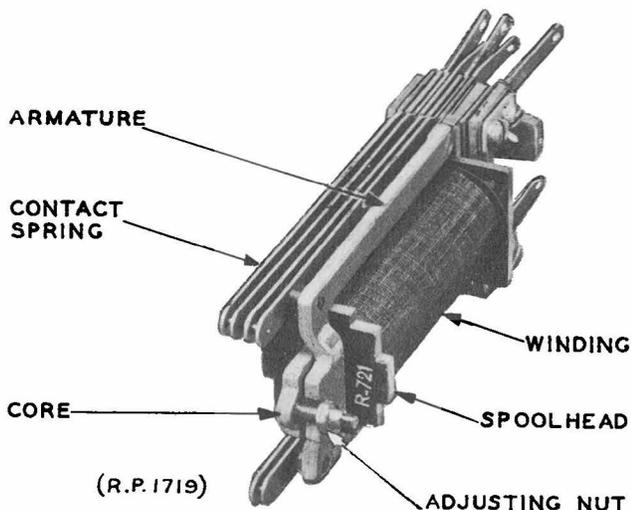


FIG. 8 "R" TYPE RELAY

The R type relay (see Figure 8) differs from the E type relay only in the use of a "swaged" core and slightly larger spoolheads. The term "swaged" denotes a pressing operation at the time of manufacture which changes the normally rectangular shape of a flat type relay core (under the winding space only) to an oval shaped core. Although the cross-sectional area remains unchanged, the swaged core affords a greater winding space and a shorter length of turn, because the winding follows more closely the contour of the core than it is possible on a rectangular shaped core. As a result, more turns of a given size wire can be wound on the swaged core of an R type relay than on the rectangular core of an E type relay and still maintain the same resistance.

The AB type relay resembles the R type relay except that the core and armature are made from thinner stock. This relay was designed to replace the A type relay and has the advantage of greater stability due to the greater number of turns on the swaged core. The use of straight springs in place of the old type formed springs also simplifies the adjustments for spring tension and contact separation.

The F type relay (see Figure 9) is a flat, punched type, slow releasing relay. It is of the same general construction as the E type relay, except for the use of magnetic bridge pieces across each hinge gap, a loosely hinged armature, a short circuited copper winding over the core, and an adjustable stop pin to regulate

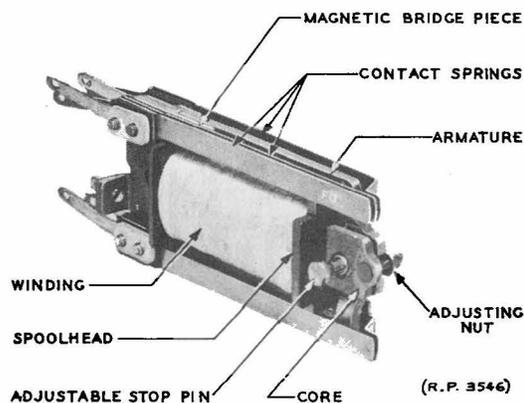


FIG. 9 "F" TYPE RELAY

the time of release. The T type relay differs from the F type only in the use of a swaged core and slightly larger spoolheads and that it has no adjustable stop pin. The advantages of using a swaged core, as pointed out for the R type relay led to the development of the T type relay. Since F and T type relays are slow releasing relays, they will be considered further under the heading of "Slow Acting Relays."

The mechanical requirements specified for flat type relays include armature travel, spring tension, contact separation contact follow and stud gap. Adjustment for electrical requirements is obtained by changes in spring tension and variations of other requirements within their specified limits. The electrical requirements in most cases cover only an operate value, the non-operate value having been replaced by minimum spring tension requirements in grams which insure a more uniform adjustment.

#### U, UA, UB and Y Type Relays

These relays are general purpose relays similar to flat type relays, but have a round core and are somewhat longer. Other outstanding differences are the use of double or "bifurcated" contact springs, multiple wound (filled) coils and the ability of most of these relays to operate as many as 26 contact springs on one relay, almost twice as many as can be used on an R type relay. This increase in load is made possible by using a larger cross-section of magnetic material in both armature and core and a low reluctance hinge arrangement in the form of a more flexible armature suspension. See Figures 10, 11 and 12.

Nearly 200 different spring combinations have been provided for these relays, and the design has been so arranged that all contact springs are mounted on one side of the relay, while all winding terminals are mounted on the other. This arrangement simplifies the method of bringing out leads in that the primary winding terminals are always nearest the core on the right-hand side of the armature, the secondary

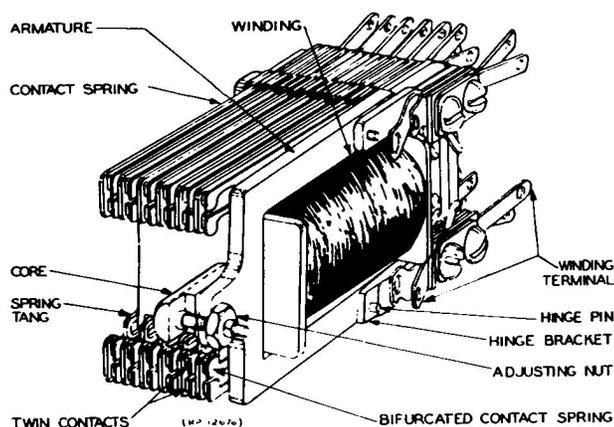


FIG. 10 "U" TYPE RELAY

winding terminals are next nearest, and the tertiary terminals, when used, are always on the outside. The contact springs, with the exception of certain moving springs on the UB type described in one of the following paragraphs, are tensioned in the same direction (to the right) in the process of adjusting the relay. The moving springs, except on the UB type, are actuated by the pressure of the armature against small insulating studs which are fastened in the springs, and which pass through holes in the stationary springs. This differs from the action on "R" type relays where the studs are fastened to the armature. For uses requiring up to four stationary springs on top and bottom, one size spoolhead has been provided, and a larger spoolhead having more notches is furnished for relays carrying up to the full number of 26 contact springs. The winding terminals project through the pileup toward the front of the relay, and are staggered in position to facilitate application of the connector used when applying electrical requirements to the relay.

The core is cylindrical in shape and is welded to the bracket, or in the case of the UA type relay held in place by means of a screw and two tapered ridges in the core which engage with two slots in the bracket. Where slow operating features are desired, provision is made to slip copper or aluminum sleeves over the core. Also, for those cases where high voice frequency impedance is desired, similar to the needs for which the "G" and "H" type relays were made, permalloy shells can be assembled to the relay. These shells consist essentially of a cylindrical permalloy tube, which fits over the relay core. The tube is split in half along its length and is then held in place over the core by means of the coil and spoolhead. Their action is similar to that of laminations. Magnetic iron and permalloy are the magnetic materials used for the cores and armatures of these relays. Relays using code numbers beginning with 6000 are made of permalloy.

To accommodate the various sizes of spring pileups, three sizes of individual covers are provided. These covers are made of sheet steel and serve both as dustproof covers and for protection against magnetic interference or cross-talk.

Contact reliability on these types of relays is insured by the use of twin or double contacts and the bifurcating of the operating springs. To illustrate the gains made by the use of twin contacts, it is expected that, if a given single contact relay were to have one failure in 100 operations caused by foreign bodies lodging between contacts, these failures would be reduced to one in 10,000 operations if twin contacts were used. The contact chatter has been greatly reduced compared with flat type relays, chiefly by the use of operating springs which are thin in comparison with the spoolhead springs, a rigid core construction, and a more flexible armature suspension. The reduced contact chatter increases the circuit reliability of the contacts, and also minimizes contact wear.

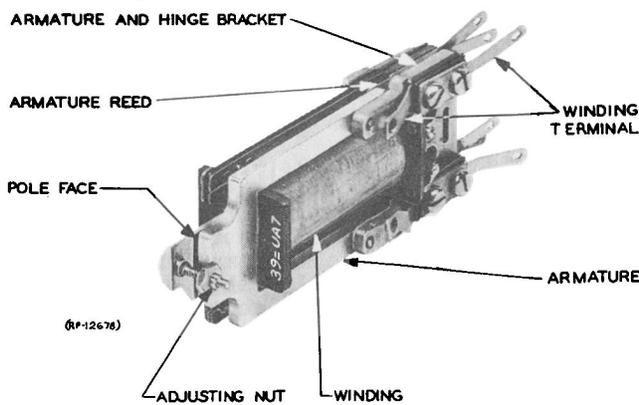


FIG. 11 "UA" TYPE RELAY

As illustrated in Figure 11, the principal difference in appearance between the UA and U type relays is that the pole face area of the UA type is much larger. The enlarged pole face area and the use of a one-piece armature and hinge bracket of thicker material lower the reluctance of the magnetic circuit, thus permitting the relay to operate on less ampere turns than the U type. Since the enlarged pole face requires mounting of the coil before the core is attached to the bracket, the core instead of being welded to the bracket is held in place by means of a screw and two tapered ridges which engage with two slots in the bracket. Other differences are the addition of phosphor bronze armature reeds to hold the armature against its bracket and the use of a smaller diameter core (1/4") and thinner armature (.083") on some UA type relays. The smaller diameter core provides increased winding space and when used with the thinner armature results in a faster releasing relay than the U type. The improved operating characteristics of the

UA type as compared with the U type permit magnetic iron UA type relays to be used in place of many permalloy U type relays. For the same reason UA type relays are also used in place of B type relays where sufficient current for operation is available.

The UB type relay shown in Figure 12 is essentially a U type relay with "card" actuation of the contact springs. The card consists of a piece of insulating material with slots that engage with the tips of the moving springs. It takes the place of the insulating studs used on U type relays which also serve as balancing springs. The card is intended to eliminate changes in adjustment due to stud wear and to reduce the tendency of the contacts to lock. UB type relays are equipped with phosphor bronze reeds for supporting the armature instead of using the loosely pivoted hinge arrangement of the U type. The reeds are attached to each leg of the armature by rivets located just in front of the ends of the hinge bracket.

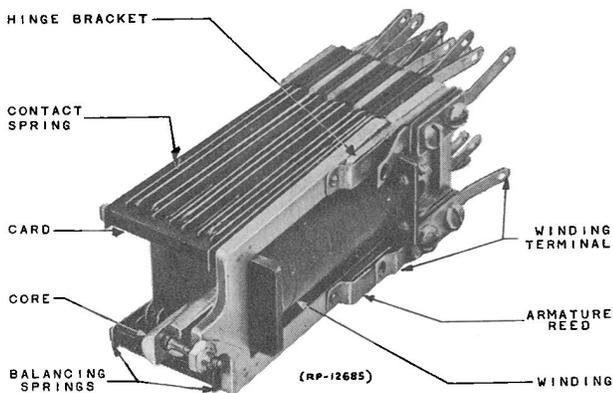


FIG. 12 "UB" TYPE RELAY

The Y type relay is a slow-releasing relay capable of replacing previous slow-releasing relays, (149, 162, 178, F and T types), while making available a larger number of contact springs per relay, more reliable contact pressures, and twin contacts. This relay is constructed essentially the same as the U type relay with suitable modifications to afford the desired slow-releasing properties. For the desired time ranges, three sizes of copper sleeves and one size of aluminum sleeve are used.

The outstanding differences from U type relays are the addition of embossed surfaces on the armature pole face and at the armature pivoting points. These embossed surfaces provide more definitely controlled operated air-gaps, assuring a uniformity of the manufactured product so far as releasing characteristics are concerned. A detailed explanation of the slow operating and slow releasing features in relays is given under the heading of "Slow Acting Relays".

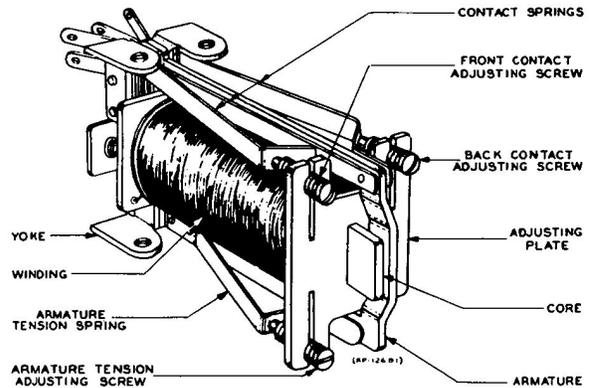


FIG. 13 "B" TYPE RELAY

#### B and G Type Relays

B and G type relays are used for supervisory purposes in trunk and cord circuits. Both relays are of the punched type and differ only in the construction of the core and the thickness of the cover used. Figure 13 shows a B type relay with the cover removed.

Due to the fact that a B type relay must operate over a wide range of current and yet release when there is still quite some current flowing through its winding, the core of this relay is of a very small cross-section. The magnetic saturation point is, therefore, quickly reached and any increase in current through the winding will not materially increase either the flux or the residual magnetism. Since the pull of this relay is necessarily small due to the small cross-sectional area of the core, the armature and core are made from silicon steel or permalloy, which have a higher permeability and lower coercive force than magnetic iron. B type relays with code numbers beginning with 1000 use permalloy and have a swaged core. Most B type relays are equipped with a soft steel can cover, with removable cap, which is securely held by screws to the yokes of the relay. The purpose of this cover is to protect the relay from dust and to strengthen it.

The core of the G type relay is of a larger cross-section than that of the B type and has laminations riveted to either side. This results in an increase in impedance at talking current frequencies and thus prevents the talking currents from passing through the winding, which would cause transmission losses. An individual iron cover with removable cap is also used for this type of relay, but is made of a much heavier stock (approximately 1/16") to prevent transformer action or crosstalk between two adjacent relays in different circuits. Since iron has a much higher permeability than air, the heavy iron cover takes up the stray flux from the relay and

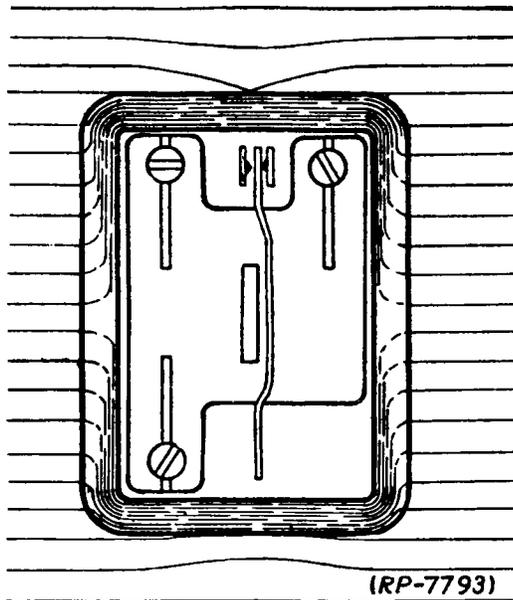


FIG. 14 EFFECT OF COVER OF "G" TYPE RELAY ON EXTERNAL STRAY FIELD

acts as a shield against the stray flux from adjacent relays. The principle of shielding against stray flux is illustrated in Figure 14.

B and G type relays are adjusted to their mechanical and electrical requirements by means of the three adjusting screws in the adjusting plate, the two upper screws being used for regulating the position of the front and back contact springs or stop springs, while the lower screw is used to regulate the tension on the armature.

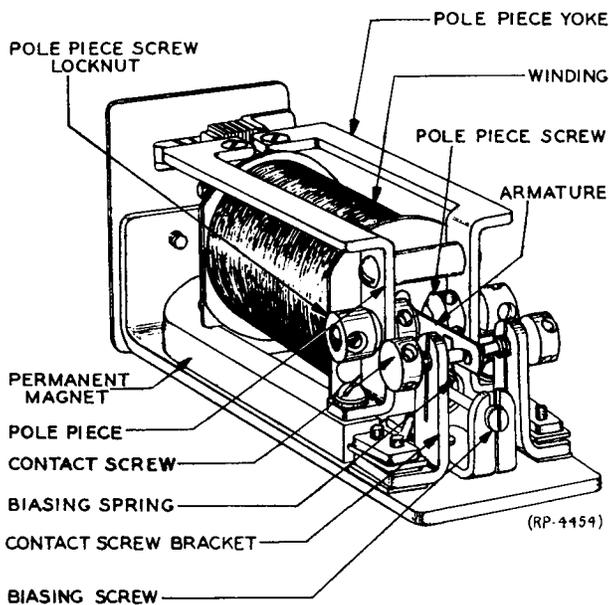


FIG. 15 206 TYPE RELAY

206, 209, 215, 218-B, 239, 255 and 266 Type Relays (Polarized Relays)

The term "polarized relays" is used to designate a relay whose armature and core are kept permanently magnetized, usually by means of a permanent magnet. The object of polarizing a relay is to make it respond to currents of a certain polarity only, and to make it more sensitive. These two points are further explained in the following paragraphs.

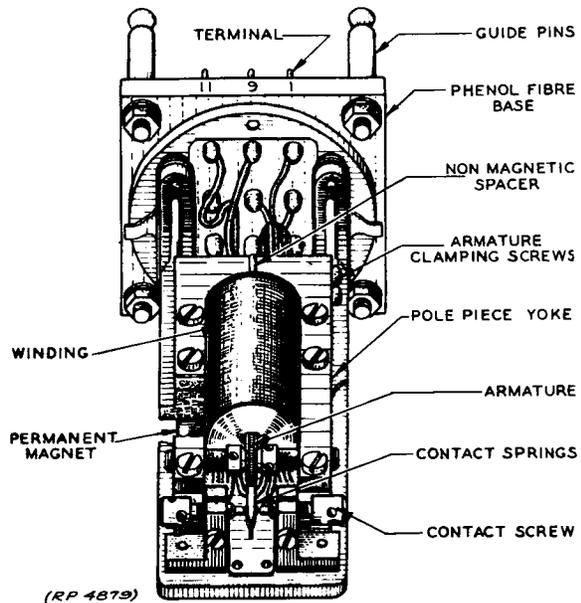


FIG. 16 209 TYPE RELAY

The magnetic circuit of the 206, 209 and 215 type relays (see Figures 15 and 16) resembles that of a Wheatstone Bridge. A permanent horseshoe magnet is mounted around the lower part of the coil of these relays with its ends at the front. Iron yokes (pole pieces) which are attached to the ends of the magnet extend upward in front of the coil and then over the full length of the coil. The armature, which is of the reed type, is rigidly secured at the rear of the relay and is separated from each of the yokes by non-magnetic material. The windings are placed over the armature in the form of a single spool, sufficient clearance being provided to allow the armature to move within the spool. The air gap between the armature and either pole piece in front of the coil can be regulated by means of pole piece screws screwed into the pole pieces. The four gaps, that is, the gaps of non-magnetic material between the yokes and the armature at the rear and the two air gaps at the contact end of the armature, may be considered as the four arms of the Wheatstone Bridge with the armature taking the place of the galvanometer and the permanent magnet that of the battery.

The action of the magnetic circuit of these relays is, briefly, as follows: With the armature in the midway or neutral position, no polarizing flux passes through it, since it connects points of equal magnetic potential. If the armature is moved toward the left pole piece (see Figure 17), thereby decreasing the air gap on the left and increasing that on the right, some of the polarizing flux will flow from the pole piece on the left (assumed to be a north pole) across the left hand air gap, through the armature, and through the non-magnetic material to the other yoke (assumed to be a south pole). A movement of the armature to the right causes some of the polarizing flux to flow through the armature in the opposite direction; that is from the yoke on the left, through the non-magnetic material to the armature, through the armature, and across the right-hand air gap to the pole piece on the right. The armature being supported in cantilever beam fashion, is resistant to displacement from

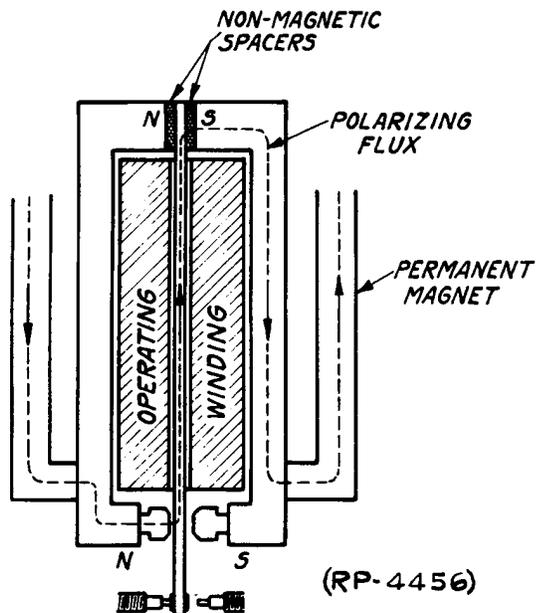


FIG. 17 POLARIZING FLUX THROUGH ARMATURE OF 206 TYPE RELAY

its midway position in the air gaps due to its natural stiffness which opposes the polarizing force as the armature is displaced. Since the relay can be adjusted by means of the adjustable pole pieces, and contact screws which limit the armature travel, so that the polarizing force is just sufficiently in excess of the opposing force of the armature to hold the armature against either contact screw, the armature is practically in a floating condition and can thus be controlled by a very small operating current. The application of this operating current causes the free end of the armature to become either a north or a south pole (see Figure 18), depending upon the direction of the current, and it is drawn toward that pole piece which possesses

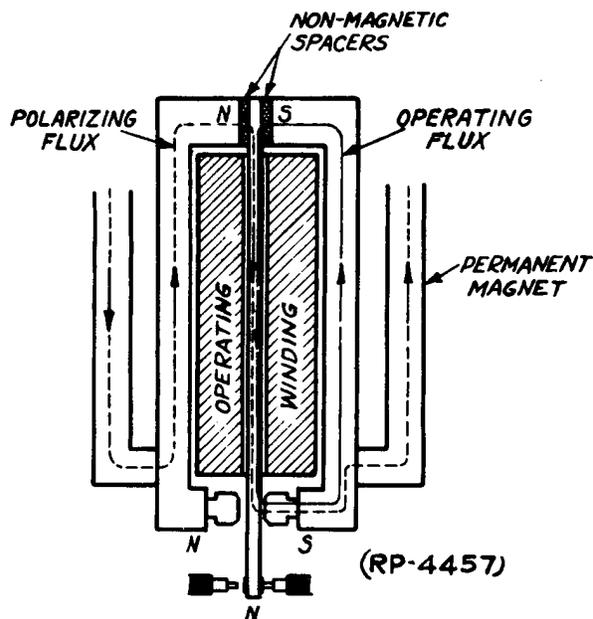


FIG. 18 OPERATING FLUX AND POLARIZING FLUX THROUGH ARMATURE OF 206 TYPE RELAY

the opposite polarity. When the relay operates under the influence of reversals of current through its winding, both the operating and polarizing fluxes reverse in direction through the armature. From the above it is evident that the relay armature will operate to either one side or the other, depending upon the polarity of the operating current. Since the polarizing flux aids the operation of the relay armature, less operating flux is required and a polarized relay is therefore, more sensitive than the ordinary neutral relay.

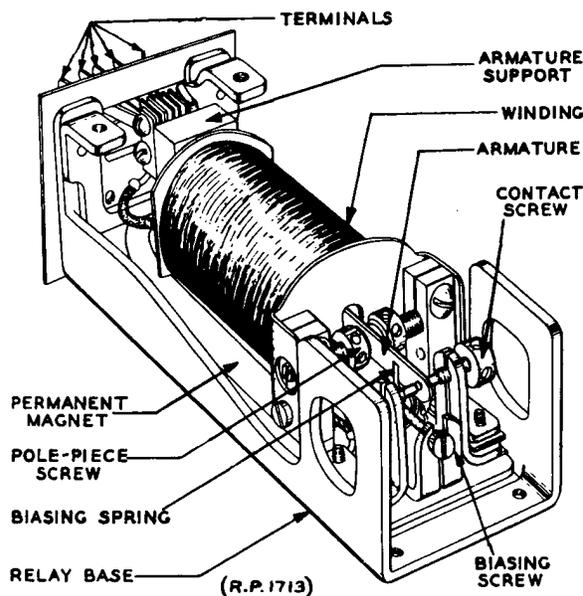


FIG. 19 239 TYPE RELAY

The 239 type relay is similar in construction to the 206 type. The pole piece yokes on these relays have, however, been omitted and a permalloy cover, securely fastened to the frame, is used to form a partial return path for the magnetic circuit. This magnetic arrangement permits the relay to operate on lower ampere turn values while producing the same or greater contact pressures. On the 239 type, the relay structure proper is mounted upon a supplementary base which is fastened to the frame in such a manner as to prevent shocks and vibrations from disturbing the adjustment of the relay. This relay also has improved features of adjustment and a cover cap design insuring stability of adjustment when the cover cap is removed and replaced. Figure 19 shows a 239 type relay with the cover removed.

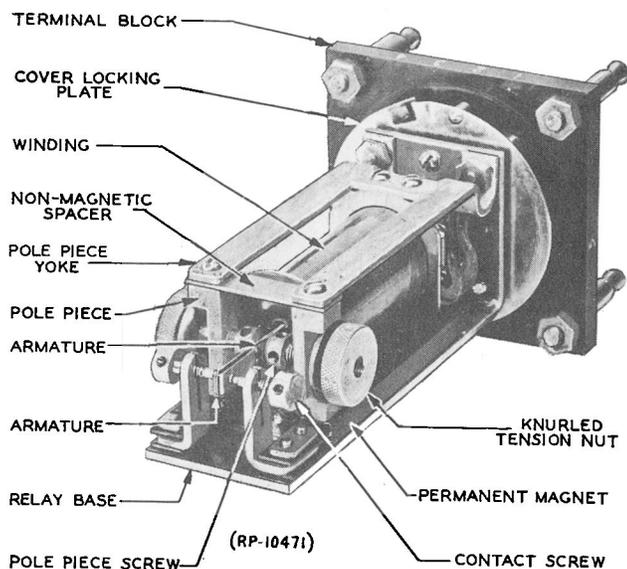


FIG. 20 255 TYPE RELAY

The 255 type relay shown in Figure 20 is primarily for telegraph service. While structurally similar to the 215 type, its more rigid construction provides for added stability in operation. This is obtained by providing the relay with a knurled tension nut and attaching the rear ends of the pole piece yoke to the upright portion of the base in the rear. The knurled tension nut consists of a knurled screw with a conical shaped spring washer which provides sufficient friction so that the pole piece screws need not be clamped after adjustment. The magnetic circuit of the 255 type is also of the Wheatstone Bridge type and follows in general the arrangement described for the 206 type.

Front and back contact or stop screws are provided on all of these relays which, in addition to functioning as contacts, also limit the armature travel as stated previously. A biasing spring, pressing lightly against the left side (near the contact end) of the armature, is used on some 206 and 239 type relays. The purpose of this spring is to hold the armature,

when unoperated, against the back contact screw. When the biasing spring is not used, the normal position of the armature may be against either the front or back contact screws, or floating between the contacts. In order to effect a longer and better contact closure, certain codes of these relays are equipped with a chatterless armature, that is, an armature which, instead of being solid at its contact end, is provided with two flexible contact springs bearing against each other at the tip. The 209, 215 and 255 type relays have no soldering terminals, their windings and contacts being connected to a terminal block which is fastened to the base plate of the relay. The terminals of the terminal block fit into corresponding terminal springs of the connecting block which is fastened to the relay mounting plate. This arrangement permits easy removal and replacement of the relay for inspection and adjustment.

The magnetic material used for the pole pieces, pole piece adjusting screws and armature on the above described relays is either magnetic iron or permalloy. Relays of the 209 and 239 type use permalloy only, whereas the other types use either magnetic iron, permalloy or both. Code letter designations beginning with FA indicate that the magnetic parts are made of permalloy. Changes in armature air gap or pole gaps (which also change the strength of the polarizing flux), armature travel, contact separation, and biasing spring tension are the means used in conjunction with the electrical values for adjusting these relays.

The 218-B relay (see Figure 21) is of an earlier design and does not use the Wheatstone Bridge type of magnetic circuit. A bar shaped permanent magnet, attached to the non-magnetic sub-base of the relay furnishes the polarizing flux. One end of this magnet is in contact with the U shaped frame supporting the two operating windings, while the other end is in contact with the iron supporting block for the armature reed. In its normal position, the reed is standing approximately midway between the poles of the two magnet cores. Since the iron supporting block is in magnetic contact with one end of the permanent magnet, the polarity

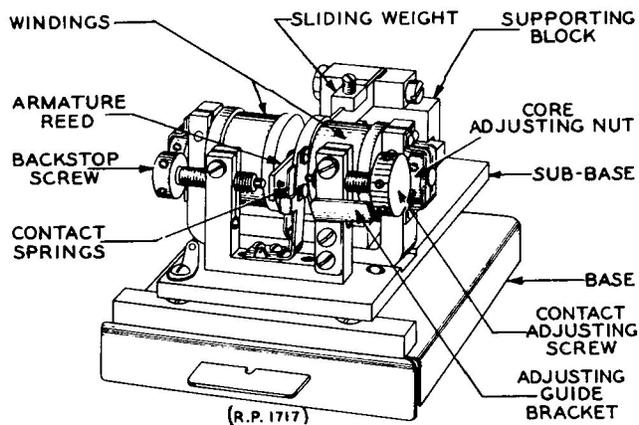


FIG. 21 218-B RELAY

of the free end of the armature reed is opposite to that of the ends of the two cores which are attached to the other end of the permanent magnet. This means that with a current passing through the windings, the operating flux will aid the polarizing flux in one of the adjacent core ends and decrease or reverse the flux in the other so that the armature reed will be attracted toward one core or the other, depending upon the direction of the current. Alternating current of a frequency of 135 cycles is used for operating these relays.

The contact spring of this relay is short and flexible, and rests against a micrometer adjusting screw with a large graduated head on which each graduation corresponds to a movement of approximately .0005". By means of this screw a normal contact separation of .0015" is obtained. Since this relay is designed to operate on .00025 amp. A.C. at 135 cycles, additional refinements are provided, such as adjustable cores, micrometer movement of the back stop screw, and a small sliding weight on the armature reed for tuning the reed as near as possible to the frequency of the operating current. A relay which is connected in series with the contacts operates when the reed starts vibrating, but does not follow the impulses because a condenser bridged across the winding holds the relay operated by its discharge at the times when the contacts are opened.

218-B relays are equipped with sponge rubber pads to prevent jarring. Plug type terminals are also used on these relays to facilitate the transfer between operating and test circuits.

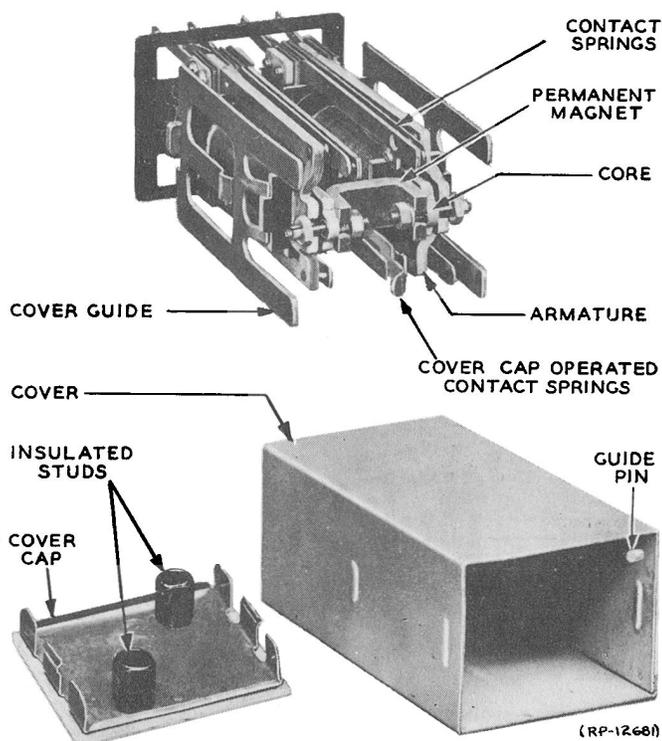


FIG. 22 266 TYPE RELAY

The 226 type relay shown in Figure 22 is primarily intended for use in panel two party message register circuits. The relay consists essentially of two permalloy R type relay structures held in combination at the rear with a permalloy bracket and in front with a remalloy permanent magnet. The assembly is enclosed in a removable dustproof metal cover with a removable cap. The cover cap is equipped with two insulated studs for closing a pair of contacts when the cover cap is in place. When the cover cap is removed for inspection or adjustment of the relay, the contacts will open. Two insulated studs instead of one are provided to insure closure of the cover cap operated contact springs regardless of the position of the cover or cover cap. One lip of the cap is partly cut away to clear the guide pin attached to the inside of the cover near the front edge. This pin is to prevent possible substitution of a cover cap without insulated studs which would not close the register circuit.

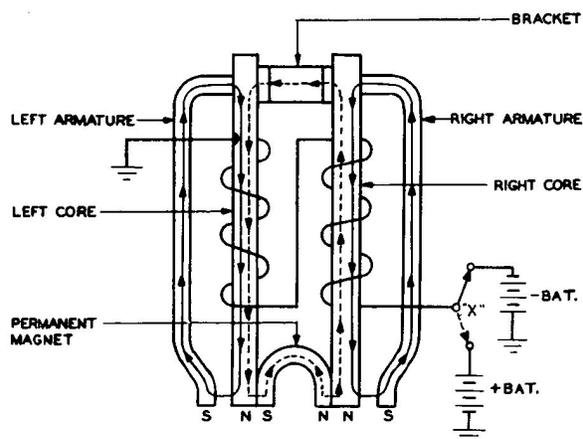


FIG. 23 FLUX DIAGRAM OF 266 TYPE RELAY

The operating principle of the relay is as follows. The magnetic flux produced by the permanent magnet, as indicated by the dotted arrowed lines in Figure 23, passes through a closed magnetic circuit and saturates the two cores. Since the path of the flux is closed, that is without air gaps, the small leakage flux at the armature air gaps is insufficient to operate either armature.

When negative battery is applied at point "X" in Figure 23, a flux is set up by the windings which will be in the same direction in the two cores, as indicated by the solid lines in Figure 23. This flux will be in the same direction as the flux from the permanent magnet in the left core and in the opposite direction in the right core. Since the cores are already magnetically saturated, no appreciable increase in flux will occur in the left core where the fluxes are in the same direction. The armature on the left will, therefore, not operate. The flux produced by the winding

in the core will, however, oppose the flux from the permanent magnet, thereby causing sufficient flux to be forced across the armature gap to operate the right armature.

When positive battery is connected to point "X" in Figure 23, the flux set up by the windings is in the opposite direction to the flux set up by negative battery. In this case, the flux set up by the windings will cause the left armature to operate and the right armature to remain unoperated.

The requirements and adjusting procedures for 266 type relays are similar to those specified for flat type relays.

### 207, 208, 213, L, N and S Type Relays (Pulsing Relays)

The 207 and 213 type relays, also known as "stepper" relays, are of the telegraph type and differ only in the provision of a dust-proof cover on the 213 type. See Figure 24. The two electromagnets are connected in series aiding so that, when energized, the end of one magnet core becomes a north pole and that of the other a south pole. A retractile spring, attached to the center of the pivoted armature, is used for

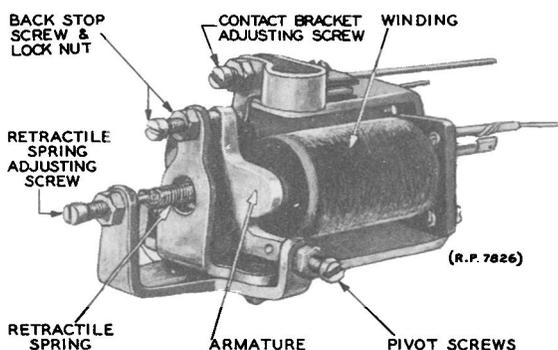


FIG. 24 207 TYPE RELAY

restoring the armature to its normal or unoperated position. The movement of the armature is controlled by means of a back stop screw and a contact bracket adjusting screw. An operated armature air gap is used to minimize the effects of residual magnetism. This gap is obtained by adjusting the relay to a specified unoperated armature air gap and a specified contact separation. A connector wire joining the armature and the base of the relay eliminates contact trouble which otherwise might result from dirty pivots.

The 208 type relay (see Figure 25), used as counting relay in dial sender circuits and in other circuits requiring a fast operating and releasing relay, is equipped with a short, light pivoted armature which, on account of its small inertia, permits the relay to more easily follow rapid pulses of current. As on the 207 type relay, a retractile spring holds the armature in its unoperated position; while front and back contact lugs are used to

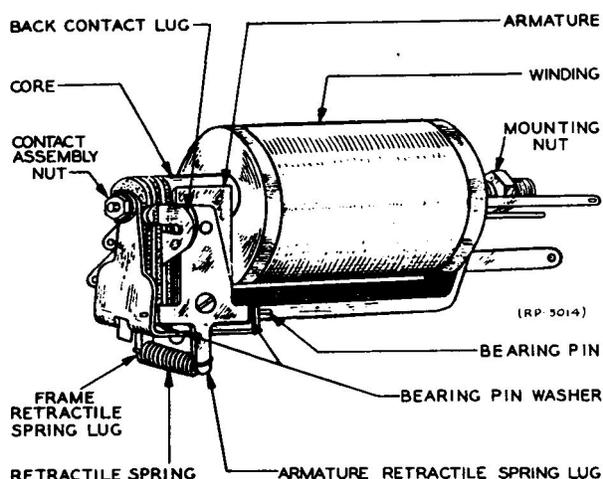


FIG. 25 208 TYPE RELAY

regulate the travel of the armature. Fast operation and quick release are insured by the use of a light weight armature, a small armature travel and the establishment of an operated armature air gap.

The L, N and S type relays are pulsing relays of the flat punched type. These three types are practically identical in design, except that the N and S types are provided with a removable crosstalk-proof cover and cap and that a laminated core is used on the N type. The magnetic circuit of these relays is similar to that of the 208 type, a return pole piece and a short armature being used. The armature is equipped with either a chatterless contact spring (a light flexible spring), which normally rests against a contact spring support, or a solid contact spring. A flexible contact spring insures contact follow and consequently a better and longer contact closure, whereas a solid contact spring is used when speed of operation is the predominating factor. A flat phosphor bronze spring is used as a retractile spring. The tension of this spring is regulated by means of a finely threaded screw in the retractile spring bracket. The base gap acts in the same

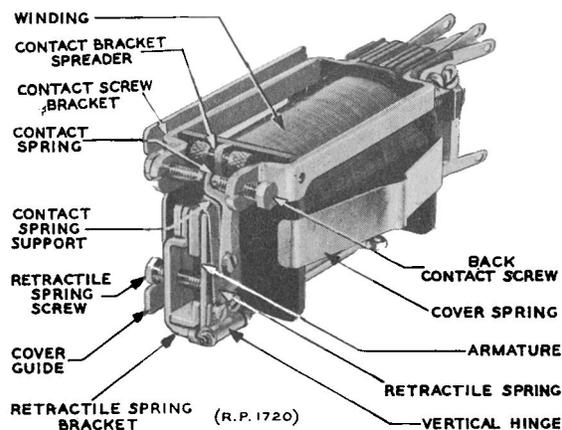


FIG. 26 "S" TYPE RELAY

manner as the operated armature air gap on stepping or counting relays, but is not dependent upon armature travel and contact separation. Contact screw brackets equipped with contact screws are used for the front and back contacts. The brackets bear against contact bracket spreaders instead of the spool head to avoid changes in adjustment caused by a slight contraction or expansion of the spool head with changes in atmosphere. Figure 26 shows an S type relay with the cover removed.

221, 222, 223, 224, 225, 247, 248, 251 and 252 Type Relays (Step-by-Step Relays)

These relays are known as step-by-step relays because they are largely associated with step-by-step equipment. The coil of these relays is wound on a round core which is fastened to the heelpiece by means of a fillister head screw. The armature is short and is attached to the forward end of the heelpiece by the armature yoke. A phosphor bronze pin secured to the armature and turning in holes in the armature yoke, forms a bearing which will not bind, will wear very slowly and is practically without side play. The armature yoke is attached to the heelpiece by means of a single armature yoke set screw, permitting an easy adjustment of the heelpiece air gap. A small brass screw passing through the armature at a point directly opposite the center of the core is used to regulate the operated armature air gap to prevent the armature from sticking to the core due to residual magnetism. This screw is known as the "Residual Screw". See Figure 27.

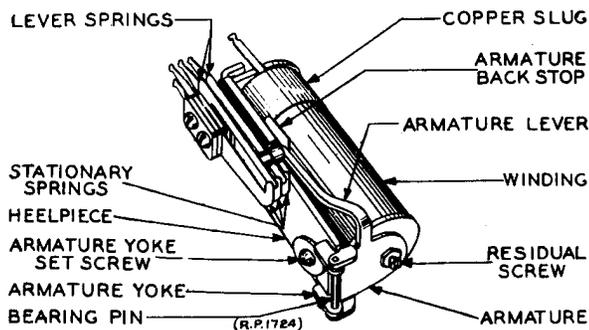


FIG. 27 221 TYPE RELAY

For operating the contact springs, the armature is equipped with either one or two armature levers, or arms, ending in a hard rubber armature stud. The contact springs are mounted at the back end of the heelpiece, with the contacts in front, except on 225 type relays where the contact springs are mounted in front and the contacts are facing the rear. To facilitate the adjustment, the relays are arranged for either left or right-hand mounting, with the contact springs in a vertical position on the side of the relay. The exception

of this method of mounting is the 225 type relay, which mounts directly on the casting of 197 or 198 type switches, with the contact springs on top in a horizontal position. Relays arranged for mounting on the left-hand side of the mounting plate include the 221, 223, 247 and 251 types, while the others, that is, the 222, 224, 248 and 252 types, mount on the right-hand side. Other outstanding differences in construction between the various types are given in the following paragraphs.

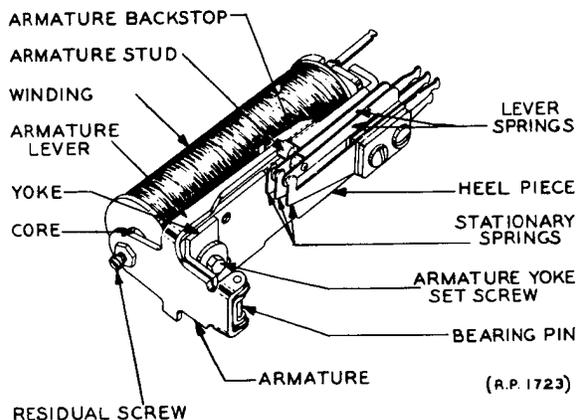


FIG. 28 248 TYPE RELAY

As previously mentioned, either one or two armature levers or arms are used for operating the contact springs. The two lever arrangement is used only on the 223 and 224 types and allows as many as 34 springs to be placed on one relay. The position of the bearing pin with respect to the rest of the armature determines the ratio of the travel of the springs (measured at the contacts) to the travel of the armature (measured at the residual screw). The ratio is approximately 2-1/4 : 1 on the relays, except on the 247 and 248 types which have a ratio of approximately 1 : 1. See Figure 28. These two types are slow releasing relays with a copper sleeve or slug over the core and use the 1 : 1 ratio lever arm to obtain greater release time capabilities than is possible with a 2-1/4 : 1 ratio arm. A copper slug or head over part of the core at either the front or rear, or a copper sleeve over the full length of the core is also used on 221, 222, 223 and 224 type relays to obtain a slow releasing or slow operating effect. A detailed explanation of these features is given under the heading of "Slow Acting Relays".

The 225 type relay is provided with a short coil, its length being about 1/2 of that used on the other relays. Since the armature lever ratio is 2-1/4 : 1, the contact springs are mounted on the front end of the heelpiece and the contacts are facing the rear.

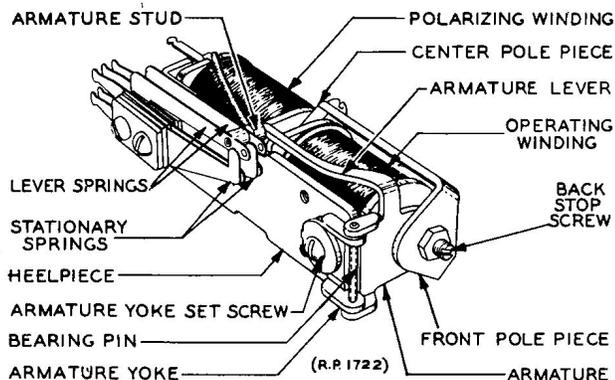


FIG. 29 251 TYPE RELAY

The 251 and 252 type relays are 3 pole electro-polarized relays. See Figure 29. These relays are equipped with two separate windings, a front winding for operating the relay and a rear winding for furnishing the polarizing flux. The latter is permanently connected across the full central office voltage supply. An iron front pole piece with two arms connects with another pole piece attached to the center of the core between the two windings. The operation of this relay is briefly as follows:

In its normal unoperated position, the armature is resting against the iron back stop screw on the front pole piece. It is held in this position by the polarizing flux instead of being attracted to the core, because the polarizing flux is splitting two ways -- (1) through the core, armature air gap, armature and heelpiece and (2) through the center pole piece, arms of front pole piece, iron back stop screw, armature and heelpiece. Since the reluctance of the second path is considerably less than that of the first path, due to the absence of an air gap, the major portion of the polarizing flux will flow through the second path and therefore hold the armature in that position.

When the operating winding is energized in the same direction as the polarizing flux, the armature will be attracted to the core, aided by the polarizing flux through the core, provided the operating flux is sufficient to overcome the effect of the polarizing flux through the front pole piece and the tension of the operating springs. At the instant the armature starts moving, that is breaking magnetic contact with the back stop screw, the relative strength of the polarizing flux through the two paths is changing, finally becoming the reverse from that with the armature in the unoperated position.

When the operating current is applied in the reverse direction, the armature will not move from its unoperated position, unless the applied operating current is increased sufficiently to overcome entirely the effect of the polarizing flux through both paths.

In general, step-by-step relays are adjusted to meet certain heelpiece air gap, residual and back stop requirements, followed by an adjustment of the contact springs to meet contact follow, contact separation, sequence and electrical requirements.

#### 114 and 198 Type Relays (Trip Relays)

These relays are tubular in shape because a round iron shell is used as the return pole piece. The armature is mounted between pivot screws and is held in the unoperated position by means of either a flat or coiled retractile spring. The two types of relays are similar in shape, except that the 198 type is longer and has two windings. See Figure 30.

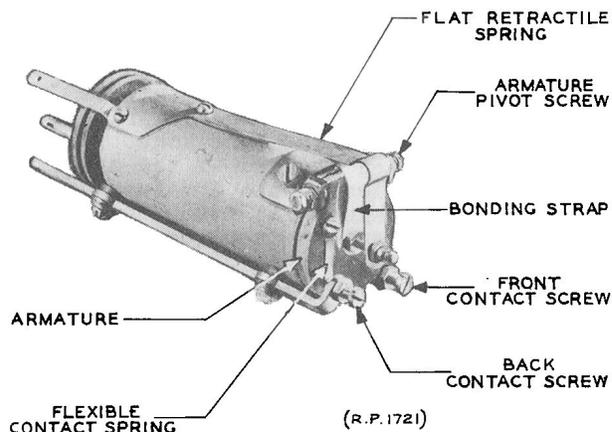


FIG. 30 114 TYPE RELAY

Most of these relays are used as trip relays in incoming trunk circuits to trip or cut off the ringing current when the called subscriber lifts the receiver off the telephone. Relays used as trip relays have a copper sleeve over the core and use a flexible contact spring. A bonding strap insures a good electrical connection between the armature and core which form a part of the local circuit to be closed by the contacts of the relay. The effect of the copper sleeve is to lower the impedance of the operating winding. This is due to the fact that when alternating current (ringing current) passes through the winding, the copper sleeve acts as a short circuited secondary winding of a transformer, setting up an opposing flux which decreases the main flux and, therefore, the inductive reactance in the winding. The tubular iron shell used as the return pole piece provides an excellent magnetic return path and, in addition, prevents magnetic interference with adjacent apparatus.

On some codes of 114 trip relays, developed in connection with 1500W subscriber's loops, such as the 114KA relay, a copper head is used in addition to the copper sleeve to further reduce the impedance of the relay. An enlarged pole face is also used on these codes to reduce the magnetic reluctance so that the relay will operate on less current. Figure 31 shows a cross-section of this relay.

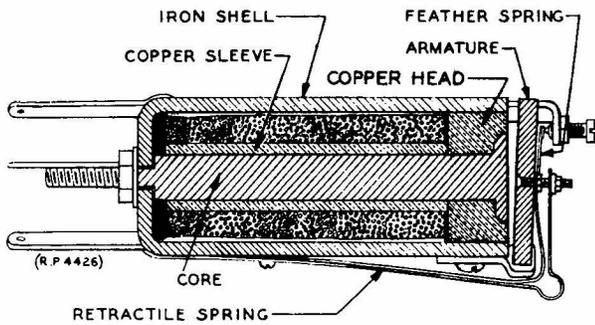


FIG. 31 CROSS-SECTION OF TRIP RELAY

A relay operating on alternating current and under close marginal conditions (which is the case with a trip relay) will necessarily have a tendency to operate only at the peak of the wave, especially if the operating point is dependent upon the tension of the retractile spring. In order to insure longer operation and also to stabilize the operation so that the relay will not respond to the non-operate current, it is desirable to use some means to make the relay depend more upon effective current values than upon instantaneous values. The flexible contact spring used on these relays allows a reduction in retractile spring tension by preventing contact separation until the armature has moved a considerable portion of its travel, and the low retractile spring tension in turn allows the inertia of the heavy armature to maintain a stabilizing effect upon the point and time of operation of the relay.

Trip relays are adjusted by setting the contact screws so that certain operated and unoperated armature air gaps and contact separations are obtained, and then changing the tension of the retractile spring to meet the operate and non-operate requirements.

#### 229, 230, 232, 263 and 264 Type Relays (Multi-Contact Relays)

Multi-contact relays, as the name implies, are relays capable of operating a large number of contact springs. The 229, 230 and 232 types are essentially gang relays, similar to a number of individual relays on a mounting plate, but operated by

a common electromagnet. Briefly, they consist of a mounting plate with a large number of spring assemblies operated by means of a draw bar attached to an electromagnet. The armature moves on a bearing pin attached to the magnet frame and is equipped with an armature arm, which is at right angles to the armature and operates the draw bar. The leverage of the armature arm is such that when operating, the draw bar moves about twice as far as the armature. The magnet is of the efficient, short, thick spool type and is partially enclosed with a soft iron frame, which acts as the return path for the flux. See Figures 32 and 33.

The 229 type relay is a single unit relay, while the 230 and 232 types are double unit relays having two magnets, each of which operates its own draw bar and contacts. The 230 and 232 type relays differ mainly in number and type of spring combinations and the addition of a condenser and resistance between the two units of the 232 type. The resistance and condenser provide protection for the contacts of the relays which operate the magnets. The 229 and 230 types are intended for use on panel dial decoder frames while the 232 type is used in the master relay circuit for regulating repeaters. The present relays handle from 16 to 52 contacts.

The 263 and 264 type relays are multi-contact relays primarily intended for use in the crossbar dial system. Each of these relays consists essentially of a frame equipped with ten groups of contact springs, two magnets and two armatures. Half of the contact groups can be operated by energizing one of the magnets, or the entire ten groups can be operated by energizing both magnets. Each armature controls from 15 to 30 pairs of contacts and by operating the two halves in parallel, a maximum of 60 simultaneous connections can be made. See Figure 34.

The contact springs on these relays are mounted between long strips of insulating material, forming one single large pileup instead of individual pileups used on other relays. At the front, the stationary contact springs are securely held in place in another pileup of insulating strips. Twin contacts are used and the operating springs are bifurcated to insure contact reliability. The advantages to be gained from this contact arrangement are the same as those given for U and Y type

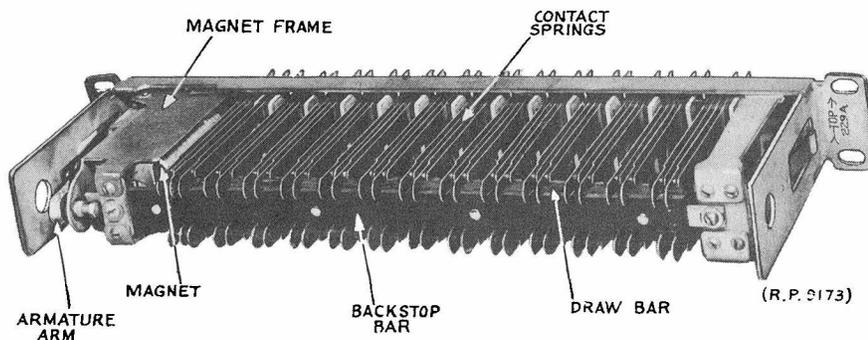


FIG. 32 229 TYPE RELAY

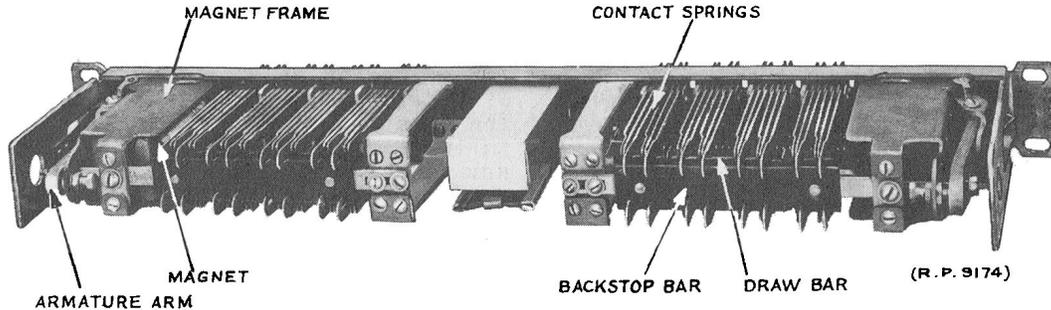


FIG. 33 232 TYPE RELAY

relays. The operating springs are actuated by pressure of the armature against insulating studs which are fastened in the springs and pass through holes in the stationary springs. The armatures are of the knife edge type and are held in place by three retaining springs. Since the armature is in direct contact with the heel-piece, a low reluctance magnetic circuit is assured. To prevent sticking, the armature is faced with a thin piece of nickel silver attached by spot welding.

263 and 264 type relays mount vertically, with the spring pileup of one relay nesting between the magnets of the adjacent relay. The two types differ only in the arrangement of the contact terminals. On the 263 type, the terminals of all stationary contact springs and the terminal of one operating spring in each group are arranged for individual wiring. The terminals of all other operating springs are arranged for horizontal strapping. On 264 type relays, the terminals of all the contact springs are arranged for individual wiring, none of these terminals having the special arrangement for horizontal strapping.

The adjustable features of multi-contact relays include changes in armature travel, spring tension, contact separation and contact make.

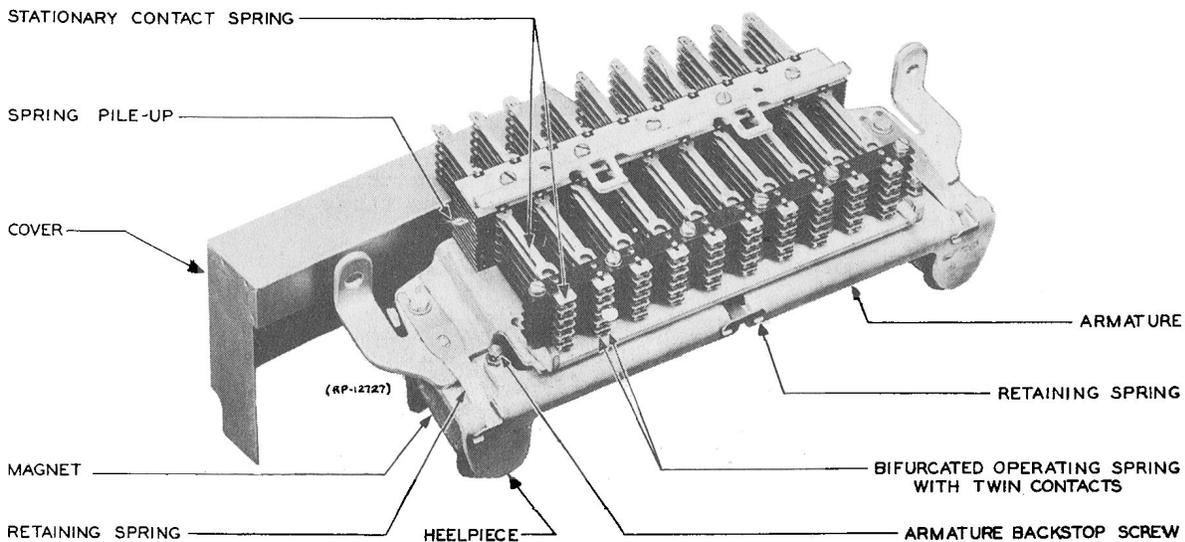


FIG. 34 263 TYPE RELAY

122, 125, 149, 162 and 178 Type Relays (Barrel or Round Type Relays)

These relays are of an earlier design and are generally known as "Barrel" or "Round" type relays because of their round or barrel shaped covers. The above types

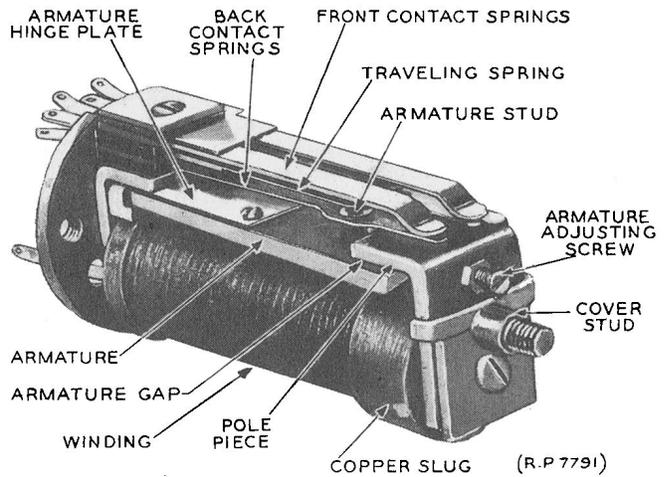


FIG. 35 178 TYPE RELAY

are almost identical in construction except for changes in contact arrangement, and in the provision or non-provision of a copper head or sleeve over the core for a slow

operating or slow releasing effect. The purpose of a copper head or sleeve is explained in the section covering slow acting relays. See Figure 35.

Barrel type relays are still used to some extent as general switching relays on additions to existing installations and where a slow acting or slow releasing effect is necessary. The armature is at the side and is hinged to the rear bent over pole piece by means of a steel hinge plate. The front bent over pole piece is equipped with an adjusting screw for adjusting the armature travel. From one to three sets of spring combinations, clamped to the rear pole piece and resting on the front pole piece, are operated by hard rubber studs, attached to the armature. Stop pins, or non-freezing discs, welded to the armature are used on a number of relays of this type which do not have a slow release requirement. The purpose of these stop pins is to establish an operated armature air gap which prevents the relay armature from sticking to the core due to residual magnetism, thereby insuring a quick release.

Individual dustproof covers of either brass or iron are used on practically all of these relays. An iron cover (crosstalk proof) is used whenever it becomes necessary to shield the relay against stray flux from adjacent relays. The principle of shielding against stray flux is explained in the section covering B and G type relays. Changes in armature travel, stud gap, contact follow, and tension of the contact springs are the means used for adjusting these relays to meet their electrical requirements.

#### 196 Type Relays

The relay shown in Figure 36 is known as the 196 type. It is equipped with a U shaped laminated square core and uses multiple wound (filled) coils. The armature is very light and is attached to a return pole piece by means of a thin steel reed. An adjusting screw, which presses against the lower free end of the steel reed, regulates the tension of the armature against the back contact screw. The armature and back contact screw assembly is supported by two armature supporting

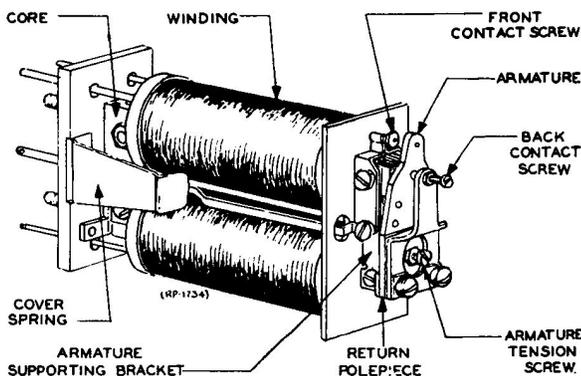
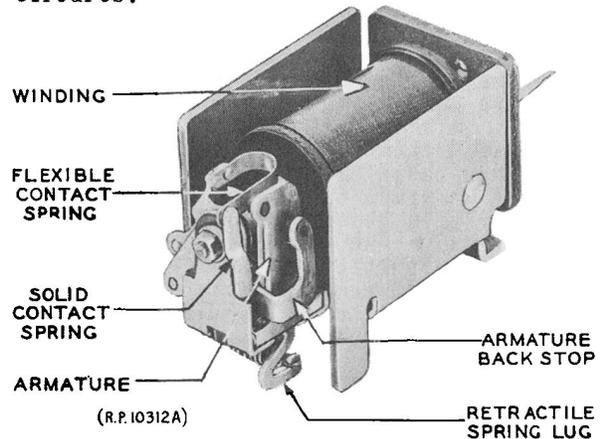


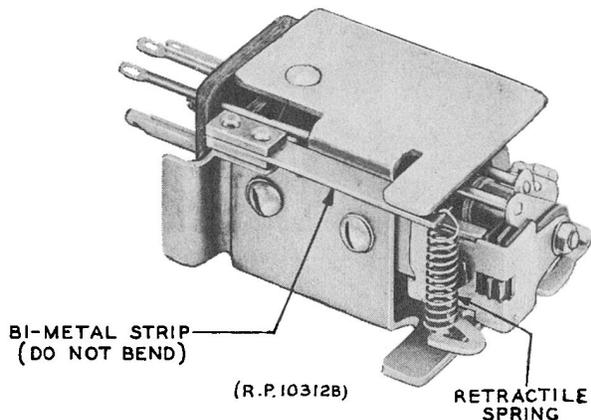
FIG. 36 196 TYPE RELAY

brackets secured to the upper and lower cores. The relay is also provided with a front contact or stop screw, attached to the armature supporting bracket but not in contact with it.

The operate and release current flow requirements and the resistance requirements in artificial line networks are met by an adjustment of the armature tension screw and the back and front contact or stop screws. Relays of the 196 type are high impedance relays. They are used mainly as ringing relays in high impedance toll cord circuits.



-FRONT VIEW-



-BOTTOM VIEW-

FIG. 37 253 TYPE RELAY

#### 253 Type Relays

The 253 type relay shown in Figure 37 is used with small batteries for PBX and community dial office power plants to control the charging rate and to switch counter EMF cells in and out of the circuit in order to maintain the battery voltage at the desired limits. In appearance it is similar to the 208 type used as a counting relay in dial sender circuits. The operating characteristics, however, are quite different. The 253 type is compensated for change in resistance of the winding and changes in voltage of the batteries due to variations in room temperature.

The temperature compensation is obtained by a bi-metallic strip attached to the underside of the relay, as shown in the bottom view of Figure 37, which changes the tension of the retractile spring. As the temperature rises, the bi-metallic strip flexes to lessen the spring tension, thus causing the relay to operate on a lower voltage. As the temperature drops, the reverse action takes place.

Since the voltage of a battery decreases as the temperature rises, the fully charged voltage will vary with changes in room temperature. This variation in battery condition is compensated for by using a 253 type relay in a suitable circuit and mounting it in close proximity to the battery so that it is subjected to the same temperature condition.

The adjustment of 253 type relays is on a voltage basis and requires that consideration be given to temperature conditions. For this reason it is important that the relay be kept energized as continuously as possible and that the cover be removed only for adjustment purposes. Adjustment for electrical requirements is made by changing the tension of the retractile spring and adjusting the resistance in series with the relay.

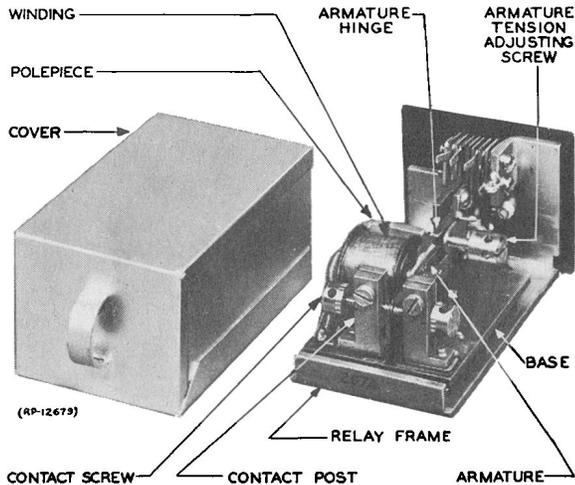


FIG. 38 267 TYPE RELAY

### 267 Type Relays

The 267 type relay shown in Figure 38 is a high speed neutral relay, primarily intended for use in echo suppressor circuits where the 209 type relay was previously employed. The armature assembly on this relay consists of a small piece of permalloy attached to a contact arm and a thin phosphor bronze armature hinge. The round permalloy core is of very small diameter and is equipped with a form wound coil. A permalloy return pole piece to which the core is attached completes the magnetic circuit. The relay is equipped with micrometer type contact screws and contact posts similar to those used on the 209 type relay, to facilitate adjustment for contact travel and operated air gap. The required tension

on the armature for meeting electrical requirements is obtained by means of an armature tension adjusting screw. The relay structure proper is mounted on a sub-base which is fastened to the relay frame.

For testing purposes, the winding and armature terminals project through the terminal block toward the front of the relay. A metal cover with grooves that engage with the sides of the relay frame affords protection against dust. Sensitivity and high speed are obtained by using a permalloy magnetic circuit with small air gaps and a reduction of the mass of moving parts to a minimum.

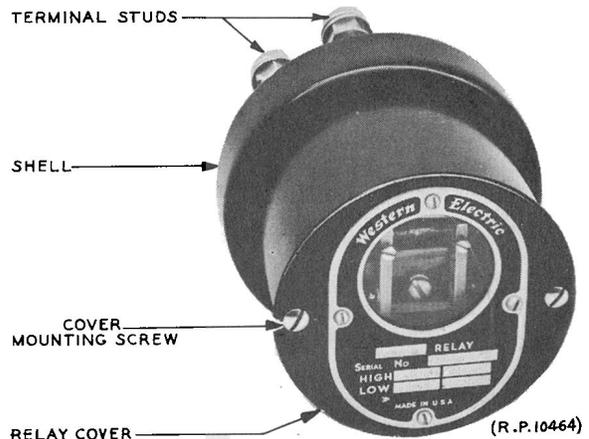


FIG. 39 260 TYPE RELAY

### 260 Type Relays (Voltmeter Relays)

The type of relay illustrated in Figures 39 and 40 is known as the 260 type. In its essential form it is a voltmeter of the permanent magnet-moving coil type equipped with a contact arm which moves between two stationary contacts. The contacting arrangement is visible through a glass window in the cover of the shell.

While the principle of operation is the same as that of the conventional permanent magnet-moving coil type of meter, the layout of the parts does not follow the usual arrangement. Instead of a large horseshoe magnet with soft iron pole pieces

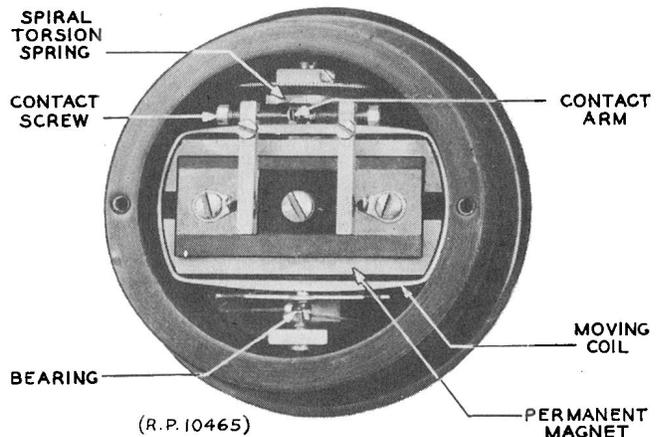


FIG. 40 260 TYPE RELAY - COVER REMOVED

surrounding the moving coil, the permanent magnet of the 260 type relay consists of two rectangular bars of "Remalloy" (an alloy with high coercive force) placed inside the moving coil. Surrounding the coil and in close proximity to it is the heavy round steel shell which forms the return path for the flux and also serves as a magnetic shield. The moving coil is otherwise of the conventional type with jeweled bearings and torsion springs. Connection to the winding and contacts is by means of terminal studs which project through the base of the relay. Two of these studs are also used for mounting purposes. 260 type relays are made for single and double voltage ranges and for differential purposes.

### Sensitrol Relays (Weston Model 705)

The sensitrol relay (see Figure 41) is essentially a direct-current meter of the permanent magnet-moving coil type equipped with one or two stationary contacts. The stationary contact is a small powerful permanent magnet attached to the end of a supporting arm. The mating contact consists of a silver plated iron "rider" mounted on the pointer or contact arm. When the operating torque set up by the current passing through the moving coil moves the iron "rider" of the pointer into the magnetic field of the stationary contact, the iron rider is drawn firmly against the stationary contact, thus closing the contacts. This arrangement insures good contact and prevents chattering. The contacts remain closed until they are reset either manually, or electrically by means of a solenoid mounted on the back of the relay.

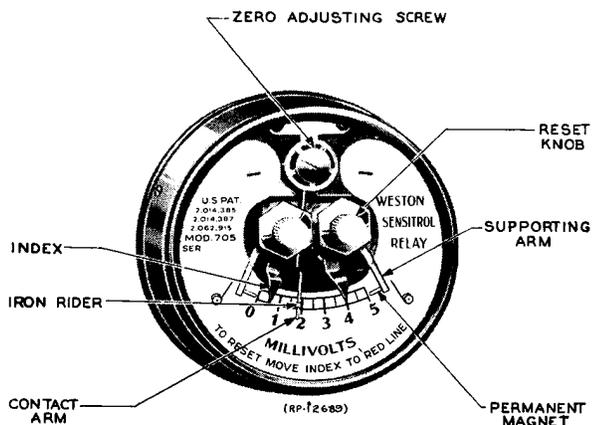


FIG. 41 SENSITROL RELAY

Figure 41 shows a sensitrol relay with two stationary contacts and arranged for manual reset. On this relay, each stationary contact and associated index are fastened to a common arm which is moved to the desired operating point by means of a knob on the front of the case. This knob is also used to disengage the pointer and reset the relay. On sensitrol relays equipped with a solenoid, the stationary contacts are usually fixed and the adjustable index when turned changes the position of the control

spring similar to the action of a zero corrector. Adjustment of sensitrol relays in the field is usually restricted to changes in the zero adjuster screw setting.

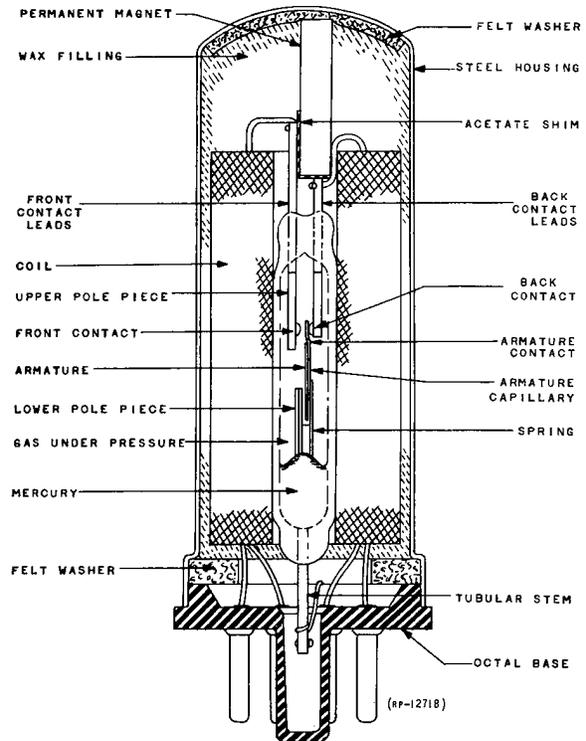


FIG. 42 CROSS-SECTION OF 276 TYPE RELAY

### 275 and 276 Type Relays (Mercury Contact Relays)

The 275 and 276 type relays are recent developments and are known as mercury contact relays. Each relay consists of a 218A mercury switch surrounded by a solenoidal coil and assembled in a metal vacuum tube shell equipped with an octal vacuum tube base. In addition, the 276 type relay is provided with a small permanent magnet for biasing the armature. A cross-sectional view of a 276 type relay is shown in Figure 42.

The 218A mercury contact switch consists essentially of an armature and two sets of contacts enclosed in a glass tube filled with hydrogen gas under pressure. The armature is a small piece of permalloy attached to a supporting spring and equipped with a contact arm. The armature is pretensioned so that it normally rests against the contacts of the back contact supports which are made of non-magnetic material. The front contacts are attached to the upper pole pieces which together with the front contact leads and the lower pole piece, all made of magnetic material, complete the magnetic circuit within the switch. On the bottom of the glass tube is a small amount of mercury which by capillary action over the armature capillary keeps the contacts coated with mercury.

Although not indicated in Figure 42 the 218A switch is equipped with two front and two back contacts brought out individually. The mating contacts on the armature, however, are on a common arm which connects with the single terminal at the bottom of the tubular stem.

When the coil of a 275 type relay is energized, the magnetic flux set up by the coil will cause the armature to be attracted by the upper pole pieces, thus closing the front contacts. The same action takes place on the 276 type relay, except that the flux from the biasing magnet, adjusted to the required value at the time of manufacture, will permit the relay to operate or release within close limits.

Mercury contact relays of the 275 and 276 types are noted for stability of adjustment, high speed operation with contact closure free from chatter, low contact resistance and relatively high current carrying capacity of the contacts. These relays mount vertically in an octal vacuum tube socket and are non-adjustable.

L1 Carrier Telephone Line Switching Relays  
per D-159188 and D-159189

The D-159188 and D-159189 relays are used in the L1 (coaxial) carrier telephone system for switching, under manual or automatic control, from a working line to a standby line in case of failure of the former. Each relay consists of a coil wound on a tubular brass core inside of which is mounted a glass vacuum tube containing a switch. The ends of the core extend outward from each end of the coil and are equipped with a brass sleeve for attaching

the coaxial cable to the relay structure. Figure 43 shows four of these relays mounted on a line switching relay panel.

In the D-159188 neutral relay which has a normally open contact, the vacuum switch contains two iron reeds which extend from the ends of the glass tube inward toward the center and overlap by an amount sufficient to make contact. When the coil is energized, the free ends of the two reeds are attracted toward each other and make contact.

In the D-159189 polarized relay, the flux from a permanent magnet associated with the relay holds the two iron reeds in contact with each other. When the coil is energized so that the flux produced by the coil is in the opposite direction and equal to the flux from the permanent magnet, the two reeds will separate, thus opening the contacts.

Slow Acting Relays

Slow acting relays, that is, relays which are slow operating, slow releasing, or both, are used in circuit design for various purposes. The principal purposes are to obtain a desired sequence of operation between several relays which are energized or de-energized simultaneously, to secure a definite time interval between the functioning of different parts of a circuit, to secure an automatic momentary circuit, or to prevent momentary disturbances in the relay circuit from affecting the circuit of which the contacts of the relay form a part. A relay is usually made slow acting by one of three methods or by a combination of these methods. The

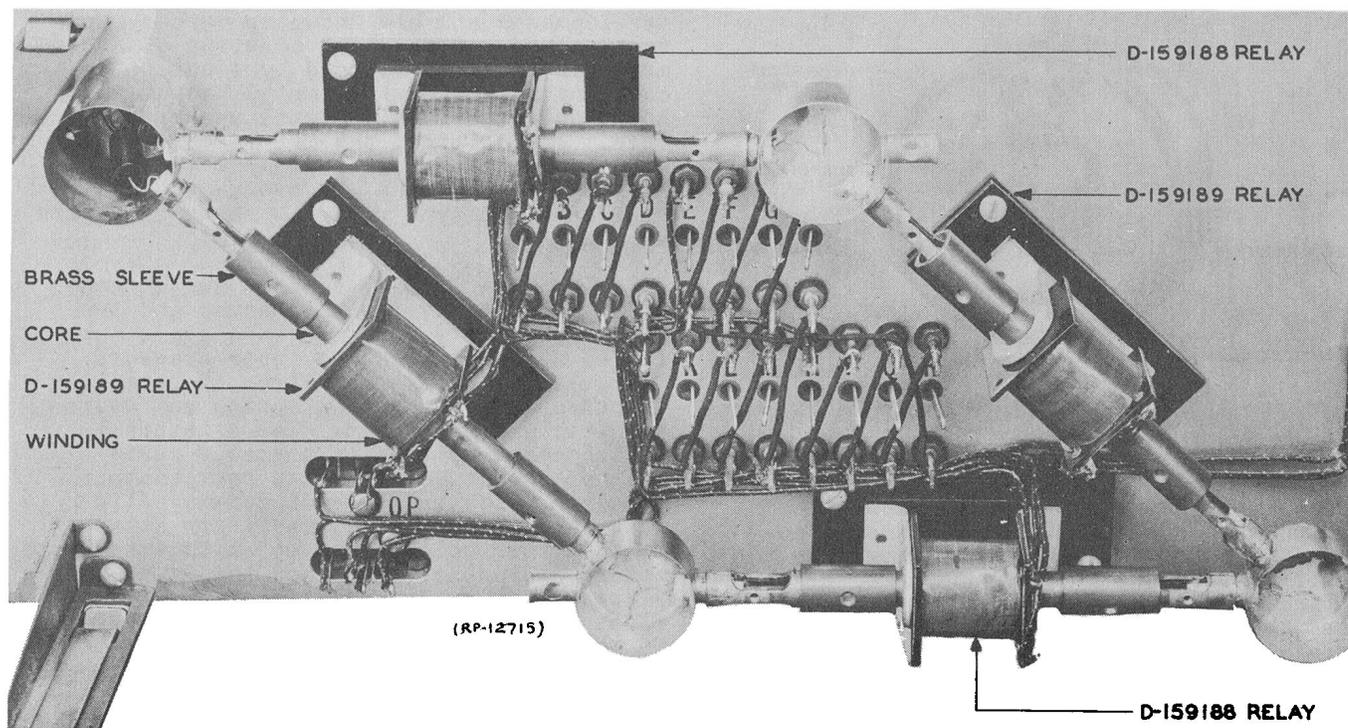


FIG. 43 D-159188 AND D-159189 RELAYS ON LINE SWITCHING RELAY PANEL

first method is produced electrically by the design of the electrical circuit; the second method is produced magnetically by the design of the relay winding and the third method is produced mechanically by the design of the relay armature. A brief description of each of these methods is given in the following paragraphs.

The first method is to design or arrange the circuit so that the current through the winding of the relay will build up or die out more slowly than if no means were taken to affect this time. This is usually accomplished by placing an impedance in series with the relay or by shunting the relay with a non-inductive resistance or by a combination of both. Placing an impedance in series with the relay slows down the time of operation of the relay, but does not affect the time of the release. Shunting the relay with a non-inductive resistance, on the other hand, slows down the time of release but has little effect on the time of operation. Slow operation and slow release may be obtained by a combination of the two. The use of an impedance in series with the relay or a non-inductive resistance in parallel with the relay prolongs the time between the closing or opening of the circuit through the winding and movement of the armature. No appreciable effect, however, is produced on the actual speed of movement of the armature. Placing the non-inductive resistance in series with the relay and impedance in parallel with the relay produce the opposite effect, namely, fast operation and fast release. This latter must be taken into account when relays are operated in parallel since if a relay is in parallel with a relay of higher impedance than itself, it will release more quickly when the circuit is broken.

This method of making a relay slow acting is used very little at the present time. It is necessary to consider its effect, however, in circuit design, as relays are often shunted by non-inductive resistances for the purpose of providing a path around the inductive winding for the passage of alternating or talking currents. Non-inductive resistances are also frequently placed in parallel with a relay to prevent arcing at the contacts through which the relay is operated. The supervisory relays in cord and trunk circuits, which have a non-inductive winding in parallel with the relay winding in order to permit the passage of the voice currents, are an example of the former condition.

The second method is to design the windings of the relay so that any change in the current of the circuit will produce a greater time interval between the change in the strength of the field or flux in the core than would occur under normal conditions. This is accomplished by the use of an additional short-circuited winding. This winding may be either a regular winding or a single turn of a very low resistance, the latter being the more

effective. This single turn takes the form of either a heavy copper head at one end of the core or a copper sleeve over the full length of the core. With this method, as with the first method, no appreciable effect is produced on the actual speed of movement of the armature. This type of construction is used on 149, 162, 178, step-by-step, F, T and Y type relays.

At the instant the circuit through the winding of these relays is closed, a momentary current is set up in the secondary short-circuited winding by mutual induction. The induced current lasts only as long as the current through the primary or operating winding is increasing, that is, until it has reached its full or steady value. The direction of this induced current is, however, such as to set up a secondary flux which opposes any change in the existing primary or operating flux. This retards the building up of the operating flux or, which is the same, makes the relay slow acting. For a maximum retarding effect the operating ampere turn requirements should be such that the relay receives just enough current to operate, because in this case the resultant flux does not become strong enough to move the armature, when the circuit is closed, until the effect of the short circuited secondary has been overcome and the flux has reached its full value. The relay will, accordingly, be slow in operation. A relay under such conditions can be made to release comparatively quickly by choosing a design that has a high release requirement, which is accomplished by means of high stop pins or non-freezing discs, in proportion to the operating requirement.

When the circuit through the relay winding is opened, an action opposite to that described above takes place; that is, the armature does not release immediately because the current induced in the secondary winding, at the instant the circuit is broken, sets up a flux which is in the same direction as the operating flux, and therefore tends to hold the armature operated. To secure slow releasing, the winding and operating requirements must be so chosen that the final value of the flux produced by the current the relay receives in the circuit is much greater than the releasing requirement. This is accomplished by choosing a relay having a high flux density and a magnetic circuit of low reluctance. The copper sleeve to obtain a slow releasing effect is used in some cases for making a relay less responsive to alternating current. This is particularly true in the case of trip relays of the 114 and 198 types.

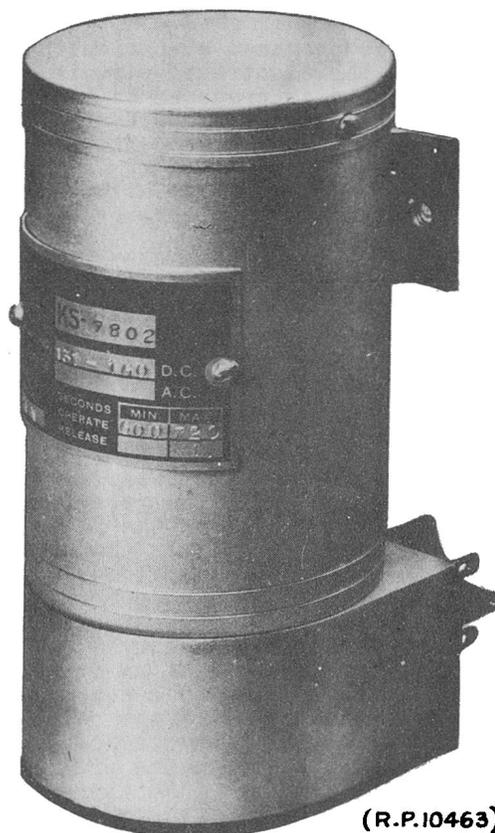
The above considerations apply to relays having a copper sleeve over the full length of the core or a copper head at the armature end. The copper head may, however, be located at the heel piece end of the core, away from the armature. This type of construction is used on some step-by-step

relays to obtain a relatively fast operating, yet slow releasing relay and may be explained as follows: At the time of circuit closure, the main flux can leak across the gap between the core and yoke until the retarding effect of the copper head has died down; in addition the reduced electrical inductance allows a faster growth of current in the relay. When the circuit is opened, the coil impedance plays no part, because the current drops to zero immediately. The secondary flux produced by the copper head, however, tends to hold the armature operated, producing the desired slow releasing effect.

The third method is to design the moving parts or armature of the relays so that their inertia makes them slow in responding to changes in the magnetizing force. On the 114 and 198 type relays, the inertia is produced by means of a heavy armature. To make the relays slow in operating, the magnetizing force must be great enough to pull up the armature, and for slow release the restoring force, must be as small as will give satisfactory action. This condition may be met by a suitable mechanical design. With this construction, the actual movement of the armature is retarded. Such a design is used for relays to be operated by alternating current, as the inertia of the moving parts prevents the opening of the contacts when the alternating current passes through zero.

Two or more of the methods outlined above may be used on the same relay, the first and second being the most common combination. It will be seen, therefore, that a relay is not generally intrinsically slow operating or slow releasing, but that these features are determined by a combination of the design of the relay itself and of the circuit in which it is used.

On the F and T type relays, in addition to winding a few layers of bare copper wire over the core, a slow releasing effect is obtained by magnetic bridge pieces. Magnetic bridge pieces are provided across each hinge gap in order to reduce the reluctance of the magnetic path which is necessary for obtaining a maximum slow releasing effect of the short circuited copper winding. For the same reason the armature is loosely mounted on pins instead of being riveted to a thin, soft iron hinge plate as on other flat type relays. This permits the armature to align itself with the magnetic bridge pieces when the relay is energized. To regulate the time of release, an adjustable stop pin is provided on the F type relay by means of which the operated armature air gap can be increased or decreased, thereby causing, respectively a faster or slower release. A nickel finish is used because it has better wearing qualities and is thinner than a galvanized finish. A thin finish is a further aid in reducing the reluctance of the magnetic circuit.



(R.P.10463)

FIG. 44 KS-7802 RELAY (ADLAKE)

Similar provisions have been made on Y type relays to obtain the desired slow releasing effect. A loosely pivoted armature suspension is also used on this relay together with a hinge bracket which takes the place of the magnetic hinge pieces on F and T type relays. Since the time of release is largely dependent upon the reluctance of the magnetic circuit, embossed surfaces at the armature pole face and the armature pivot points have been provided on Y type relays to insure uniformity of slow releasing characteristics between relays.

Where time delays of relatively large duration are required, slow acting relays of the KS-7800 series ("Adlake" relays) and the KS-13542 and KS-13543 (Edison thermal) relays are used. An external view of an "Adlake" relay is shown in Figure 44.

The operating mechanism, (see Figure 45), is completely sealed in a glass tube. This tube which is surrounded by the winding contains a hollow cylindrical iron plunger floating on mercury. The tube also contains two electrodes, one of which is always in contact with the mercury and the other insulated from the mercury. A small cup of insulating material which contains mercury is mounted at the top of the insulated electrode thus providing the mercury contact.

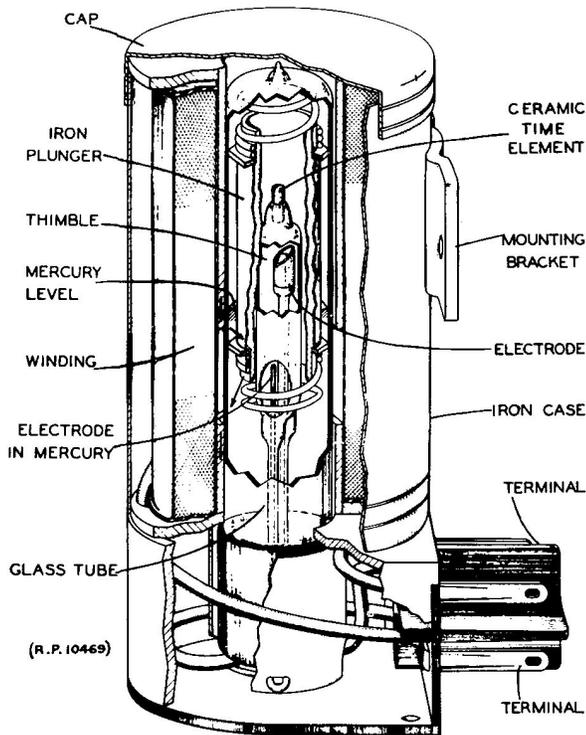


FIG. 45 SECTIONAL VIEW OF KS-7802 RELAY

The relay with the normally open contacts functions in the following manner. The plunger, when the winding is energized, is pulled down into the mercury thereby causing an immediate displacement of the latter. The rising mercury column traps the inert gas which is in the glass thimble surrounding the electrodes. A further rise of the mercury to a level sufficient to make contact with the mercury in the insulated cup depends upon the time required for the gas to flow through minute pores of a piece of ceramic fused in the top of the thimble. When the winding is de-energized the iron plunger immediately restores to normal thereby causing the mercury to assume its normal level. The recession of the mercury opens the contacts and permits the gas pressure inside and outside of the thimble to become again equalized.

The relay with the normally closed contact functions similarly to the relay with the normally open contact as described above, except that the iron plunger is pulled upwards instead of downwards when the winding is energized. This causes the mercury level outside of the thimble to drop. The mercury inside of the thimble then recedes under control of the gas passing through the ceramic plug and eventually opens the contact. When the winding is de-energized the plunger returns to normal which in turn causes the mercury to assume its original level.

Relays of the KS-7800 series are not adjustable, as the required time delay is determined at the time of manufacture by the selection of the proper ceramic time element. They are made to delay the opening, or closing, or both of a single normally open or normally closed contact from 3/10 second to 12 minutes or more. While the majority of the relays are equipped with windings suitable for operation on direct current, some of the relays operate on alternating current or on both.

The KS-13542 and KS-13543 relays are thermal relays, enclosed in a glass vacuum tube equipped with an octal vacuum tube base. Both relays are identical in appearance but have different timing intervals. The KS-13542 is arranged to operate on minimum 13 - maximum 32 seconds at an applied voltage of 45 to 50 volts, whereas the KS-13543 relay has a time delay range of minimum 2 - maximum 5 seconds on the same voltage limits. Figure 46 shows a KS-13542 thermal relay.

The mechanism of this relay consists essentially of two bimetallic strips attached to a ceramic support at one end and carrying a contact at the other. A heater winding is wound around one of the bimetallic strips. Attached to the free end of this strip is a short arm with an adjusting screw and a flexible contact spring.

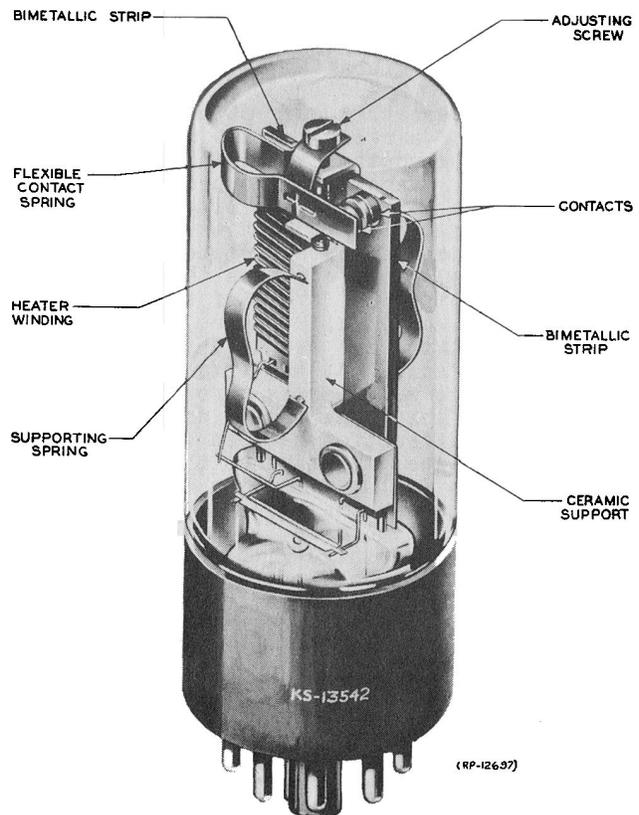


FIG. 46 KS-13542 THERMAL RELAY

adjusting screw regulates the contact spacing which is adjusted at the time of manufacture to the value required for obtaining the desired operating time. Two E shaped springs attached to the ceramic support hold the relay structure in position inside the glass vacuum tube.

When current is applied to the heater winding, the bimetallic strip associated with the heater winding is deflected and causes the contact on the flexible spring to make contact with the stationary contact on the other bimetallic strip. As the bimetallic strip with the heater winding moves further the flexible contact leaves its support, thus avoiding overstressing the bimetallic strips. The use of similar bimetallic strips for both contacts provides compensation for changes in room temperature. As the latter changes, both strips are affected in the same manner and by the same amount. Thus the spacing between the contacts which determines the timing is unaffected. The KS-13542 and KS-13543 relays are non-adjustable and may be mounted in any position.

#### Alternating Current Relays

Although a number of relays previously described, for example, the trip relays, and polarized relays of the 209 and 218 types, are operated on alternating current, they are not considered alternating current relays because the armature vibrates (chatters) or follows the impulses of the alternating current through the operating winding. The reason for this vibrating is as follows:

When alternating current passes through the winding of a relay, a flux is set up in the magnetic circuit, the direction of which is constantly changing in accordance with the reversals of the alternating current. The direction of the flux, however, does not affect the attraction between the armature and core, since during either the positive or negative half cycle of the alternating current wave, unlike poles (which attract each other) are set up in the core and armature ends. At the time the alternating current wave passes through zero, however, no flux is generated and consequently, no attraction between armature and core takes place. This means that the armature tends to fall away during that part of the cycle in which the attraction is less than the restoring force. Consequently, the contacts associated with the armature do not remain operated but alternately open and close. The methods employed to overcome this condition on the 186 and J type relays, known as alternating current relays, are described in the following paragraphs.

#### 186 Type Relays

Satisfactory operation of this relay on alternating current is based on mechanical means. For this reason, the relay is equipped with a light armature, pivoted in the side of the U shaped relay frame which forms the return path for the magnetic circuit. The armature is shaped so that its movement is similar to a circular body on offset

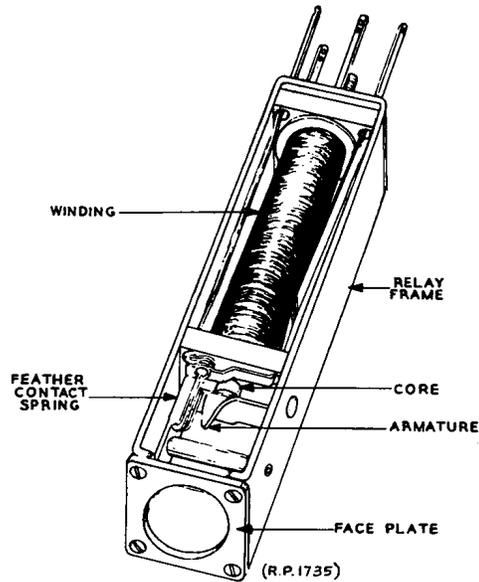


FIG. 47 186 TYPE RELAY

centers, resulting in a long swing. The armature engages with a pair of very light feather contact springs before coming to rest on the underside of the core. Although light in weight, the armature does not vibrate sufficiently to open the contacts, because its restoring force, due to its light weight and the use of feather contact springs, is small. See Figure 47.

#### J Type Relays

As previously explained, the alternating current in passing through the winding of the relay creates in the armature a tendency to follow the impulses of the current; that is, operate on the positive and negative peaks and release on the zero points of the wave. To obtain continuous operation it is, therefore, necessary to prevent the armature from releasing at the zero points of the wave. On J type relays this is accomplished by setting up an additional flux which is out of phase with the main flux and is of sufficient strength to hold the armature operated.

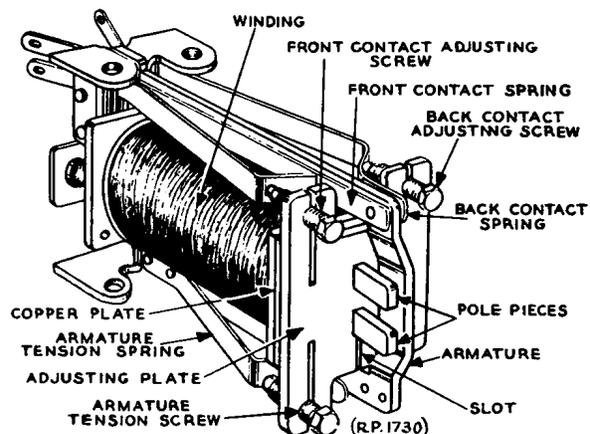


FIG. 48 J TYPE RELAY

For this purpose, the J type relay, which is similar in construction to the B type, is provided with a forked pole piece and a nickel plated copper adjusting plate. Another copper plate, also nickel plated and of the same size as the front spoolhead, is riveted to the rear of the adjusting plate. Figure 48 shows a J type relay with the cover and cover spring removed. It will be noted that the two copper plates entirely surround the upper leg of the forked pole piece, but are slotted just below the lower leg. The object of these copper pieces is to act as a short circuited winding of a single turn over the upper leg, in a local magnetic circuit consisting of the upper leg, armature, lower leg and core. When the winding of a J type relay is energized, a secondary flux is set up by the short circuited winding which is out of phase with the main flux (see Figure 49). Although small, this flux is sufficient to prevent the armature from releasing at the zero points of the alternating current wave.

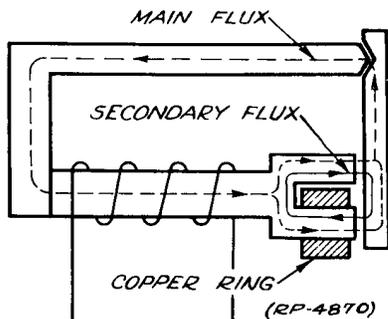


FIG. 49 FLUX DIAGRAM OF J TYPE RELAY

A weighted contact spring is used on some J type relays and when so equipped, the relay is called a "Pendulum" J type relay. See Figure 50. The purpose of this weighted contact spring is to prevent the

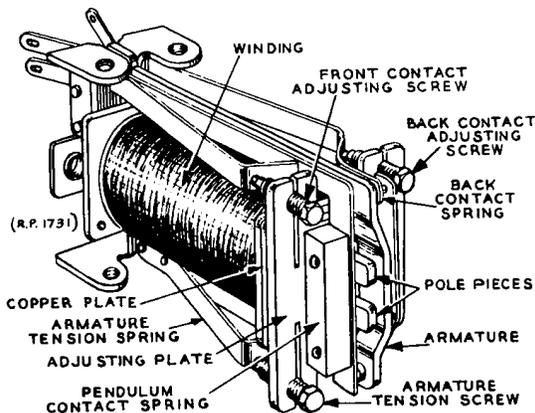


FIG. 50 PENDULUM J TYPE RELAY

relay from operating on momentary surges of current. The pendulum contact spring vibrates for a brief period of time before making continuous contact with the contact on the armature. This delay in contact closure is sufficient to prevent a lock-up of the relay on momentary surges of current on its locking winding which is in series with the pendulum contact.

J type relays are equipped with a removable dustproof cover and cover cap. The cover spring, attached to the bottom of the relay structure and supporting the cover, is similar to a shell, partly surrounding the relay. This arrangement is intended to prevent possible changes in the alignment of core and armature when the cover is removed, because correct alignment of these parts is essential for satisfactory operation.

The J type relays are adjusted by means of the adjusting screws in the adjusting plate, the two upper screws being used to regulate the position of the front and back contact springs or stop springs, while the lower screw is used to regulate the armature tension.

#### QUESTIONS

1. What is the purpose of the stop pins on an armature?
2. Why is a heavy iron cover used on "G" type relays?
3. What is meant by the "swaged core" of a flat type relay? What is its advantage?
4. Why is a laminated core used on some relays?
5. What is the purpose of a copper head at the armature end of a relay core?
6. What is the object of polarizing a relay? How is this accomplished?
7. What type of relay is used as a counting relay? Why is this relay particularly adapted for this purpose?
8. What is the purpose of twin contacts?

QUESTIONS

9. Why are J type relays equipped with a copper adjusting plate?
10. What is the difference between E and R type relays?
11. Why does an ordinary relay chatter on alternating current?
12. Explain briefly the operation of the 251 type relay.
13. What is the purpose of the weight on the armature of a 218-B relay?
14. Explain briefly the action of the magnetic circuit of a 206 type relay?
15. What are the principal differences in construction between U and UA type relays?
16. Explain briefly the operation of the 266 type relay.
17. Describe the construction of the 276 type relay.
18. What types of relays are used for obtaining time delays of relatively large duration?

INDEX OF RELAYS DESCRIBED IN THIS SECTION

<u>Type of Relay</u>	<u>Page No.</u>	<u>Fig. No.</u>	<u>Type of Relay</u>	<u>Page No.</u>	<u>Fig. No.</u>
114	16	30,31	260	20	39,40
122	18	-	263	17	34
125	18	-	264	17	-
149	18	-	266	10	22,23
162	18	-	267	20	38
178	18	35	275	21	-
186	26	47	276	21	42
196	19	36	A	6	5
198	16	-	AB	6	-
206	10	15,17,18	B	9	13
207	14	24	E	6	-
208	14	25	EA	6	6
209	10	16	F	6	9
213	14	-	G	9	14
215	10	-	H	6	7
218-B	10	21	J	26	48,49,50
221	15	27	L	14	-
222	15	-	N	14	-
223	15	-	R	6	8
224	15	-	S	14	26
225	15	-	T	6	-
229	17	32	U	7	10
230	17	-	UA	7	11
232	17	33	UB	7	12
239	10	19	Y	7	-
247	15	-	Sensitrol	21	41
248	15	28	D-159188	22	43
251	15	29	D-159189	22	43
252	15	-	KS-7800(Adlake)	24	44,45
253	19	37	KS-13542	25	46
255	10	20	KS-13543	25	-
			Slow Acting Relays	22	-

## SECTION 2

DROPS, SIGNALS, RINGERS AND BUZZERS

This section covers the common types of visual and audible signaling apparatus with the exception of switchboard lamps. These will be covered in another section. The signaling apparatus discussed herein consists of drops, signals, ringers and buzzers. This apparatus is very similar in theory and in construction to relays which were considered in the preceding section, and consequently will be covered very briefly in the paragraphs which follow.

DROPS

The usual function of a drop is to signal an operator by means of alternating current. The shutter (armature on 22 type) drops by gravity when released by the tripping latch as soon as the drop is energized. Drops are extensively used on magneto boards and P.B.X.'s, operating either on magneto current or ringing current.

22 Type Drops

This type of drop consists of two separate tubular type magnets, a line and a restoring magnet. When the line magnet operates, the tripping latch attached to the heavy armature of this magnet releases the armature of the restoring magnet. The latter falls against a light aluminum shutter and swings out from a vertical position to a 45° angle. See Figure 51.

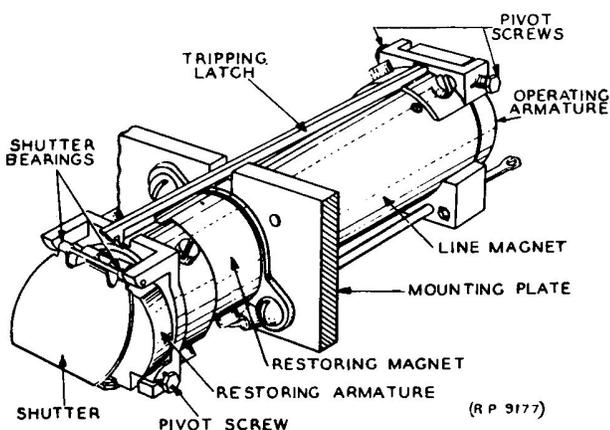


FIG. 51 22 TYPE DROP

When the restoring magnet is energized, the armature of this magnet operates, slips back under the hook of the tripping latch and restores the shutter to normal. The armature of the restoring magnet is drilled out in the center so as to accommodate the end of the core which projects into it. This feature reduces the reluctance of the magnetic circuit which otherwise would be very high because of the large unoperated armature air gap. The drop is also provided with contacts operated by the restoring magnet to give a night alarm signal.

35 And 56 Type Drops

These drops are also of the tubular type, a round iron shell being used as a return pole piece. At the front, attached to the mounting plate, is a heavy curved shutter mounted on a hinge pin so that it is slightly off balance and will drop from a vertical to a horizontal position when released by the tripping latch. A night alarm spring is pushed against a contact wire when the shutter falls, giving an additional signal if desired. The armature, mounted on pivot screws, is in the rear and operates the tripping latch.

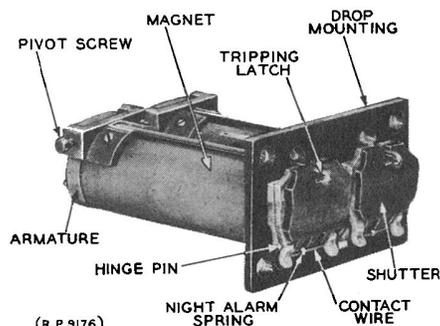


FIG. 52 35 TYPE DROP

The 35 and 56 type drops are practically identical in construction, except that the 35 type has two windings, while the 56 type has only one. Figure 52 shows two 35 type drops mounted on a drop mounting.

SIGNALS

Signals are used for signaling an operator or for marking a busy line. They operate on direct current only. Signals give an indication only while energized, whereas drops leave a permanent indication upon application of the operating current until restored to normal either electrically or manually.

34 And 41 Type Signals

These signals are familiarly known as "bull's eye" signals due to the fact that an aluminum signal ball 7/8" in diameter is visible in the window when the armature is operated. See Figure 53. The armature and signal ball are pivoted at the front end of the magnet core, the armature being heavier than the signal ball to keep it raised up out of sight when the armature is unoperated. The armature has a curved triangular shaped "tail" or extension which extends near enough to the core to be attracted when the coil is energized. The curvature of the "tail" of the armature is such that the armature air gap becomes less and less as the armature

proper swings toward the core, so that a magnetic balance is not obtained until a stop on the armature strikes the core. The two types of signals are almost alike in construction except in winding and contact arrangement and the use of a cross-talk proof shell on the 41 type.

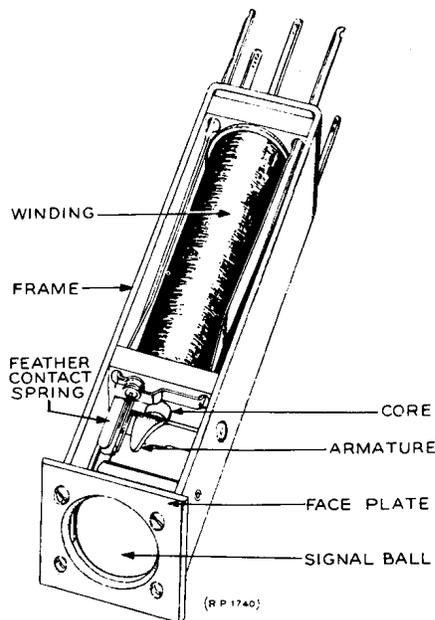


FIG. 53 34 TYPE SIGNAL

#### 42 Type Signals

These signals are used as busy signals to mark a busy line on toll boards and are multiplied to every section of the board where this line appears. Since all the signals remain operated during the entire duration of the call, four of them are connected in series to cut down the current flow. As shown in Figure 54 there is an "L" shaped pole piece at each end of the core and the armature acts as the magnetic bridge between them. The shutter is merely an extension of the armature which is pulled up in front of the window when the signal operates.

This type of signal is uneconomical from a current consumption standpoint and its use on new installations has been discontinued in favor of 6 volt lamps lighted by AC current. The current for the lamps is secured from transformers connected to the lighting mains, while that used for the signals is drawn from the office storage battery.

#### RINGERS

A considerable number of polarized ringers have been coded, but in general they may be classified as biased and unbiased. All of these ringers consist essentially of two electro-magnets wound in series and mounted on a strip of soft iron. The armature is pivoted beneath the magnets with a slight air gap between the ends and the respective magnet cores.

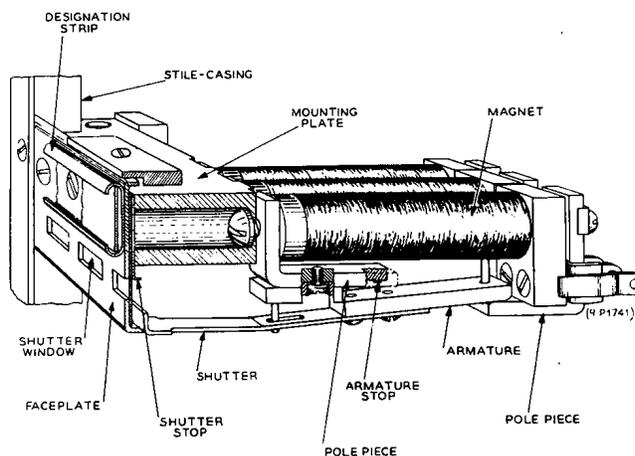


FIG. 54 42 TYPE SIGNAL

A permanent magnet is attached to the soft iron strip above the electro-magnets and extends to a point underneath the armature. This permanent magnet by induction gives the cores of the electro-magnet a normal south polarity, and the ends of the armature a north polarity. The center of the armature, therefore, is a south pole. The diagram shown in Figure 55 illustrates the polarizing action of the permanent magnet.

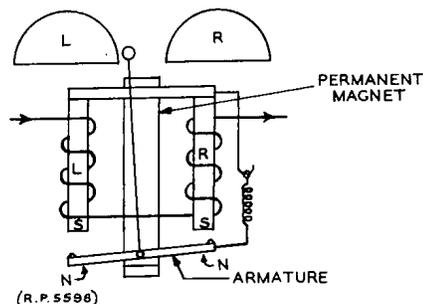


FIG. 55 DIAGRAM ILLUSTRATING ACTION OF A RINGER

#### Unbiased Ringers

Unbiased ringers are intended for use on alternating current only. When alternating current passes thru the magnets, the magnetism set up by the permanent magnet is strengthened in one coil and diminished or overcome in the other on the first half cycle. The armature now tilts toward the core having the strongest magnetism and the clapper ball strikes one gong. As the current is reversed on the next half cycle, the other coil has the greater attraction and the clapper ball strikes the other gong. See Figure 56 which shows an unbiased ringer of the 51 type.

#### Biased Ringers

The biased ringer is used in all cases where superimposed current (direct current superimposed on alternating current) is used for ringing. The biased ringer is constructed like the unbiased ringer except that it is equipped with a biasing spring to hold one end of the armature against the

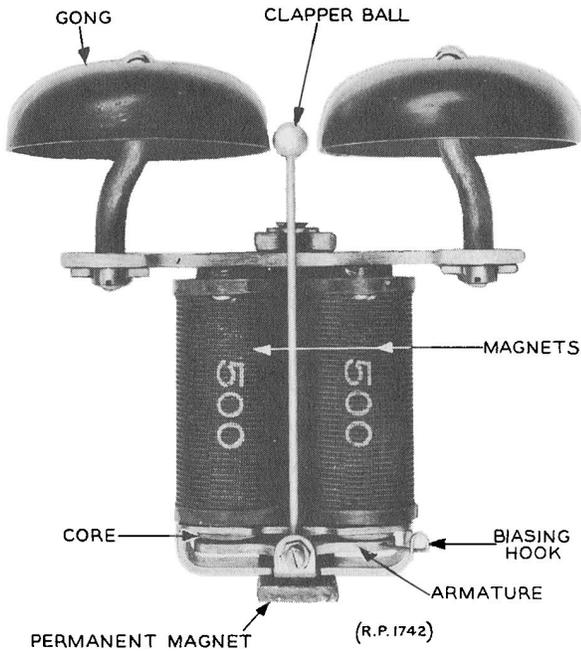


FIG. 56 UNBIASED RINGER

respective magnet core. See Figure 57. A pulse of the proper polarity will overcome the pull of the spring and pull the armature against the other core, ringing first one gong and then the other as the armature is released and returned to the biased side. Pulses of the opposite polarity would, of course, have no effect on the ringer. This makes it possible to ring either of two ringers on one wire by choosing the polarity of pulses to be sent out or any one of four parties when two ringers are rung from either side of the line as in the case of the four party full selective system.

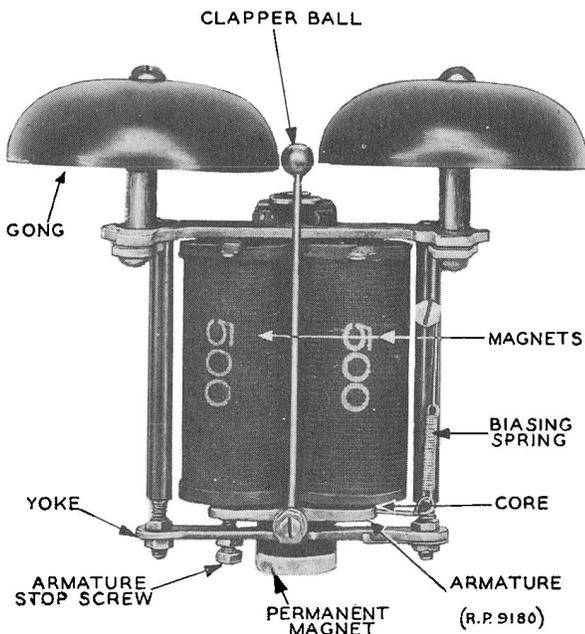


FIG. 57 BIASED RINGER

A biased ringer of a more recent design, coded B1A, is shown in Figure 58. The permanent magnet of this ringer is U shaped and the conventional retractile spring has been replaced by a cantilever type biasing spring arranged for 3 different tension settings. The gongs on this ringer are mounted vertically and are provided with excentrically located mounting holes for obtaining the necessary clearance between the gong and the clapper ball. B1A ringers are principally used in telephone set mountings and in telephone sets.

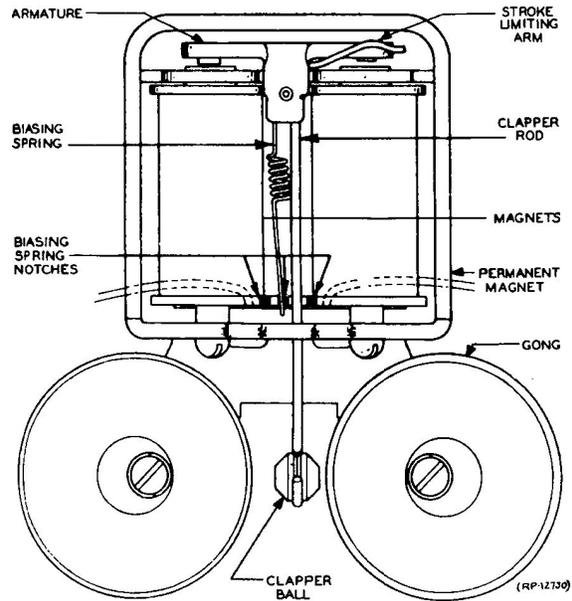


FIG. 58 B1A RINGER

BUZZERS

Buzzers are not used to a very great extent in telephone central offices, although several different types have been standardized. These will be discussed very briefly in the paragraphs which follow. Alternating current buzzers are designed to follow the polarity reverses. In a direct current buzzer, the current passes thru a contact which is broken just before the armature hits the core, allowing the armature to fall back and complete the circuit again.

4 Type Buzzer

This type of buzzer is mostly used on small private branch exchange switchboards. It is shown in Figure 59. Some of these buzzers are designed for operation on 16 2/3 or 20 cycle alternating current and 24 volt DC current, while others operate on AC current only. The electro-magnet is of the thick spool type, and the armature itself acts as the return pole piece for the magnetic flux. A notch is cut across the underside of the armature near one end, to serve as a bearing point for a knife edge.

The armature retractile spring, attached back of the fulcrum, has as a tension regulator a movable slide. When the buzzer is to operate on direct current, a contact spring is provided to break and make the circuit. On alternating current, the armature returns to normal at the zero point on each half wave, the armature air gap being easily adjustable to facilitate the quick operate and release features required.

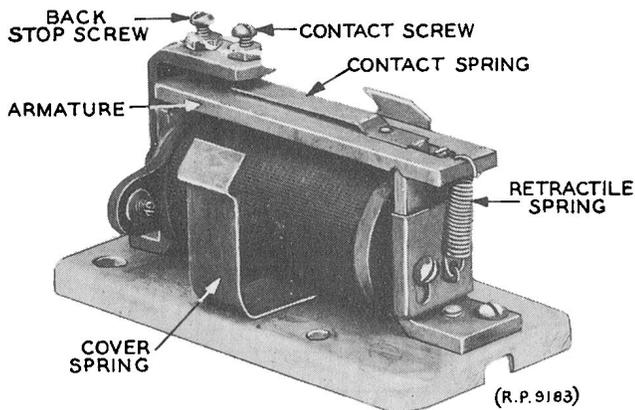


FIG. 59 4 TYPE BUZZER

#### 7 Type Buzzer

This is a general purpose buzzer and its design is similar to that of the ordinary commercial buzzer. It is arranged for either direct current, or 50-60 cycle alternating operation. When operated on alternating current, connections are made directly to the winding. On direct current, the buzzer operates on self-interruption over its back contact in series with the winding.

The buzzer is equipped with heavy platinum contacts and uses a reed mounted armature with a flat armature tension spring. The tension of the latter is regulated by an adjustable armature tension spring stop which bears against the free end of the tension spring. Figure 60 shows a 7 type buzzer with the cover removed.

#### 12092 And 12093 Type Buzzers

These are "one stroke" buzzers used in the flash and recall circuits. While these buzzers operate on DC current, they have no contact springs and hence depend

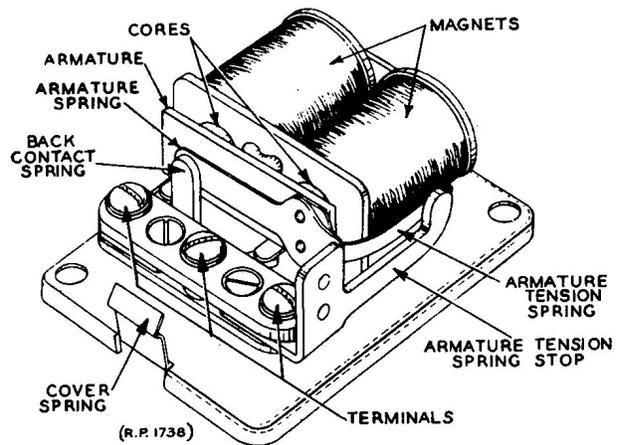


FIG. 60 7 TYPE BUZZER

on other apparatus to break the circuit and release the armature. Due to this fact they operate exceedingly slow in comparison with other types of buzzers. Like nearly all of the other buzzers, these types have two magnet coils acting directly on the armature. The 12092 and 12093 buzzers are used interchangeably, the major difference between them being the type of armature retractile spring used. The 12092 uses a flat spring and the 12093, a coil spring. See Figure 61.

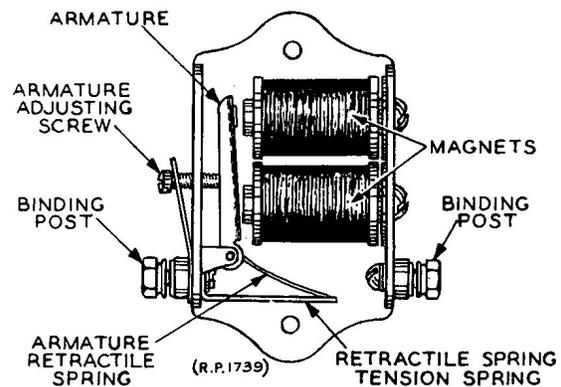


FIG. 61 12092 TYPE BUZZER

#### QUESTIONS

1. What type of apparatus is used to signal the operator on magneto boards?
2. What type of drop is self-restoring?
3. What kind of current is required to operate a signal?
4. What type of signal is used as a busy signal?
5. What is a biased ringer?
6. What kind of current is used to operate 7 type buzzers?

## SECTION 3

REPEATING COILS, INDUCTION COILS, INPUT TRANSFORMERS,  
OUTPUT TRANSFORMERS AND RETARDATION COILSREPEATING COILS AND INDUCTION COILS

Repeating coils and induction coils are terms used to designate certain types of telephone transformers. A telephone transformer is generally called a repeating coil when it has a low ratio of transformation, and is not used in connection with vacuum tubes, where the terms input transformer and output transformer are used. An induction coil is the special name given to certain types of repeating coils which generally are associated with telephone sets and use either the straight core or shell type of construction.

According to their mechanical construction, repeating coils may be of the toroidal, shell, or straight core type.

The core of a toroidal type of repeating coil consists generally of a ring of silicon steel laminations, or pressed permalloy dust rings. The windings are uniformly applied to this circular core by means of a special winding machine in which a circular shuttle threading through the center of the core is used to hold the wire which is wound on the core by means of a motor driven annular part of the machine. After the finished coil has been impregnated to make it moisture-proof, which is usually effected under vacuum after a baking period, it is sealed or potted with rosin into a pressed steel cup of a cast or sheet iron case. This cover makes the coil crosstalk proof and provides a protection against mechanical injuries.

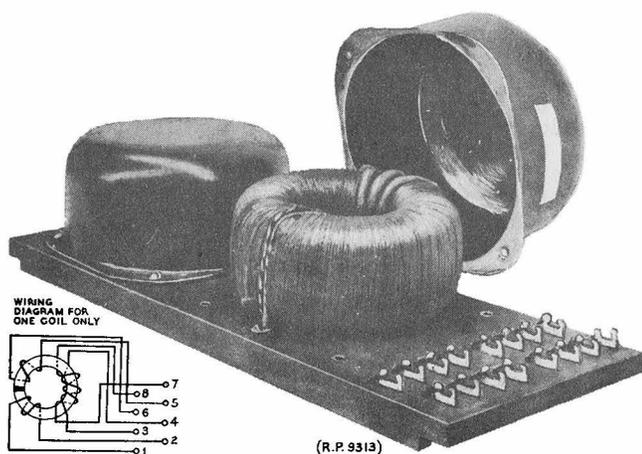


FIG. 62 75 TYPE REPEATING COIL

When the steel cup is used, the coil is generally mounted on a wooden base which is slotted on the underside so that the lead-in wires may be placed in these slots and connected to terminal clips on the end of the board. Repeating coils of the 75 and 77 types are examples of this type of construction. Figure 62 shows a 75 type

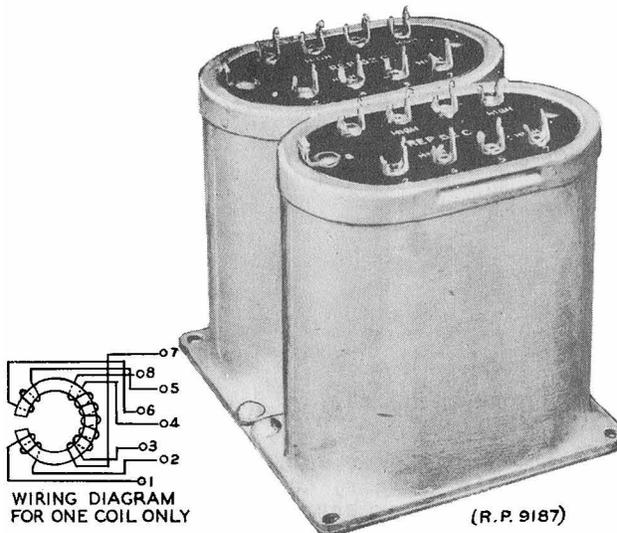


FIG. 63 62 TYPE REPEATING COIL

repeating coil, consisting of two coils on a common wooden base. The cover has been removed from the front coil to show the construction.

The cast or sheet iron case as a housing for the coil is used on repeating coils of later design, such as the 62, 74 and 93 types. These coils are intended for relay rack mounting and are made in either single or double units. The windings terminate at a phenol fibre terminal strip in front of the case, or soldering terminals in the rear. See Figure 63.

The core of a shell type repeating coil consists of silicon steel or permalloy laminations of various shapes similar to those shown in Figure 64(A). A number of these laminations are riveted together, forming butt joints when assembled. Two brackets and screws are used to hold the parts together. The windings are generally on a spool which fits over the center leg of the core. The 94 and 120 type repeating coils are examples of this type of construction. See Figure 65.

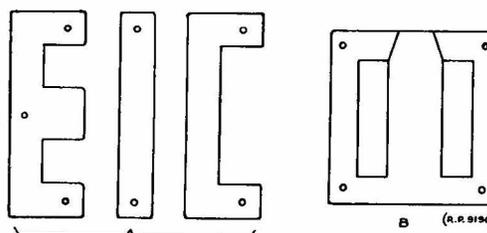


FIG. 64 TRANSFORMER LAMINATIONS

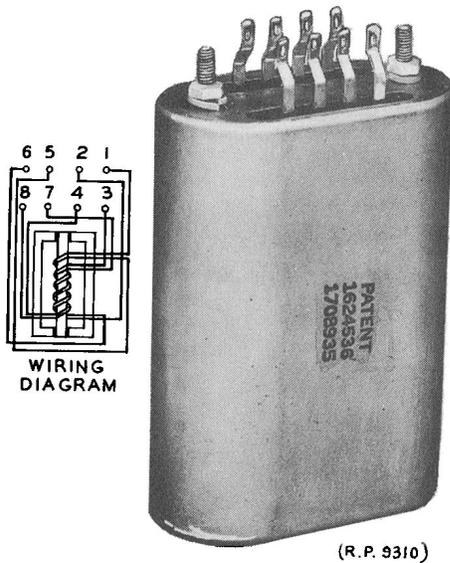


FIG. 65 94 TYPE REPEATING COIL

Another type of lamination shown in Figure 64 (B) is also used for some repeating coils and a number of input and output transformers. This type is slitted on one side so that the center leg may be passed through the form wound coil. In assembling such a core, the slitted part is alternately placed on one or the other side of the coil.

Shell type repeating coils are generally enclosed in a sheet iron case suitable for relay rack mounting, with terminals on the mounting side.

The straight core type of repeating or induction coil has an open magnetic circuit core of silicon steel strips. The windings are brought out to terminals attached to the spoolhead. Examples of this type of construction are the 62, 63 and 72 type induction coils and 20 and 110 type repeating coils. See Figure 66.

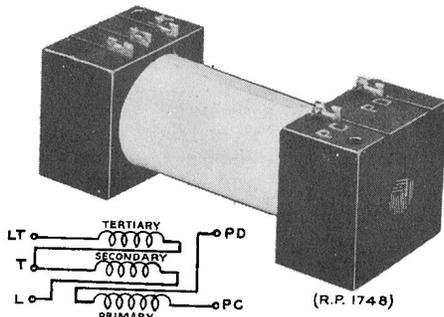


FIG. 66 62 TYPE INDUCTION COIL

Another example of the straight core type of construction is found in the 103 type repeating coil where a laminated core and cross-talk proof cover, similar to that of an "H" type relay is used. Repeating coils of this type can be mounted interchangeably with flat type relays or 40 type resistances.

A shell type induction coil used in operator's telephone circuits is shown in Figure 67. It is enclosed in a rectangular metal case lined with steel for crosstalk shielding purposes. Induction coils of this type mount like relays and replace the old open type on new installations.

In general, most repeating coils may be classified as battery supply repeating coils and phantom repeating coils. Battery supply repeating coils are, next to the subscriber's induction coil, the most commonly used transformer in the telephone plant. One of these coils is used in every conversation between two subscribers in the same common battery office, while two are necessary when the subscribers are in different offices. They are called battery supply coils because the direct current, which is necessary for the operation of the transmitter, is fed through the winding of these coils. Repeating coils are necessary to prevent the battery from short-circuiting the voice frequency currents passing from one subscriber to another.

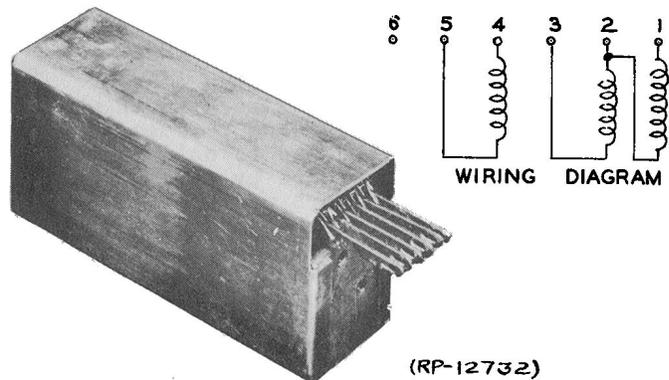


FIG. 67 178 TYPE INDUCTION COIL

Until recently, battery supply repeating coils were of the toroidal type. The size of this type of core is such, however, as to require considerable mounting space when adopted for relay rack mounting. This led to the development of the now standard 94 type of repeating coil which is of the shell type and mounts on 1-3/4" horizontal and 3-1/2" vertical centers. See Figure 65. The magnetic circuit of this coil is not continuous, non-magnetic spacers being used between the butt joints in order to reduce the DC flux.

Phantom repeating coils are used in the telephone plant to obtain an additional telephone channel or phantom circuit for two pairs of conductors known as side circuits. By this means three conversations are carried by four wires, thereby making a saving in the number of wires required for telephone service.

The present standard toroidal phantom repeating coils can be divided into two major classes from an electrical standpoint, those that transmit 20 cycle signals and those that do not. The 62 type for example

is a phantom coil that does not transmit 20 cycle signals while the 75 and 93 types will transmit 20 cycle signals. The "non-ringing through" characteristic of the 62 type is obtained by introducing an air-gap into the core of this coil, which makes the coil inefficient at 20 cycles. A gap in the core is also used for the 75 and 93 types of coils, the gap in this case, however, being filled with a compressed powdered magnetic material. This gap is for the purpose of preventing magnetization under abnormal service conditions.

#### INPUT TRANSFORMERS AND OUTPUT TRANSFORMERS

The terms "input transformer" and "output transformer" refer to telephone transformers used in connection with vacuum tubes. An input transformer is a transformer designed to work into the grid of a vacuum tube, while an output transformer is intended to operate from the plate of a vacuum tube.

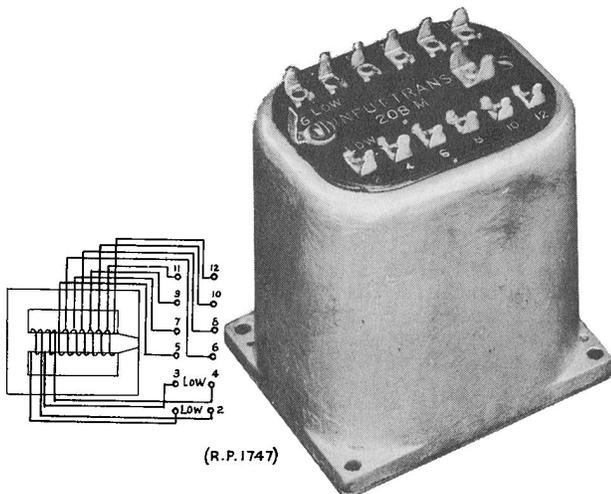


FIG. 68 208 TYPE INPUT TRANSFORMER

The cores of input and output transformers are similar to those used for repeating coils, consisting of either toroidal or shell type laminations of silicon steel or permalloy. In addition, laminated wooden cores, toroidal in shape, are used for some input and output transformers in carrier current systems. Transformers of this latter type are really air core transformers, the wood merely being used as a winding form. Air core transformers are used in this case because a core of magnetic material would cause excessive losses due to the high frequency currents used in carrier current circuits. Cast iron or sheet metal cases similar to those used for repeating coils are also provided for most input and output transformers. Figure 68 shows a typical shell type input transformer of the 208 type, potted in a cast iron case. Another input transformer of the shell type, used extensively in ringer oscillator circuits is the 602 type which is similar in appearance to the 94 type repeating coil shown in Figure 65.

For the purpose of improving the amplification of the lower frequencies, permalloy is used as the core material for a number of input and output transformers. In order to reduce the magnetizing effect of direct current on the core, small air-gaps filled with compressed powdered magnetic material are introduced into a number of toroidal shaped cores, while butt joint construction produces a similar effect on shell type cores. An electro-static shield, consisting of a thin piece of metal placed between windings and forming an open circuit, is frequently used to prevent capacity coupling between windings.

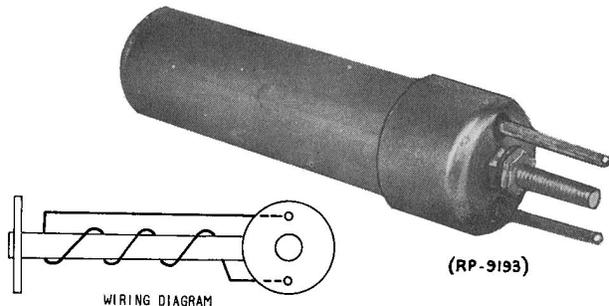


FIG. 69 47 TYPE RETARDATION COIL

#### RETARDATION COILS

Retardation coils, also known as impedance or choke coils, are electro-magnetic coils used to retard or choke back the flow of rapidly varying currents, but at the same time allow the comparatively free passage of direct current.

There are a great many different kinds of retardation coils, but only such types as are most commonly used in the central office will be covered in the following paragraphs.

Among the most commonly used retardation coils are the 47 and 54 types. These coils are small tubular coils of the straight core type, having a solid core of soft iron. A tubular shell of soft iron surrounds the coil, completing the magnetic circuit and making the coil cross-talk proof. These coils are arranged to mount on mounting plates and differ only in terminal arrangements and size. See Figures 69 and 70.

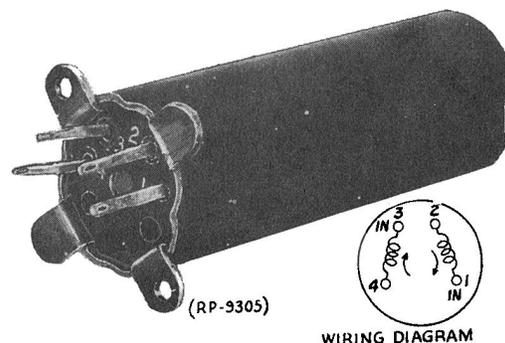


FIG. 70 54 TYPE RETARDATION COIL

The toroidal type of core, as used for repeating coils, is also used for a considerable number of retardation coils. The 91 and 94 types are examples of this kind of construction. As mentioned previously, the toroidal type of core consists generally of a ring of silicon steel laminations or pressed permalloy dust rings. Mounting and terminal arrangements for toroidal type retardation coils are in most cases practically the same as those described and shown for toroidal type repeating coils. The type of coil shown in Figure 71 is also of the toroidal type, but uses a rectangular sheet metal can with mounting lugs as a housing.

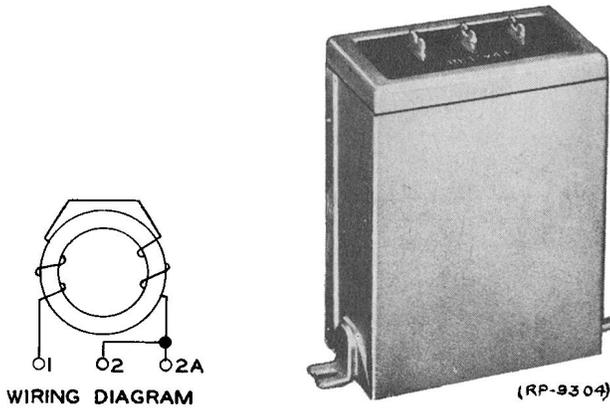


FIG. 71 94 TYPE RETARDATION COIL

The shell type of core construction is also used for a number of retardation coils, as for example the 149 and 158 types. The construction and external appearance of the 149 type is practically identical with the 94 type repeating coil shown in Figure 65. The 158 type, however, represents a particular arrangement designed to meet the operating conditions encountered on toll lines which are also used for telegraph purposes.

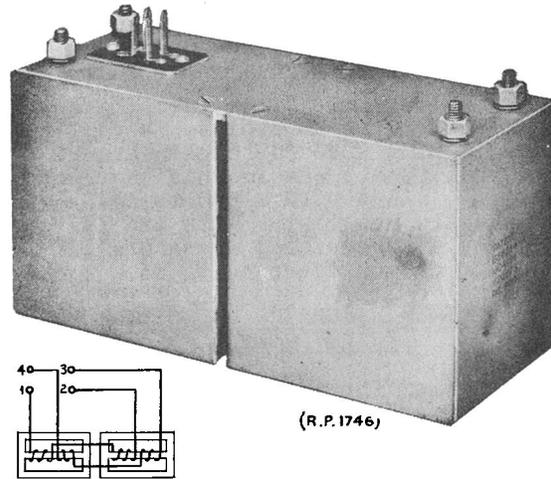


FIG. 72 158 TYPE RETARDATION COIL

This latter type of coil consists of two separate shell type cores, each potted in a rectangular sheet steel can. The two cans are mounted adjacent to each other on a common steel mounting plate. The windings are interconnected to obtain two independent inductive windings which have substantially the same electrical characteristics and a very low mutual coupling. See Figure 72.

In addition to the above mentioned types, relay cores are also used as retardation coils. The 85 type coil for example is similar to an "H" type relay with the armature and contact springs omitted. See Section 1 for a description of the "H" type relay.

#### QUESTIONS

1. What materials are used for the cores of toroidal type repeating coils?
2. What is meant by battery supply and phantom repeating coils?
3. Why do some input and output transformers use laminated wooden cores?
4. What means are used to reduce the magnetizing effect of direct current on the cores of some input and output transformers?
5. What are retardation coils used for?

## SECTION 4

## CONDENSERS

A condenser consists essentially of two plates or sheets of conducting material separated by a dielectric or an insulator. Such a device when placed in the circuit acts as a barrier to the flow of direct current but permits the easy passage of alternating current.

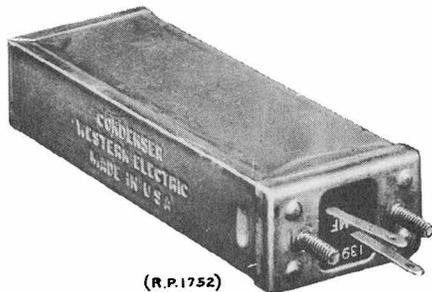


FIG. 73 139 TYPE CONDENSER

The majority of condensers used in the telephone plant are of the paper insulated type. In these condensers, the conducting material consists of long strips of tin foil approximately .003" thick and the insulators are strips of very thin high grade tissue paper about .0005" thick. To make a paper condenser, two strips of tin foil and four strips of paper are wound together so that each foil strip is insulated from the other by two paper strips. Connection to the foil strips is made by means of two contact strips which are wrapped into the ends of the foil strips before winding. After the proper number of turns have been wound together into a cylindrical form, the form is removed from the winding machine, baked for a number of hours in order to exclude moisture and then impregnated with wax in a vacuum tank. While still hot, the condenser is flattened to remove excess wax and to raise the capacity. The condenser is next tested for breakdown strength and capacity and then sealed into a metal container with an asphalt preparation.

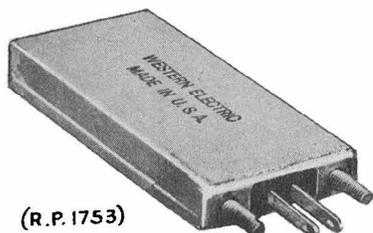


FIG. 74 141 TYPE CONDENSER

Among the typical types of paper condensers most commonly used in the telephone plant are the 137, 138, 139 and 141 types. See Figures 73 and 74. These condensers are equipped with two studs for mounting on plates and have the terminals on the rear or wiring side. These types differ only in size, capacity and breakdown voltage requirements.



FIG. 75 147 TYPE CONDENSER

Condensers not intended for mounting plate use, are generally of the 147 and 149 types. See Figure 75. These condensers have the terminals in front and are equipped with a mounting tab at the lower edge of the condenser. They are mounted by means of this tab and a mounting strap.

The 187 type condenser shown in Figure 76 is of the multi-unit type, that is having more than one capacity sealed into the same can. It consists of 10 small paper units potted in a metal can with a removable cover in front. One side of each unit is connected to a common terminal, while the other side is connected to one of ten terminals in front. The condenser is provided with two line terminals terminating at the front and rear. One of the line terminals is connected to the common terminal, while the other line terminal is strapped to the units as required to secure the desired capacity.

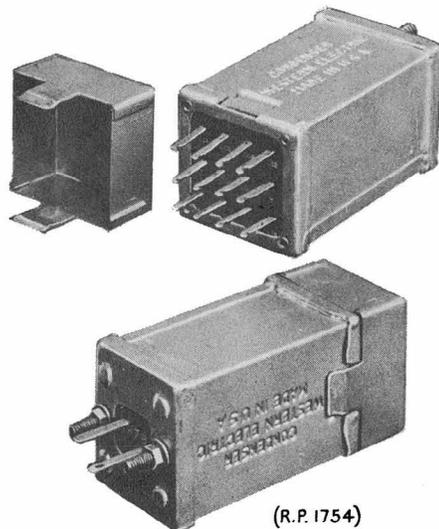


FIG. 76 187 TYPE CONDENSER

There are a number of other types of paper condensers which are designed to fit special needs, but these do not differ essentially from the types described and shown above.

While paper condensers have the advantage of being inexpensive, there are certain limits to the accuracy with which they can be commercially produced. Ordinarily a tolerance of +25% in capacity is allowed. By selection after manufacture, condensers of closer limits may be obtained. There are cases, however, where still closer limits are required, such as in filter circuits of carrier current systems. To obtain a high degree of accuracy, particularly on the lower values, mica is used as the dielectric. Instead of being rolled, alternate layers of conductor and mica are laid one on top of the other. Alternate sheets of foil extend beyond the mica on opposite sides and are connected together when the stack is completed. For adjusting purposes some of the conducting foils are made of brass so that an accurate capacity adjustment may be obtained by pulling these foils partly out from the stack. After

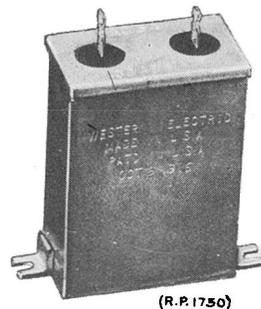


FIG. 77 AC TYPE CONDENSER

assembling the required number of mica and foil pieces, the stack is clamped between steel clamping plates, adjusted for capacity and breakdown and then potted in a tin can filled with an asphalt preparation.

The AC type condenser shown in Figure 77 is an example of this type of construction.

#### QUESTIONS

1. What are the component parts of a paper condenser and how is it made?
2. What types of condensers are most commonly used?
3. Why do some condensers use mica instead of paper for the dielectric?

## SECTION 5

JACKS, LAMPS, LAMP SOCKETS AND MOUNTINGSJACKS

Jacks are used in a great variety of circuits and consequently require considerable variation in construction. Several hundred different jacks have been coded, but only a few general types will be considered in this section. Fundamentally, jacks, together with plugs and cords, are a flexible switching device with as many choices as there are jacks.

Besides provision for making connections with the cord conductors attached to the plug, a number of auxiliary springs and contacts are often part of the jack, so that other connections are made or broken by means of make, break, or transfer contacts. In this way, the insertion of a plug in the jack may be made to automatically open the circuit of drops, lamp relays, etc. Jacks may be so connected that a meter, an operator's talking set, etc., can be inserted in series with the line by plugging into the jack. A few of these uses are illustrated in Figure 78. Note that Figures 78-A and 78-B show the same jack connected for different uses. Figure 78-B illustrates how the jack would be connected to allow a meter, telegraph set or talking set to be inserted in the circuit. Figure 78-C shows the 3 conductor jack used on the No. 12 switchboard. Note the auxiliary break contact springs which perform a function similar to the cut-off relay used with the No. 1 switchboard. Figure 78-D illustrates a common two-conductor jack wired to restore a 22 type drop to its normal position.

Jacks may be divided into two general physical classes, those mounted in strips and those which can be mounted individually. The strip jacks are usually manufactured as an integral part of the mounting with which they are associated. The sleeves of the jack are fastened into a hard rubber strip which forms the face of the jack strip. The contact springs are separated by insulators and assembled in a pile-up at the rear of the jack strip. Individually mounted jacks have a sherardized iron frame with a brass sleeve fastened to its front face.

Jack strips are used principally on switchboards, where the jacks serve either as multiple jacks or answering jacks. On common battery switchboards the jacks used are three-conductor jacks, that is, they are designed to contact with the tip, ring, and sleeve of the plug. Only the tip and ring connections are used in the talking circuit, the sleeve being used to operate the cut-off relay, disconnect the lamp relay, etc.

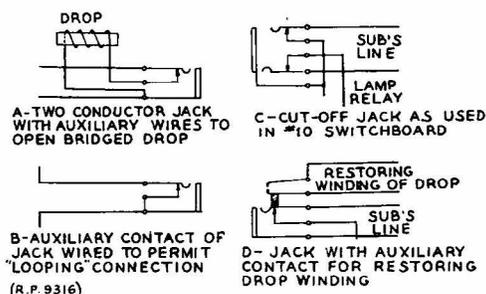


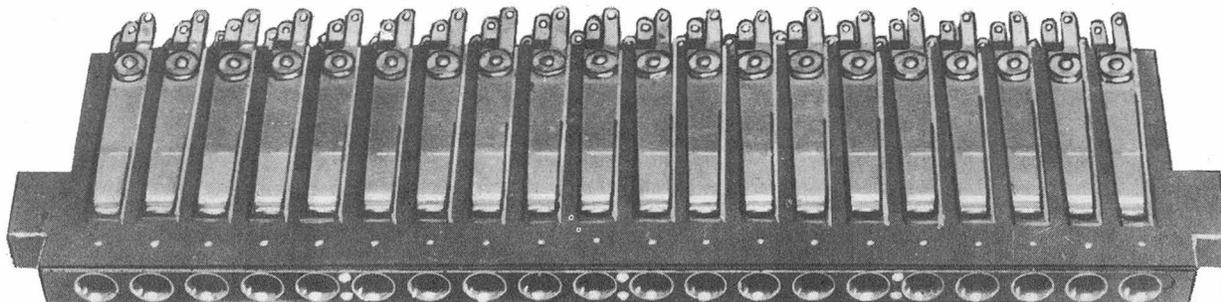
FIG. 78 VARIOUS USES OF AUXILIARY CONTACTS OF JACKS

49 Type Jack

This is a three-conductor jack mounted in strips of 5, 10, or 20 and is used on P.B.X., small manual, and toll switchboards. See Figure 79. It is designed to take the 310 plug. When mounted in strips of 20, there is just  $7/16$ " between centers, and when strips are mounted one above the other, there is also  $7/16$ " between centers, thus giving the same vertical distance between jack centers as the horizontal distance.

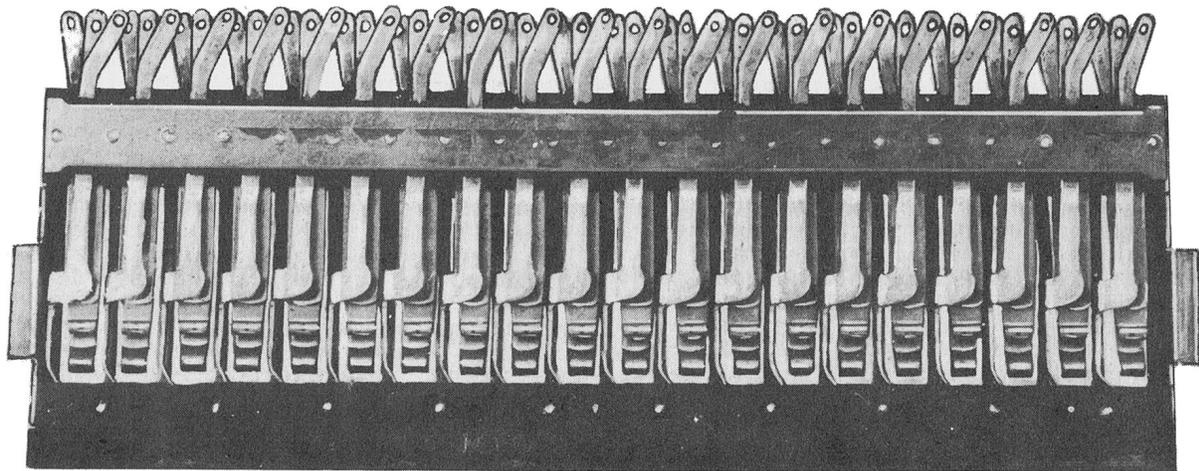
92 Type Jack

This jack is usually mounted in strips of twenty, and more of them are used than of any other type. A strip is shown in Figure 80. The 92 type jack takes the 309 plug and is the smallest switchboard jack made by the Western Electric Company. When mounted in the switchboard with one jack



(R.P. 9317)

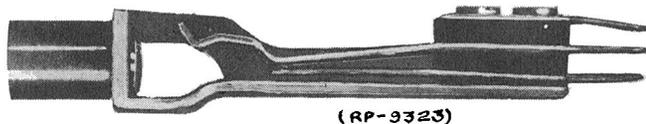
FIG. 79 114 TYPE JACK MOUNTING EQUIPPED WITH 49 TYPE JACKS



(R.P. 9318)

FIG. 80 113 TYPE JACK MOUNTING EQUIPPED WITH 92 TYPE JACKS

strip above another, there is only 3/8" between centers vertically and horizontally. The compactness of this jack makes it possible for 10,500 lines (jacks) to be within reach of one operator, consequently, it is used on all of the largest switchboards, such as the No. 11.



(RP-9323)

FIG. 81 218 TYPE JACK

218 Type Jack

This is a typical individually mounted two conductor jack having an auxiliary break contact spring. This jack is shown in Figure 81 and two methods in which it is used are shown in Figures 78-A and 78-B.

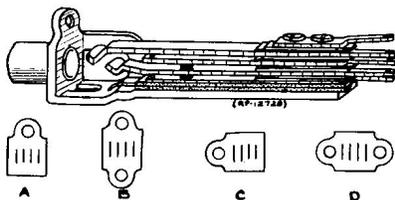
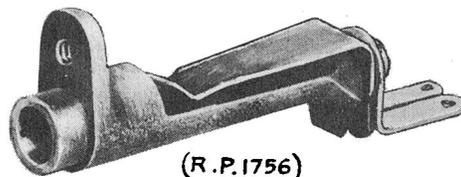


FIG. 82 239 TYPE JACK

239 Type Jack

Figure 82 shows the 239 type jack, a typical three conductor individually mounted jack. Note that in this case transfer contacts are actuated through the insertion of the plug. The letters A, B, C and D associated with the code number of this and similar types of individually mounted jacks indicate the number of mounting lugs and their arrangement with respect to the plane of the contact springs. This is illustrated in Figures A, B, C and D of Figure 82.



(R.P.1756)

FIG. 83 364 TYPE JACK

364 Type Jack

The 364 type jack is of the individually mounted type and is used alone as well as in pairs. The two jacks (operator's jacks) mounted in pairs on the switchboard keyshelf are of the 364 type. They are two conductor jacks, that is, they are designed to contact with a plug having tip and sleeve only. See Figure 83.

444 Type Jack

This is a special type of jack used instead of protectors in the downtown areas of large cities where incoming cables are all underground. It is described in the section covering Protectors and Fuses.

JACK MOUNTINGS

Numerous types of jack mountings have been designed to furnish a ready means for mounting the jacks securely and obtaining uniformity in their location. There are two general types of jack mountings; those designed for jacks which will mount individually and those in which the jack is a part of the mounting and cannot be separated from it in an assembled form. The former consist of strips of hard rubber or black insulating material drilled to fit the sleeves of the jacks. The individual jacks are fastened to the mounting by screws from the rear. The latter have either a hard rubber or a metal frame to which the jack springs are clamped, and a hard rubber face strip in which the jack sleeves are fixed. On jack strips which have a hard rubber frame, the face is part of the frame as may be seen in Figure 79.

Jack mountings of both types, which are intended for switchboard use, are equipped with mounting lugs at each end of the strip as shown in Figures 79 and 80. The front of the mounting lugs rest against the rear of the stile case mounting and "butterfly" clamps against the rear of the mounting lugs hold the jack mountings firmly in position.

A 114 type mounting equipped with 49 type jacks is shown in Figure 79. This is an all rubber mounting and has the jacks separated into groups of five by pairs of white dots. The 114 type mounting is typical of those having hard rubber frames.

A good example of a jack mounting having a hard rubber face and a metal frame is the 113 type mounting equipped with 92 type jacks shown in Figure 80. These jacks are also separated into groups of five by pairs of small white dots on the face of the strip.

There are large numbers and varieties of mountings available for the individually mounted jacks, mounting from one to 64 jacks. The 80 type mounting, for example is equipped with two 364 or similar type jacks for a double plug (operator's) and the 78 type mounting is designed for 3 pairs of 223 type jacks. Typical among the jack mountings carrying a large complement of individually mounted jacks is the 185 type mounting, having 48 jacks of the 218 or similar types in two rows.

#### LAMPS

Switchboard lamps perform the same function as the magnetic signals which were discussed in a preceding section. A burning lamp, unless used as a busy signal, always means that the operator has some duty to perform, as a connection to be made or a cord to be removed. Both lamps and signals are used for signalling the operator and each has its advantages.

The lamp is more insistent, and attracts attention even when partially obscured by cords. It also occupies much less space. It is, however, less rugged than a signal, and will not stand great fluctuations of circuit conditions. The winding of a signal will stand an increase of current as great as ten times without damage and hence may be placed directly in the subscriber's line. A lamp will burn out if the current is more than doubled. For this reason, if a circuit which operates a lamp satisfactorily over a long line were short circuited near the central office, the increase in current would ruin it. Consequently, lamps are used directly in the line circuit only where the lines are short as in a P.B.X. This disadvantage is overcome in a central office by inserting a line relay in series with the line which closes a local circuit to light the lamp. The relay is sensitive to a wide range of current while the lamp is exposed to very little current fluctuation.

Lamps are used for signalling purposes on a switchboard as line lamps and pilot lamps, and as supervisory lamps in the cord circuit. Associated with switchboard lamps are lamp caps. Although the lamp caps vary greatly in size, the same lamp is used as the source of light. Lamps are also used in fuse alarm circuits to designate blown fuses.

Switchboard lamps use either a carbon or a tungsten filament. See Figure 84. They vary in voltage from 4 to 48 volts and in current consumption from .018 to .3 amperes. The type of filament may be readily determined by the code designation branded on the wooden base. If the letter is preceded by a numeral the filament is carbon; if the letter comes first, the filament is tungsten. Thus a 2-G lamp has a carbon filament and an A-2 lamp a tungsten filament. As a further aid in distinguishing between the two types of filaments, the wooden base of carbon lamps is dyed red, while the color of the base of tungsten lamps is natural.

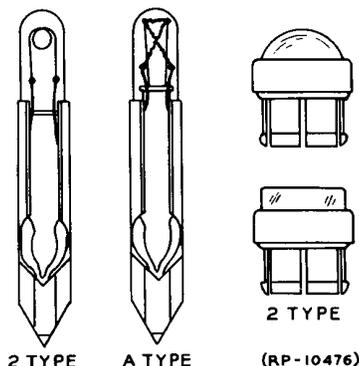


FIG. 84 SWITCHBOARD LAMPS AND LAMP CAPS

Switchboard lamps are approximately 1-3/4 inches in length and 5/16 of an inch in diameter. The lamp proper is mounted between two tinned brass terminals attached to a wooden block which is V-shaped at the end to facilitate insertion into the lamp socket. The terminals make contact with the springs in the lamp sockets and carry the current to the filament.

#### LAMP CAPS

Lamp caps are made in several colors and in several diameters. They consist of a hemispherical lens and a brass sleeve. The lens is slightly clouded or cut in facets in order to distribute the rays of light so that the signal may be seen from all angles. The sleeve serves to confine the light so that no light will reach other lenses than the one directly in front of the lamp. See Figure 84.

#### LAMP SOCKET MOUNTINGS

For the purpose of this discussion a lamp mounting will consist of the lamp socket and lamp socket mounting. A lamp socket mounting, strictly speaking, is a hard rubber or metal face plate and frame

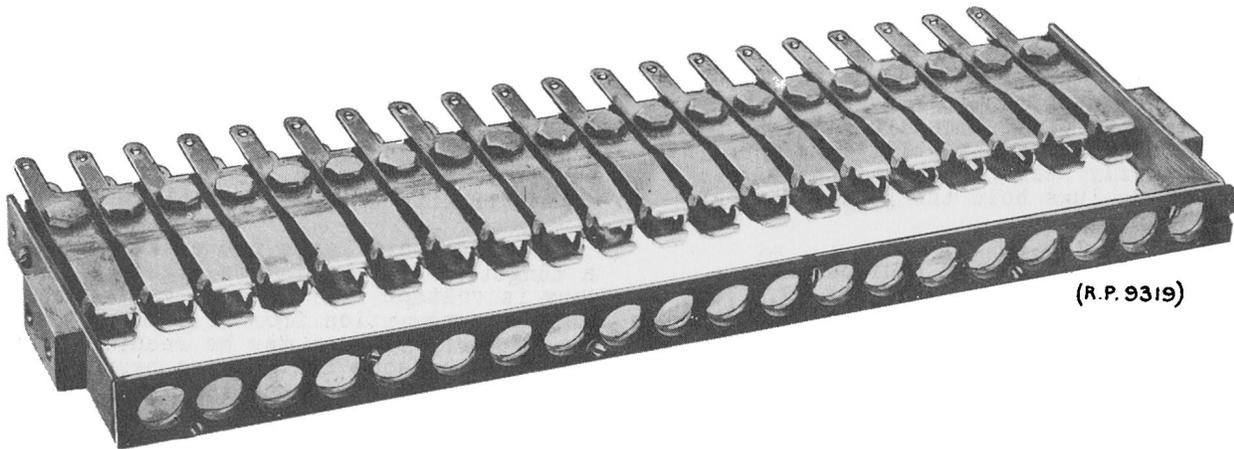


FIG. 85 278 TYPE LAMP SOCKET MOUNTING EQUIPPED WITH 43 TYPE LAMP SOCKETS

for mounting lamp sockets in strips, usually on a switchboard. There are a large number of these mountings, as one is required to match nearly every type of jack-strip for horizontal spacing and length, and its face must be flush with the face of the jack-strip. These mountings are equipped with mounting lugs at the ends of the strip and are secured in place in the same manner as a jack mounting. A 278 type lamp socket mounting with 43 type lamp socket is shown in Figure 85.

Lamp sockets are of two general types, one consisting of a pair of springs which are clamped onto a lamp socket mounting, and the other having a metal frame which

surrounds the springs and serves as a mounting for the lamp cap. This frame has metal lugs extending from the sides for individual mounting. A lamp socket of this type is shown in Figure 86.

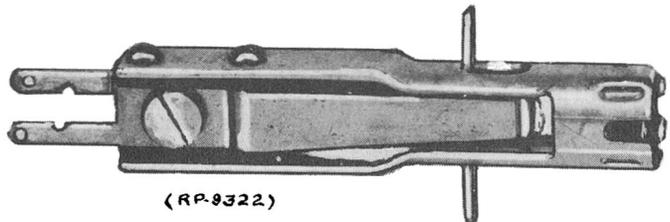


FIG. 86 13 TYPE LAMP SOCKET

#### QUESTIONS

1. What is the function of auxiliary jack springs?
2. Where are three conductor jacks used?
3. How many 92 type jacks can be placed within reach of one operator?
4. How are switchboard jacks held in place?
5. What advantage does a switchboard lamp have over a signal? Disadvantages?
6. How may a carbon filament lamp be easily distinguished from a tungsten filament lamp?
7. Why are the lenses in lamp caps clouded?
8. What is the purpose of the sleeve on a lamp cap?
9. How is a lamp mounting secured to the switchboard?

## SECTION 6

## PLUGS AND CORDS

There are about four general types of plugs. These are the two conductor plug, the double plug, the small three conductor plug, and the large three conductor plug. These plugs are each associated with jacks designed for them. Since most of the plugs are among the four general types, only a few representative plugs will be considered in the following paragraphs.

TWO CONDUCTOR PLUGS

A good example of a two conductor plug is the 47 type plug shown in Figure 87. This plug is used on magneto switchboards, test boards, and P.B.X.'s. It has a pear shaped tip insulated from the sleeve which serves as the frame of the plug. Under the fibre shell are two screws which serve as binding posts to connect the cord conductors to the respective plug parts. This type of plug may be used with nearly all of the two conductor jacks.



(R.P.9325)

FIG. 87 47 TYPE PLUG

THREE CONDUCTOR PLUGS

The two plugs most commonly used today are the 309 and 310 type plugs. The 309 type plug is the smaller of the two and is designed for use with the 92 type jack. The 310 type plug is almost a duplicate, except for size, and is used with the 49 type jack. As may be seen from the cross-sectional view in Figure 88, the connection of the cord tip and ring is made with small button head binding screws inside the shell. Connection to the sleeve is made by folding the bare end of the sleeve conductor back over the cord insulation. When the cord is screwed into the threaded end of the sleeve, the exposed conductor is wedged against the inner threads and makes contact with them. In addition, the outer braid of the cord is held by these threads so that the strain is borne by the outer braid rather than by the conductors. Essentially these plugs are made up of concentric tubes, alternately of metal and of insulation. The principle member, outermost, is of brass; at one end it forms the sleeve contact, and at the other the body, around which the shell is

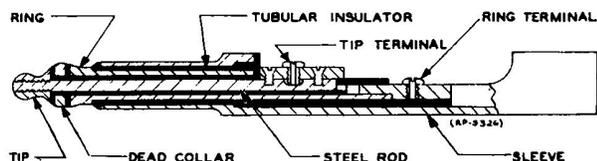
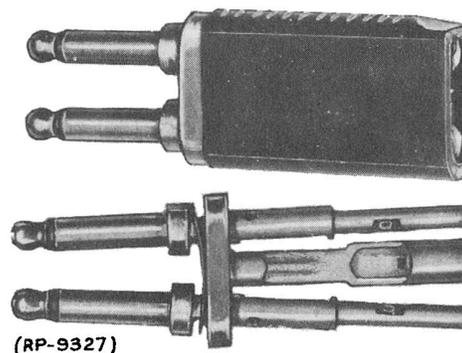


FIG. 88 CROSS SECTION OF 309 TYPE PLUG

placed. Directly inside is a tubular insulator with a flange at the end to form a spacer between sleeve and ring. Inside this insulator is a thin brass tube bearing at one end a flange which forms the ring contact, and at the other end, a short brass rod semicircular in cross section to which the ring conductor of the cord is fastened by a binding screw. Enclosed in the ring tube is another insulating tube, and inside of that is a steel rod which forms the center and backbone of the plug. To the outer end of the rod the tip contact is screwed, and at the other end is fastened a connection plate to which the tip conductor of the cord is fastened. The dead collar, made of an alloy chosen for its wearing qualities, is placed between the tip and ring; it is separated from them by insulating washers and from the plug center by the inner insulating tube. This dead collar acts as a spacer between the tip and ring, preventing them from touching simultaneously the ring contact spring or the sleeve of the jack during insertion or withdrawal. The tubular shell by which an operator grasps the plug is of fibre fastened to the main body by a small screw.

DOUBLE PLUGS

The double plug connected to the operator's breast transmitter and head set is the 289 type plug. It consists of two two conductor plugs insulated from each other and being held apart by means of a flat spring. There is sufficient play between the plug bodies to take up inequalities in either the plugs or jacks. The plugs are arranged so that each plug body may be turned 90 degrees in the shell to present a new surface for wear. The twin plug shown in Figure 89 is the 241 type plug which is used at toll test boards. This plug



(R.P.9327)

FIG. 89 241 TYPE PLUG

also has flexible "fingers" to permit them to align themselves readily with jacks whose spacing varies somewhat. The shell is made of either black or red insulating compound and butts against a brass bridge which serves as a common electrical connection for the two plug sleeves. The tips are separately insulated and provided with binding screws for connecting them to cord

tips on the switchboard cord. One edge of the shell is grooved to mark the proper way to insert the plug in the jack.

Twin plugs are also made with three conductors in each finger, such as the 338 type. This plug consists essentially of two 310 type plugs mounted in a single shell and is intended principally as a patching plug in patching jack and cord circuits in toll systems.

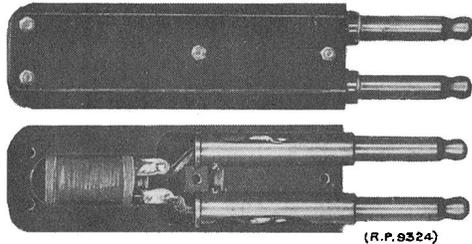


FIG. 90 217 TYPE PLUG

The twin plug shown in Figure 90 is unique in that the shell encloses a resistance which is bridged across the tip of the two plugs. This plug is the 217 type and is made with several resistance values. 217 plugs are used for balancing toll circuits during test.

#### CORDS

The large variety of cords has made a distinctive system of numbering advisable, thus the code number of switchboard cords commences with S as S3A; the code number for patching cords commences with P, as P3A, and T3A is a transmitter cord. The second character (3) in each of these cases denotes the number of conductors in the cord. The third character (A) of the code has no special significance and is arbitrarily assigned to indicate variation in physical structure such as insulation, cord tips, etc. In this discussion only the switchboard cords will be considered. Patching cords resemble switchboard cords in construction except that they have a plug at each end.

Switchboard cords are manufactured with from one to four conductors. Nearly all of them are furnished in red, white, or green and some of them in black. The usual length is 6 feet. Since the S3A and S3B cords, used with 309 and 310 plugs, are the most familiar because of the general use of one or the other on all of the larger boards, they will be described in detail. Figure 91 shows the general construction.

The conductors are of tinsel to secure the greatest flexibility without danger of breaking. Tinsel is made by wrapping an extremely thin copper ribbon spirally around a thread, several of these threads being twisted together to form a conductor. A covering of silk floss is then wrapped around the conductor to thoroughly insulate it and a cotton braid is put on over this. The cotton braid is a different color for each conductor, the tip being white, ring blue, and sleeve red.

These conductors are twisted together and threads are wound in the crevices so that the cord will be smooth and round when the cover is braided on. The cover is of cotton and is glazed to make it moisture proof and to lessen the tendency for wear. The tip and ring conductors at the plug end of the cord terminate in little ring shaped tips to facilitate fastening to the plug. The sleeve conductor has no terminal, as it is held against the sleeve of the plug by pressure as described previously in this section.

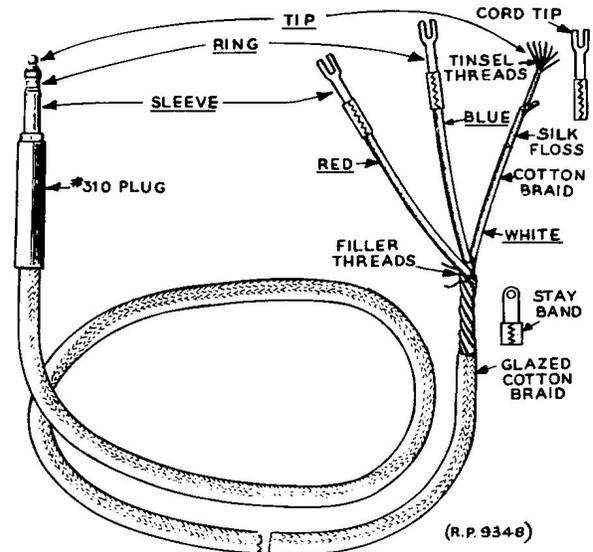


FIG. 91 SWITCHBOARD CORD

On the cord fastener end of the cord, each conductor terminates in a cord tip designed to fasten under a screw head. About five inches from the end, the conductors leave the braided cover. Attached to the cord at this point is a brass stay band designed to fasten on a hook and to relieve the conductors from strain.

#### QUESTIONS

1. What type of plug is used on magneto switchboards?
2. How are the cord connections made to 309 and 310 plugs?
3. What is the purpose of the dead collar on three conductor plugs?
4. Why is there "play" between the plug body and fingers on a double plug?
5. Why do many of the double plugs have grooves on one side of the shell?
6. What is a tinsel conductor?
7. What are the colors of the tip, ring, and sleeve conductors in the ordinary switchboard cord?

## SECTION 7

KEYS

Keys are manually operated devices for closing or opening telephone or telegraph circuits. There are a great many different kinds of keys, but all consist essentially of a number of contact springs operated by a lever or a plunger. We may, therefore, from a mechanical standpoint, divide keys into two major groups, lever type keys and plunger type keys. While a number of keys consist of just a single lever or plunger unit with various spring combinations, a considerable number of keys are equipped with two or more lever or plunger units, or consist of a combination of both, mounted together on a common base.

The various types of keys are designated by either a code number or letter, such as 92 type and C type. The individual keys are designated (or coded) by adding letters or numbers of the type designation mark, such as 92-B and C-1D. Keys using a letter as the type designation mark are known as universal type keys. They are arranged to mount in a universal type key shelf, which instead of being drilled and tapped for a definite location for each key, is provided with two mounting slots running lengthwise of the key shelf.

Universal type keys consist of a base with a hard rubber top and one or more key units. Two types of key units have been developed - one in which the springs are operated by a lever and the other in which the springs are operated by a plunger. The key base is equipped with mounting studs, one at each end, which fit into the key shelf slots and hold the key in place by means of the associated screws and washers. In coding these keys they have been divided into three types according to the length of the base; A type 7-1/2", B type 4-9/16" C type 2-3/4", E type 11-1/16" and G type 5-1/2".

Each of these three types are further classified according to the type of units for which the base is arranged, such as A-1, A-2, B-1, C-1, etc. Following the first letter and number, another letter (or letters) is added to denote the order of development, for example B-1GU.

LEVER TYPE KEYS

A typical lever type key, known as the C-1 type, is shown in Figure 92. A "U" shaped iron frame is used for mounting the lever cam and spring assembly. This frame in turn is fitted into a metal key base with hard rubber key top and mounting studs. The peculiar shape of the phosphor bronze contact spring on the right, bearing against the roller and marked "crook plunger spring," is for the purpose of holding or locking the lever in the operated position when moved in that direction. A straight lever

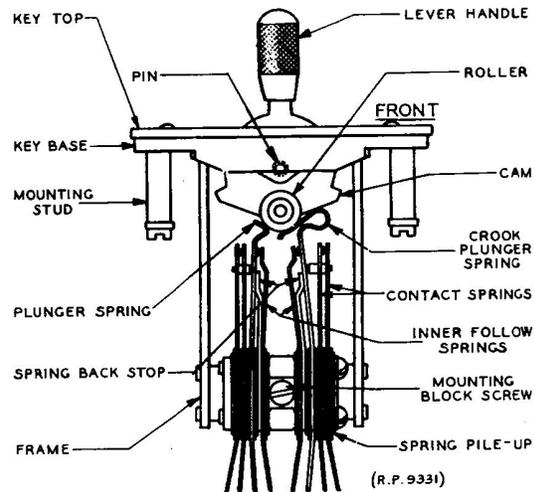


FIG. 92 C-1 TYPE KEY

spring is used whenever a non-locking spring combination is desired. All contact springs with the exception of the crook plunger spring, are generally made of nickel silver. C-1 type keys may be of the two position or one position type. In a two position key, the lever handle may be moved to either side of the normal position, while in a one position key, the lever can be moved to one side only. Since there is a roller on each side of the cam, a maximum of four spring pileups may be used on this type of key.

Figure 93 shows a lever type key of the B-1 type. The key consists of two lever units, each unit having a locking spring combination on one side and a non-locking on the other.

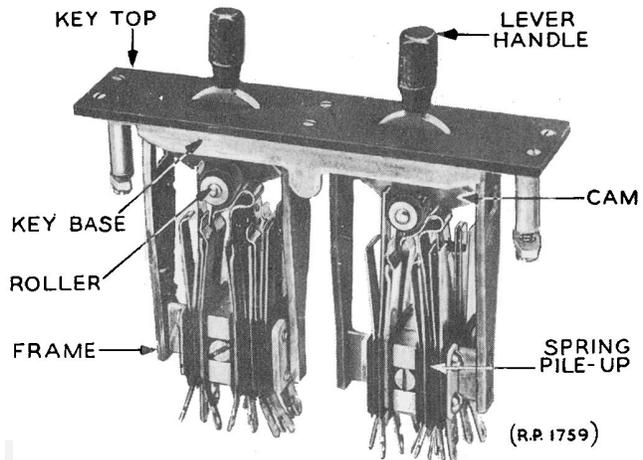


FIG. 93 B-1 TYPE KEY

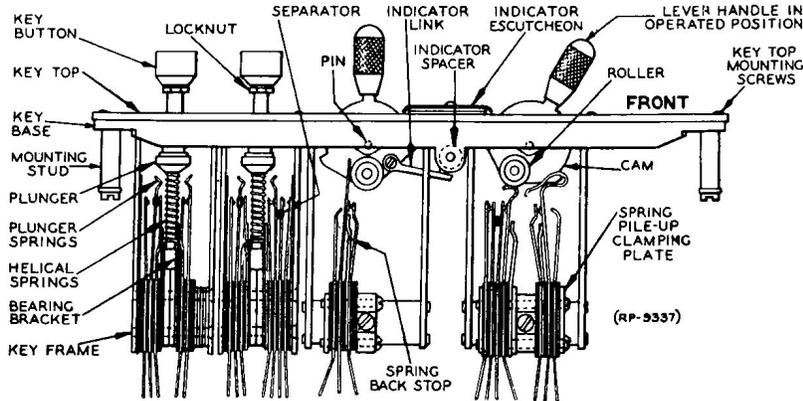


FIG. 94 A-2 TYPE KEY

Another universal type key is shown in Figure 94. This is an A-2 type key consisting of two lever type and two plunger type units. Associated with the two lever type units is an indicator operated by links attached to the cams. The purpose of this indicator is to show which one of the levers has been operated to the ringing position. This type of key is used for message register, coin control, talking and two-party ringing.

Figure 96 shows a 498 type key which is similar to the 92 type except that a rotating plunger button is used for operating the contact springs. The end of the plunger is rectangular in shape and when turned, forces the plunger springs outward.

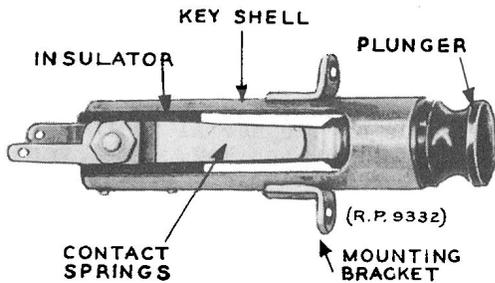


FIG. 95 92 TYPE KEY

PLUNGER TYPE KEYS

Among the most commonly used plunger type keys is the 92 type shown in Figure 95. This key consists essentially of a hard rubber plunger and a cylindrical shell, the lower end of which clamps the hard rubber block on which the contact springs are mounted. The shell is provided with adjustable mounting brackets which will permit the key to be mounted in various thicknesses of wood. The key is operated by depressing the plunger which actuates the spring combination. 92 type keys may be locking or non-locking, depending upon the shape of the hard rubber plunger. Other keys of similar construction are the 424, 464 and 527 types of keys.

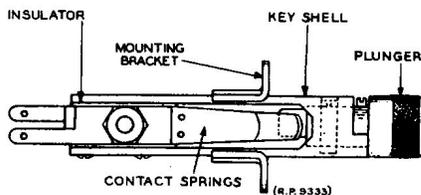


FIG. 96 498 TYPE KEY

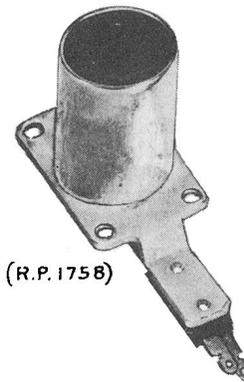


FIG. 97 520 TYPE KEY

Another plunger type key, known as the 520 type is shown in Figure 97. This key is similar to an ordinary push button, but has a button almost 1" wide. It comes in various lengths, depending upon the thickness of the key shelf.

An A-6 type key is shown in Figure 98. This is a typical four-party ringing key consisting of four plunger units arranged to operate the key contacts when depressed all the way down. Each plunger, when released from the way down position, is held

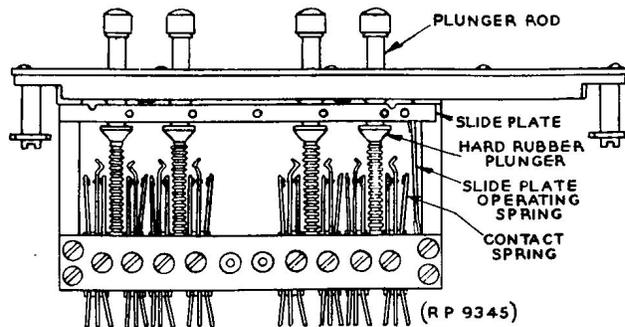


FIG. 98 A-6 TYPE KEY

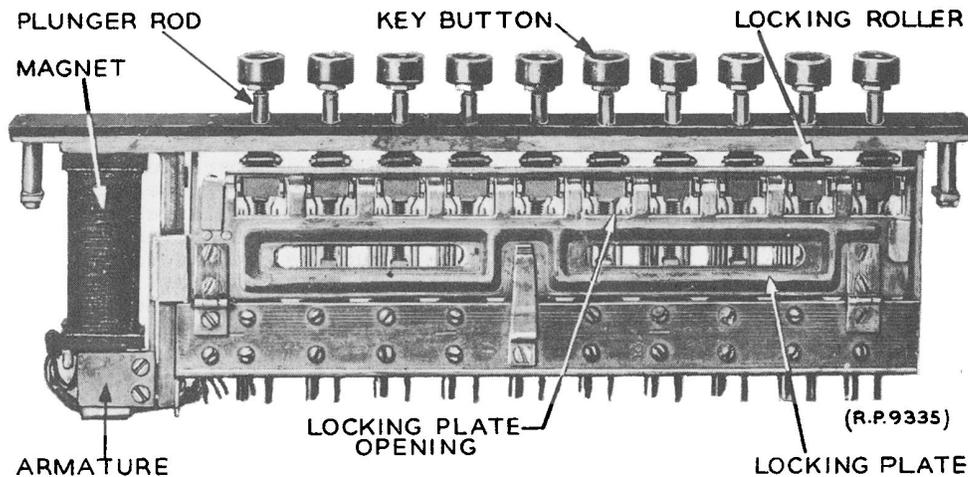


FIG. 99 E-1 TYPE KEY

in an intermediate position by means of a slide plate engaging with a projection on the plunger rod, thus indicating the party called. Any plunger locked in this semi-depressed or indicating position is released by the operation of any other plunger.

Another plunger type key, the E-1 type, is shown in Figure 99. This key consists

of ten plunger units mounted in a metal frame. Each plunger is equipped with a locking roller which when the plunger is operated causes the latter to lock in the rectangular opening of the locking plate. Any operated plunger may be released by the operation of any other plunger, or by an electrically operated restoring magnet.

#### QUESTIONS

1. What are the two major types of keys?
2. What is the purpose of a crook plunger spring on lever type keys?
3. What is meant by universal type keys? How are they coded?
4. Name one of the most commonly used single plunger type keys.
5. What type of key is used for four-party ringing?

## SECTION 8

LINE, TRAFFIC AND PEG COUNT REGISTERS  
AND SWITCHBOARD CLOCKSLINE, TRAFFIC AND PEG COUNT REGISTERS

These registers are devices used in the central office for counting either subscriber's telephone calls or other circuit operations. Line registers are used for counting individual subscriber's calls, whereas traffic registers count such circuit operations as are required for traffic study. Peg count registers are manually operated traffic registers used by operators for counting subscriber's calls.

large number of operations make it desirable to employ a register having an increased life. The increased life is obtained through design changes in the 5 type structure and the use of phosphor bronze in place of brass for parts subject to wear, such as the ratchet, cyclometer frame and overthrow stop.

The 14 type register is a new high speed register primarily intended for use in the line and traffic register circuits of the No. 1 and No. 5 crossbar systems. In appearance it is similar to the 5 type, except that it is 1" shorter in length. The operating mechanism of the 14 type, however, is somewhat different from that used on the 5 type. The heavy armature, and associated operating pawl details on the 5 type have been replaced by a lightweight armature with spring-like operating pawl and back stop. A flat spring engaging with the teeth of the ratchet takes the place of the shaft mounted stop pawl on the 5 type. While the units wheel on the 5 type advances when the armature operates, the reverse action takes place on the 14 type, that is, the units wheel moves when the armature is released. High speed of operation on the 14 type is obtained by a reduction in the mass of moving parts and a greatly reduced armature travel.

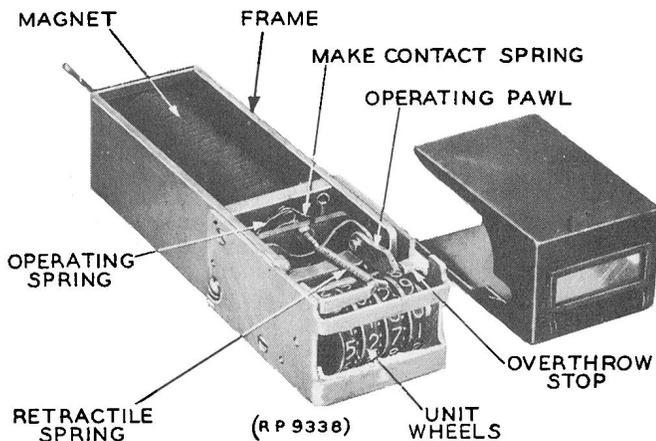


FIG. 100 5 TYPE REGISTER

There are two kinds of registers used in the central office, the 5, 12 and 14 types, which are electrically operated and used for line and traffic purposes, and the 13 type which is a manually operated peg count register. A 5 type register with the cover removed is illustrated in Figure 100. This register consists in its essential form of a geared counting mechanism, operated by an electromagnet. Each of the four number wheels of the counting mechanism is figured 0 to 9, thus permitting a total count of 9999. When the armature is operated, the operating pawl attached to it engages the ratchet wheel of the units wheel, and moves it clockwise 1/10 of a turn. A stop pawl and an overthrow stop prevent excessive backward and forward movement of the units wheel. As a protection against dust, the meter end of the register is enclosed in a removable black finished cover which is provided with a glass window.

The 12 type register is practically of the same construction as the 5 type. From an external appearance standpoint the two types of registers are identical. The 12 type was developed to replace the 5 type for high duty service, such as peg count and counting registers, where the very

A 13 type register is shown in Figure 101. This is a manually operated portable register, having a counting mechanism similar to that one used for 5 type registers. Instead of an electromagnet, however, this register uses a plunger, which when depressed, causes the associated operating pawl to engage the ratchet wheel of the units wheel, and move the register one figure. The register is enclosed in a nickel plated case, and is furnished either, as a single unit or several attached to a common base.



FIG. 101 13 TYPE REGISTER

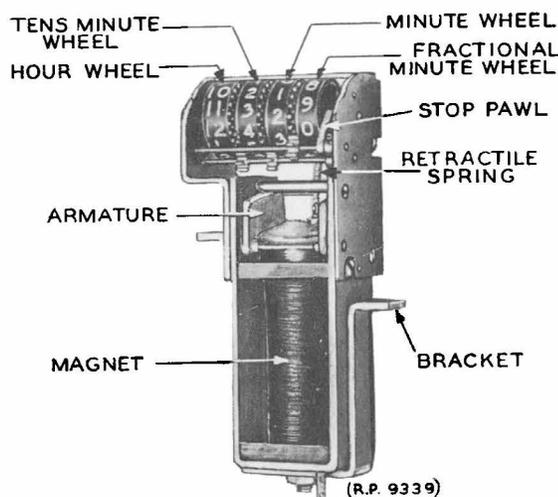


FIG. 102 1 TYPE CLOCK

SWITCHBOARD CLOCKS

Switchboard clocks are timing devices used by telephone operators for the timing of calls. Figure 102 shows a 1 type clock without cover, arranged to give the time in hours, minutes and 10th of minutes. It operates on direct current impulses furnished by a master clock. The operating mechanism of this clock is similar to that one used for 5 type registers, consisting of an electro-magnet which operates a set of four number wheels. The four number wheels are geared together so that the first wheel indicates hours, the second and third, minutes, and the fourth, 10th of minutes. The first or hour wheel, is therefore, figured 1 to 12, the second and third or minute wheels 0 to 5 and 0 to 9 respectively, and the fourth, or 10th of minutes wheel, 0 to 9. A black finished cover with a celluloid window is used over the indicating end of the clock as a protection against dust and mechanical injury. 1 type

clocks are mounted in a switchboard key shelf in a vertical position by means of a mounting bracket and an escutcheon plate.

The type of clock shown in Figure 103 is a synchronous motor-driven clock, designated KS-8263. This clock operates on 20 volts alternating current having a frequency of 60 cycles. The clock mechanism and its motor are completely enclosed in a black molded case. The clock motor is of the self-starting type and drives a clock mechanism consisting of an hour drum, 10 minute drum, minute drum and a continuously rotating seconds drum. As compared with the 1 type clock, it is practically noiseless and since it can be read to the seconds rather than tenths of a second, permits a more accurate timing of calls. The KS-8263 clock is used extensively in place of the 1 type clock where the required power supply is available.

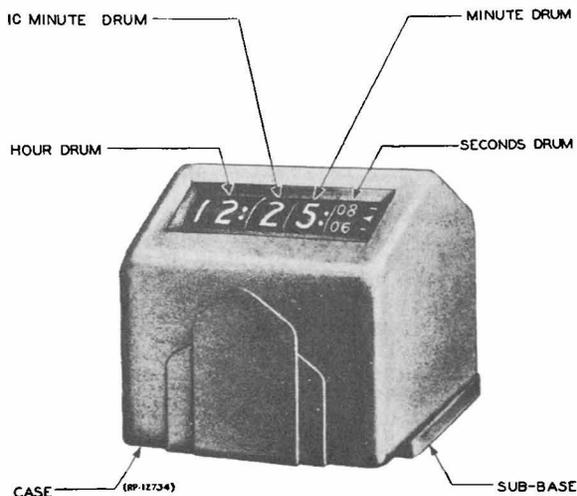


FIG. 103 KS-8263 CLOCK

QUESTIONS

1. What are traffic registers used for?
2. What are the essential parts of a 5 type register?
3. What is the difference between 5 and 12 type registers?
4. What is a 14 type register and how does it differ from the 5 type?
5. How does a 1 type clock indicate time?

## SECTION 9

206 AND 209 TYPE SELECTORSGENERAL

This type of apparatus acts as a rotary switch, and may be made to hunt for the proper connection or may operate from pulses received from some such source as a dial or a relay. Rotary type selectors are used in manual and dial switchboards, on panel and crossbar frames, and on nearly all automatic test and routine frames.

206 and 209 type selectors are almost identical in construction, except for the addition of a pawl guide to guard against overstepping and a few other minor changes on the 209 type.

GENERAL CONSTRUCTION

The selector consists of a bank having from two to six arcs with either 22 or 21 phosphor bronze terminals and a phosphor bronze feeder brush in each arc. A set of rotor brushes, also of phosphor bronze and corresponding numerically to the number of arcs in the bank, is mounted on a shaft with a 44 tooth ratchet wheel. The rotor is made to revolve by means of a driving pawl acting on this ratchet wheel. See Figure 104. The rotor brushes form a connection between the feeder brushes and the bank terminals. The driving pawl is an extension of the magnet armature. When the magnet is energized, the armature is drawn against the magnet core, at the same time distending a heavy retractile spring. When the current is cut off, the retractile spring pulls the armature away from the core, causing the driving pawl to plunge forward with considerable force against a tooth on the ratchet wheel. This plunge of the driving pawl causes the brushes to step from one set of terminals to the next. A pair of interrupter springs is also actuated by the driving pawl. The contacts open each time the armature operates and close when the armature is released. This feature permits wiring of the interrupter contacts in the magnetic circuit so that the selector may be made to rotate under self-interruptions. The operating principle of a rotary type selector is shown in Figure 105.

In front of the magnet is a brass stiffening bracket. This bracket is necessary to overcome the tendency of the magnet to move toward the armature. The path of the magnetic flux is thru the soft iron frame of the switch to the armature. The armature is turned up at the sides to reduce the reluctance and thus strengthen the magnetic flux.

SPECIAL FEATURES

**Magnet:** The magnets of 206 type selectors vary from 15 ohms resistance to 210 ohms due to the great variety of circuits and the different voltages used.

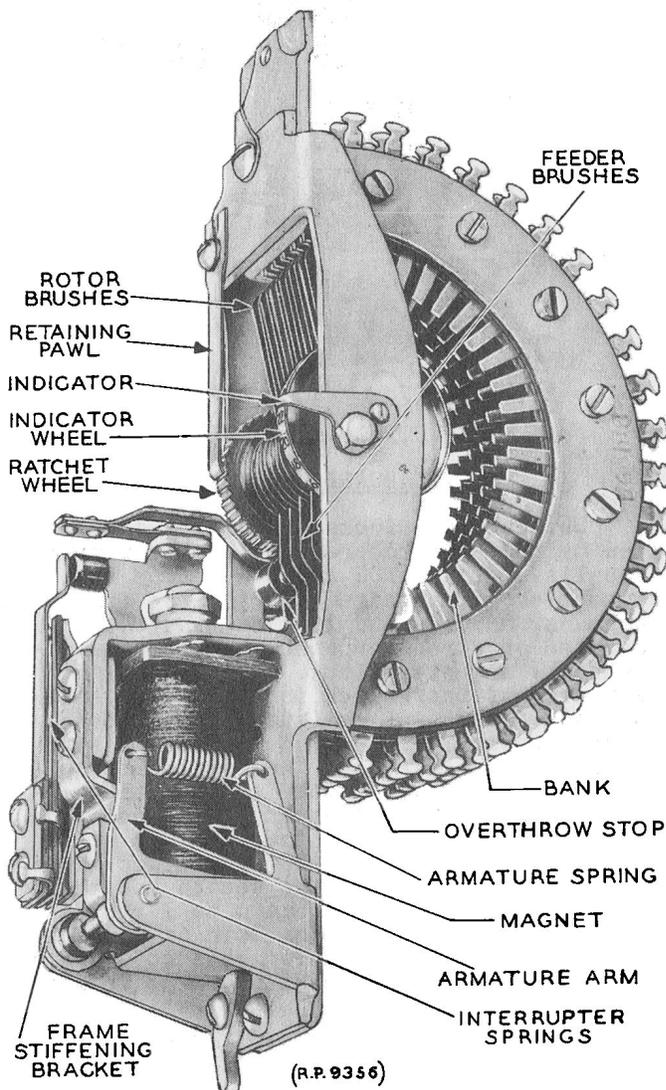


FIG. 104 206 TYPE SELECTOR

Many of the magnet cores in the more recently coded selectors are of permalloy. The use of permalloy speeds up the operation of the selector considerably because of the more rapid build up of the magnetic flux and quicker falling off. Consequently permalloy is used for magnet cores on selectors which must operate at higher speeds.

**Rotor Brushes:** Rotor Brushes have two types of contacting surfaces, bridging and non-bridging, as shown in Figure 106. The bridging brush has a contacting face approximately .110" long. These brushes are in continual contact with a terminal of the bank at all points in the rotation of the selector. There is usually a relay in series with this type of brush which would deenergize if there was even a momentary break in the circuit while the brush was passing from one terminal to the next.

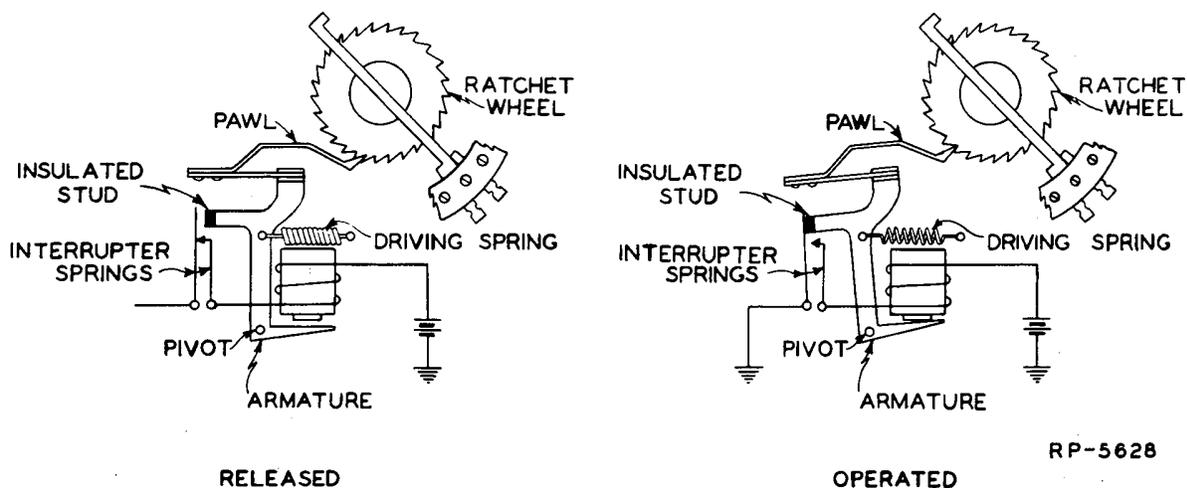


FIG. 105 OPERATION OF ROTARY SELECTOR

The non-bridging brushes have only a line contact face. These brushes, as well as the bridging brushes, have two contact fingers on each side of the brush. The object of the additional contact fingers is to increase the probability of contact. If one finger rides up over a dust particle the other finger is not lifted out of contact with the terminal.

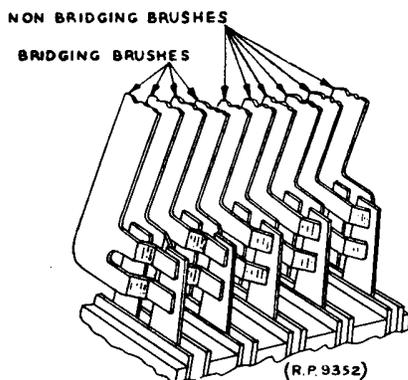


FIG. 106 BRIDGING AND NON-BRIDGING BRUSHES

206 and 209 type selectors have a percentage of lead in the phosphor bronze brushes and terminals. This lead acts as a lubricant which makes the brushes slide along over the terminals with less friction and consequently less wear.

There are several different arrangements of rotor brushes aside from the various combinations of bridging and non-bridging brushes. The ordinary rotor brush is double ended so that as soon as the brushes step off the last row of terminals at the top of the arcs, the brushes at the opposite end step onto the first row at the bottom of the arcs. Since there are but 22 terminals in an arc, the maximum circuit choices with a doubled ended

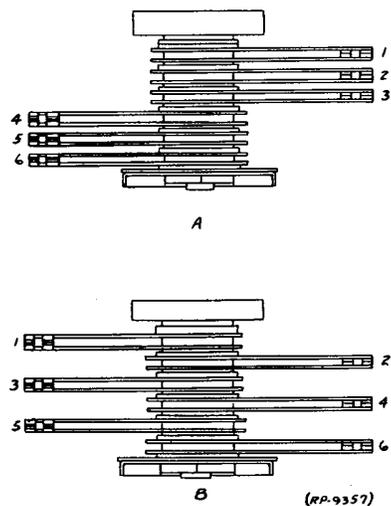


FIG. 107 BRUSH ARRANGEMENTS

brush are 22. By using pairs of single ended brushes pointing in opposite directions the number of circuit choices can be increased to 44. The example shown in Figure 107-A is the brush arrangement for the 206-M selector. The 206-AS, BA, BF, BP and BU selectors use the arrangement shown in Figure 107-B. These selectors are used in trunk hunting circuits in dial and manual offices.

#### FEEDER BRUSHES

The feeder brushes are fork shaped. They are situated in front of the first terminal of each arc and extend up to the rotor brush hub where each prong of the fork contacts with the hub. To reduce the possibility of harmful high resistance contacts developing between the feeder brushes and the rotor, some selectors are equipped with a detachable feeder brush unit. This unit clamps on to the selector at the top and the feeder brushes reach downward to

the rotor hub. A selector equipped with such a unit is shown in Figure 108. The 206 BE selector for example, used on Automatic Display Call Indicator and in the Central Information Desk, has this extra feeder unit as standard equipment wired in parallel with the other set of feeders. Detachable feeder brushes are also used where the existing brushes are worn. The latter are cut off and the detachable brushes then take their place.

#### NON-RIDIG MOUNTING

When 206 type selectors mounted adjacent to each other have talking circuits running thru the rotor brushes, they are usually mounted on heavy shock absorbing felt pads. An adjacent selector while rotating may set up enough vibration to cause noisy lines if the pads are not used.

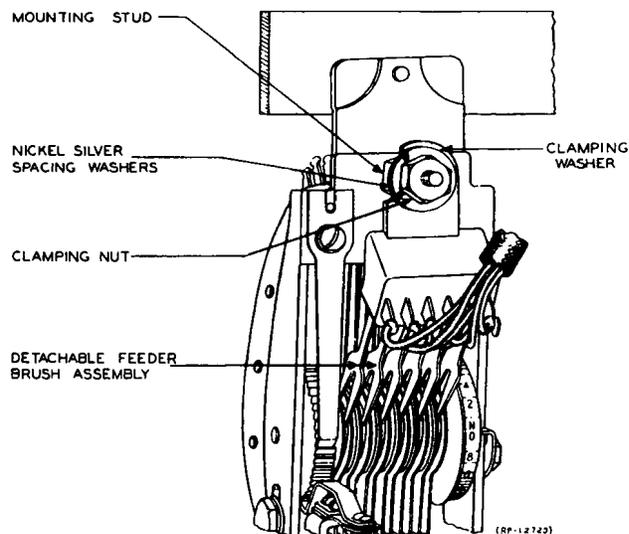


FIG. 108 SELECTOR EQUIPPED WITH  
DETACHABLE FEEDER BRUSH UNIT

#### QUESTIONS

1. Do the rotor brushes advance when the armature operates or when it releases?
2. What is the function of the interrupter springs?
3. What is the function of the brass stiffening bracket?
4. Why is the armature turned up at the sides?
5. What is the difference between a bridging and a non-bridging brush?
6. Why are bridging brushes used?
7. Why are single ended rotor brushes used?
8. Why are detachable feeder brushes used?
9. When are felt mounting pads furnished?

SECTION 10  
PROTECTORS AND FUSES

Practically every telephone circuit in the central office must be equipped with some form of protection which is sufficiently sensitive to operate before any damage to the equipment is done, but is not too sensitive to cause an unnecessary number of service interruptions. For the protection of the inside equipment, telephone lines enter the central office through protectors mounted on the main frame. These protectors consist of a protector mounting equipped with protector blocks and heat coils.

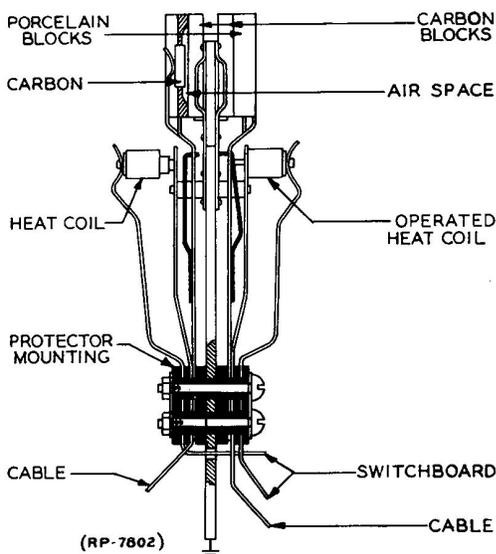


FIG. 109 DIAGRAM OF A PROTECTOR

A diagrammatic view of such a protector unit with protector blocks and heat coils is shown in Figure 109. The protector blocks on each side of the line, as shown in this figure, consist of a plain carbon block and a porcelain block. A small carbon block is mounted in the center of the porcelain block by means of a fusible cement. When held in the protector, the plain carbon block and the carbon insert of the porcelain block are separated by a gap of approximately .003". Any lightning or other high voltage discharge will jump across this small gap between the two carbon blocks and follow the framework of the protectors to ground. Sparking will cause the fusible cement in the porcelain block to melt, thus permitting the small carbon insert to make direct and permanent contact with the larger block and ground.

The heat coils associated with the protector are for protection against damage which may be caused by a subscribers line coming in contact with a power line. A 76 type heat coil, shown in Figure 110, consists essentially of a winding of fine alloy wire on a copper sleeve which is

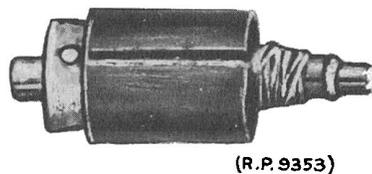


FIG. 110 76 TYPE HEAT COIL

soldered to a pin. When an excessive electric current passes through the winding of the coil, the soldered joint inside the coil will melt. Upon melting, the pressure of the protector spring on the head of the coil causes the pin to slip through the copper sleeve. An auxiliary contact spring resting against the free end of the heat coil pin is thereby brought in contact with the frame thus grounding the line as shown on the right-hand side of Figure 109. A cross-sectional view of a heat coil mounted in a protector is shown in Figure 111.

In the downtown offices of large cities, such as New York, where incoming cables are all underground, it is the practice to omit protector blocks and heat coils and replace them with dummy apparatus. The only function the protector mounting serves in this case is to provide a means for opening the lines for test purposes. This feature can be obtained by a simplified jack arrangement, known as the 444 type jack. Figure 112 shows a section of a 444 type jack. It consists essentially of a 1/8" vertical steel plate with pile-ups of terminals on each side of the plate. Contact springs connected to these terminals extend forward from the plate, forming two sets of normally closed contacts on each side. Each wire of an incoming line is brought through a pair of these normally closed contacts. By means of a special plug, the contacts may be opened and connections made to the contact springs for testing purposes.

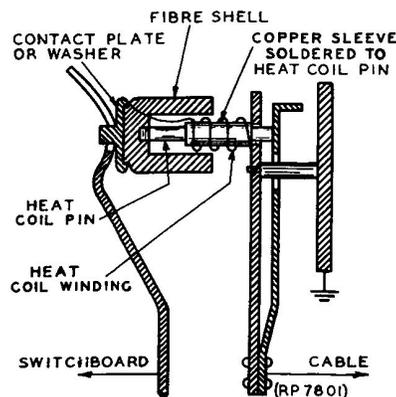


FIG. 111 CROSS-SECTION OF HEAT COIL

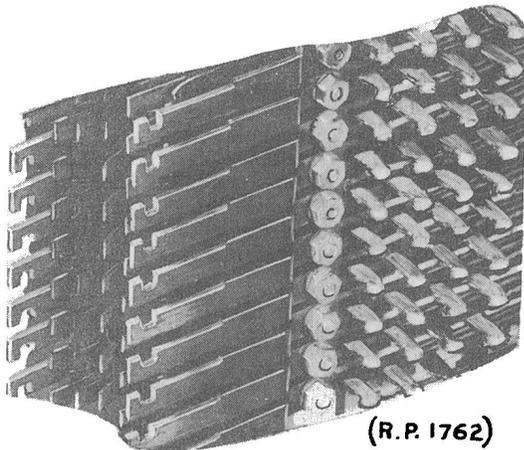


FIG. 112 SECTION OF 444 TYPE JACK

For the protection of local circuits in the central office against abnormal current values due to a short circuit or similar causes, fuses are used. The operation of a fuse is based upon the melting of an alloy at a low temperature. A fuse is usually constructed with a small wire or ribbon of the alloy, either encased in a fireproof container or arranged for mounting on fireproof panels.

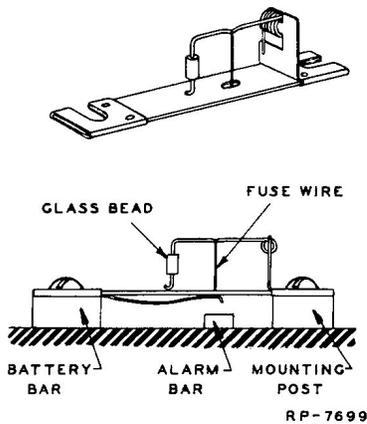


FIG. 113 35 TYPE FUSE

Fuses used for local telephone circuits are usually of the open type. Figure 113 shows one of the most commonly used fuses known as the 35 type. This fuse is

of the indicator alarm type and is generally referred to as a "grasshopper" fuse. It consists of a thin piece of mica with slotted tinned terminals at each end. The fuse wire is held taut between a small coil spring on top and a leaf spring on the bottom.

When the fuse blows, the springs are released and take up a position shown in Figure 114. The released leaf spring underneath the fuse now makes contact with a contact bar on the fuse board, thereby closing an alarm circuit which notifies the maintenance man by the ringing of a bell that a fuse has blown. In order to facilitate the location of a blown fuse on the fuse board, a glass bead is placed at the end of the coil spring. When the fuse blows, the beaded end projects beyond the line of the other fuses in such a way as to be readily located. 35 type fuses are made in various capacities and in order to facilitate selection, different colored beads are used with each separate capacity.

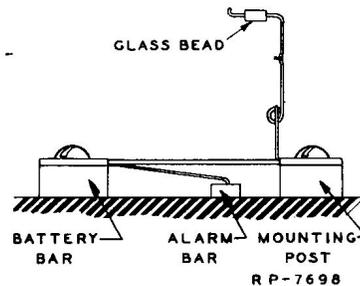


FIG. 114 35 TYPE FUSE BLOWN

Another open type fuse used quite extensively is the 24 type. This fuse is of the non-indicating type, consisting merely of a piece of mica with slotted copper or tinned copper terminals at each end and a piece of fuse wire strapped between the two terminals. See Figure 115.

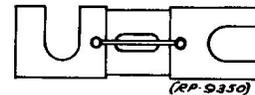


FIG. 115 24 TYPE FUSE

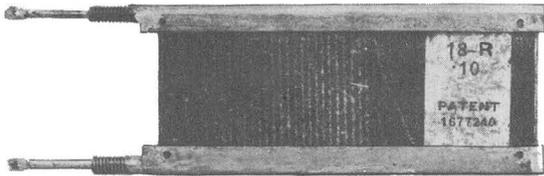
#### QUESTIONS

1. What are the component parts of a protector?
2. What is the function of a heat coil and how does it operate?
3. What happens when a protector block is subjected to prolonged sparking?
4. What kind of protection is used for local telephone circuits?
5. Why are 35 type fuses equipped with different colored glass beads?

## SECTION 11

## RESISTANCES

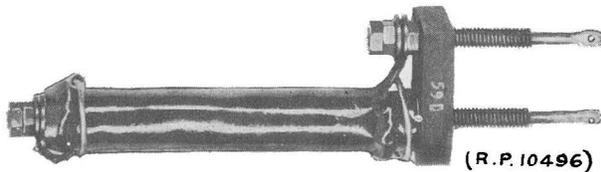
Resistances are one of the most commonly used devices in the telephone plant. In the majority of cases they are used to control the flow of current in a circuit, such as lighting of switchboard lamps, regulating current values through relay windings, etc. There are a number of different types of resistances, but all consist essentially of the resistance element proper and a suitable mounting.



(RP-9347)

FIG. 116 18 TYPE RESISTANCE

Two types of resistances similar in construction and used very extensively are known as the 18 and 19 types. The 18 type shown in Figure 116 is a single resistance while the 19 type has a third connection to an intermediate point of the resistance winding. These resistances consist of bare high resistance wire wound on a card of micanite, the windings so spaced that the turns are not in contact with each other. The winding is covered with micanite and the whole bound in place by metal strips which give mechanical strength to the edges and serve as terminals for the winding. Each terminal is equipped with two clamping nuts and insulating washers for mounting on a standard steel mounting plate. 18 and 19 resistances are made with resistance values from less than one ohm to nine thousand ohms and have a safe carrying capacity of approximately five watts.



(R.P. 10496)

FIG. 117 59 TYPE RESISTANCE

Another type of resistance used quite frequently in cases where the required current carrying capacity is above the maximum rating of the 18 or 19 type is shown in Figure 117. This is a vitrohms resistance of the 59 type, consisting of a porcelain spool and a resistance winding which is completely covered with vitreous enamel. The resistance unit is mounted on a small mounting plate by means of a metal rod passing through the center of the unit.

The ends of the winding are connected to terminals similar to those used for 18 type resistances. Other examples of resistances using vitreous enamel units are the 44, 60 and 71 types. Units of this type are also sometimes equipped with an Edison base for mounting in lamp sockets.

A typical high resistance of small size, known as the 38 type is shown in Figure 118. This resistance consists of either a carbon filament or silk core mandrelated resistance wire placed in the spiral groove of a cylindrical core of porcelain. Brass caps with mounting lugs on each end of the porcelain core serve as mounting and terminals. 38 type resistances are practically non-inductive and are used chiefly in connection with vacuum tube circuits.



(RP-9344)

FIG. 118 38 TYPE RESISTANCE

Resistances tubular in shape and having a low reactance, similar in appearance to the familiar pig-tail resistors in radio circuits, are also used in the telephone plant, primarily in carrier equipment. The 106 and 107 type resistances are examples of this kind, consisting essentially of a coil impregnated with bakelite and placed in a phenol fibre tube. Short pieces of tinned wire extending from both ends serve as terminals and are also used to support the resistance.

Another type of resistance used extensively for testing purposes is the 63 type shown in Figure 119. It consists of a non-inductive winding wound on a hollow brass spool equipped with phenol fibre spoolheads. Two winding terminals attached to one of the spoolheads serve as connecting points. The 3/16" diameter hole through the center of the core facilitates mounting by means of a screw, either singly or several mounted one above the other.



(RP-12731)

FIG. 119 63 TYPE RESISTANCE

In order to facilitate the mounting of resistances on relay mounting plates, 40 type resistances use an "E" type relay core as a support for one or more non-inductive windings. A non-inductive winding is generally made by winding simultaneously two conductors instead of one, with the two conductors short circuited at one end and the other ends brought out to terminals. Connection to a 40 type resistance is made through soldering terminals as on flat type relays.

For the protection of ringing and battery supply leads against short circuits and overloads, resistance lamps are placed in series with these circuits. The resistance of the tungsten filament in a resistance lamp increases considerably with the applied voltage, thus protecting the apparatus against abnormal current flow.

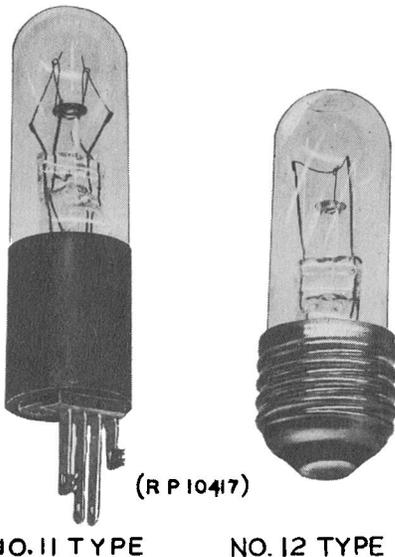


FIG. 120 11 AND 12 TYPE RESISTANCE LAMPS

Two of the most commonly used types are shown in Figure 120. The 11 type has two filaments and is equipped with a molded base with four soldering terminals. The 12 type has one filament and is equipped with the conventional medium Edison screw base.

Two other types of resistance lamps known as ballast lamps are shown in Figure 121. Ballast lamps are used as current regulators to maintain an approximate constant current within a rated voltage range. The filament is made of iron, the resistance of which increases much more rapidly at certain temperatures than at others. By designing the filament so that it operates at the point where this rapid increase in resistance takes place, the current through the filament (which is in series with the device to be controlled) is held very nearly constant even through the applied voltage may increase considerably.

Ballast lamps are usually equipped with either a screw base or a four prong radio base as indicated in Figure 121.

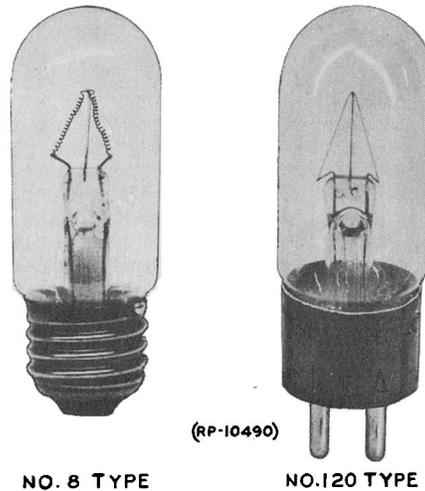


FIG. 121 8 AND 120 TYPE BALLAST LAMPS

While the above mentioned resistances have a definite specified value, except for changes due to temperature variations, variable resistances, called varistors are used in the Telephone Plant. They are either of the copper oxide or silicon carbide type. Both types possess the characteristic of decreasing in resistance with an increase in voltage applied to its terminals, thus permitting an increase of several times the normal current flow with but a small increase in potential. In addition, the copper oxide type is unidirectional, permitting current to flow freely through in only one direction.

A typical varistor of the copper oxide type used for the reduction of clicks in operator's telephone circuits is shown in Figure 122. It consists of two sets of three 3/4" diameter copper discs, oxidized on one side and bolted to a mounting bracket. Connections to the discs are made by two terminal lugs. The unit is covered with a black moisture proof varnish to increase its useful service life. The two sets of discs are connected in parallel so that a voltage of given polarity impressed across the unit will cause current to flow in the conducting direction through three of the washers, while with an opposite impressed polarity, current flows through the other three.

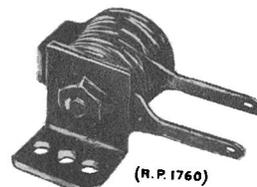
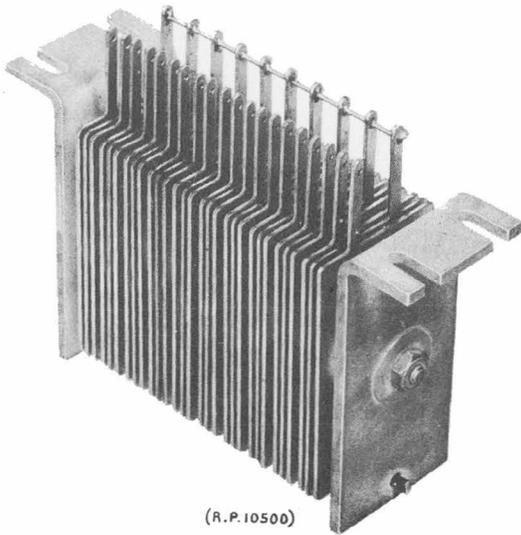


FIG. 122 3 TYPE VARISTOR

Since the direct current resistance of a copper oxide varistor decreases as the impressed voltage increases, the varistor when connected in shunt with an operator's receiver will by its operation effectively limit the amount of current which would otherwise flow thru the receiver.



(R.P.10500)

FIG. 123 300 TYPE VARISTOR

A silicon carbide type varistor is shown in Figure 123. This type is used in switchboards to protect line lamps in circuits which are exposed to severe induced voltages. It consists of an assembly of 20 silicon discs to form a unit which will provide protection for 20 subscriber's lines. When connected across a line the resistance of the varistor decreases rapidly as the voltage impressed across it is increased, thus providing a protective shunt for the lamp when abnormal voltages are impressed on the line conductors.

In addition to the above described varistors, other types have been coded and are mostly used as rectifiers in telephone power supply equipment.

#### QUESTIONS

1. What are resistances used for?
2. What is the approximate safe carrying capacity of 18 and 19 type resistances?
3. Where are resistance lamps used?
4. What is a varistor?
5. What type of varistor is used for click reduction purposes and how does it function?