Relays and Apparatus

Western Electric

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, fourth and fifth editions of this pamphlet, information on newly coded relays, crossbar switches, step-by-step switches and other apparatus has been added. Descriptive matter relating to obsolete equipment has been omitted and other changes have been made to bring the pamphlet up-to-date.

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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 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 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.

Other extensively used electrically operated switching devices described in this pamphlet are the crossbar switch and the step-by-step switch. While there are but a few basic types of these two devices, they vary in units to be operated and contact arrangements. 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, inductors and capacitors. Although there are a great many different kinds of transmission apparatus, only the mechanical and contructional details of representative types have been discussed.

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

SECTION 1

RELAYS

SECTION 1-A OPERATION AND GENERAL FEATURES OF RELAYS

In the discussion which follows it is assumed that the student has a general knowledge 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.)

GENERAL THEORY OF RELAY OPERATION

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.

MECHANICAL AND ELECTRICAL FEATURES OF RELAYS

Core and Armature

Magnetic Iron, Silicon Steel and a nickel steel alloy, called Permalloy, are the magnetic materials used for relay cores and armatures. Magnetic iron, a soft grade of iron, is used for most of the general purpose relays, such as the E, R, U, 221, 222, etc., types. Silicon steel and permalloy, which have a much higher permeability and lower coercive force, are principally used for relays requiring fast operate and release characteristics. Examples of relays with silicon steel magnetic parts are the AF, AG, AJ (wire spring) and B types. Silicon steel is also used for relays operating on ac, such as the J type. Typical examples of relays with permalloy magnetic parts are polarized relays of the 209 and 280 types.

Windings

There may be from one to four windings on a relay, designated Primary, Secondary, Tertiary, or Quarternary. At least one winding on every relay must be an inductive winding. In an inductive winding the current will always flow around the core in the same direction and thus cause the core to become magntized. 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 for relay windings on the older type of schematic circuit drawings.

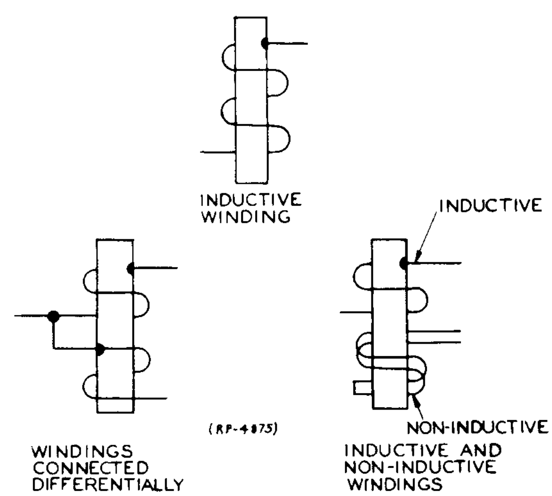


FIG. 1 RELAY WINDINGS

Annealed copper wire, ranging in size from No. 20 to No. 42 B & S gauge and having, as insulation, a covering of either enamel, formex, enamel and silk,or enamel and nylon 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 windings are made either by winding the required number of turns directly on the relay core,or by using multiple wound (or filled) coils which are slipped over the core. 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.

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 materials primarily used for relay contacts are No. 2 contact metal (palladium) and silver. Other materials sometimes used are tungsten and No. 4 contact metal (an alloy of palladium and copper).

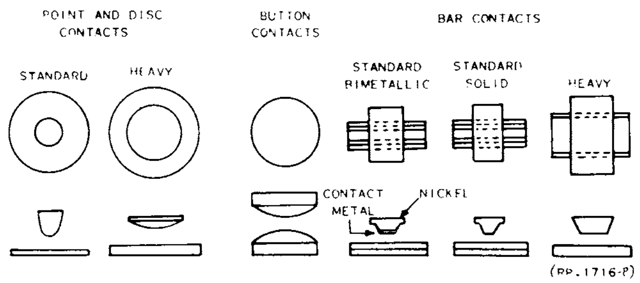


FIG. 2 RELAY CONTACTS

The sizes and shapes of relay contacts most widely used are shown in Figure 2. Contacts are either spot welded to the contact springs or tightly fitted to contact screws.

In order to prolong the life of contacts, contact protection networks are frequently used. They are for the purpose of eliminating the arcing at the contacts and consist of capacitance in series with resistance connected either directly across the winding of the relay,or across one end of the winding and battery or ground, as required.

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, which are necessary to insure satisfactory operation.

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 value only. Non-operate, hold and release values are specified where it is necessary to meet marginal circuit conditions. 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.

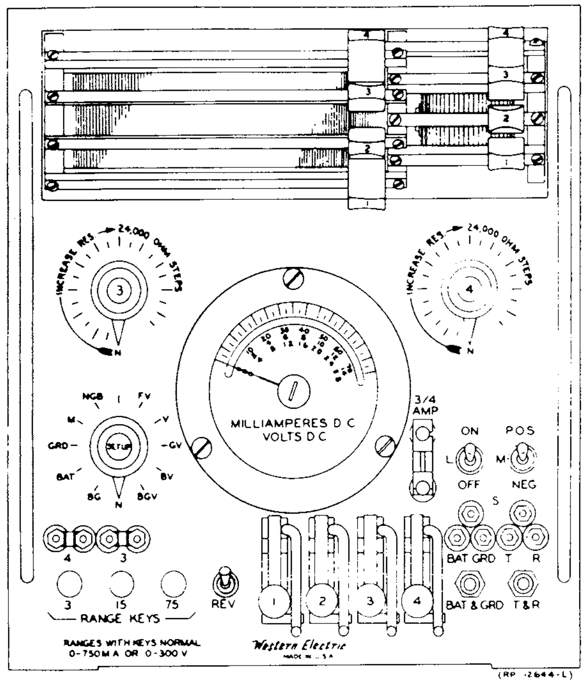


FIG. 3 D.C. ADJUSTING SET

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.

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. For the low shunt method of adjusting, the Telephone Company's maintenance test equipment, such as the AC Relay and Signaling Test Set (J68602-AJ) is generally available. A panel layout of this set is shown in Figure 4.

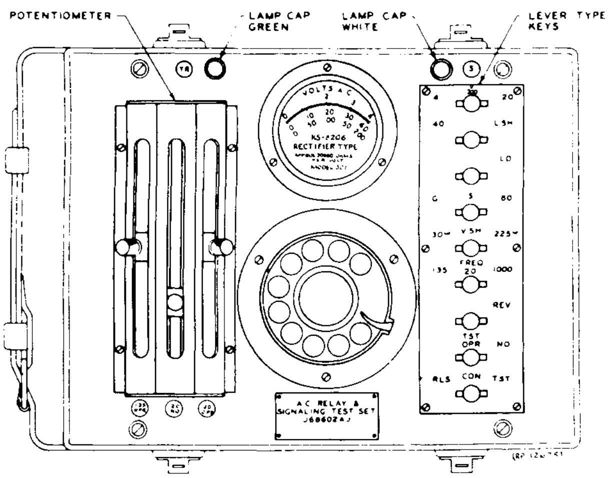


FIG. 4 AC RELAY AND SIGNALING TEST SET (J68602-AJ)

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 U type and 114 type. The individual relays are designated (or coded) by adding a number or letter to the type designation mark, such as U-188 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 is meant by a differentially wound relay?
4. What is the theory of a non-inductive winding?
5. What are the electrical requirements specified for relays?
6. What is the purpose of a soak value?
7. 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 RELAYS

A, 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. The punched design permits more flat type relays than relays of the old types to 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. 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.

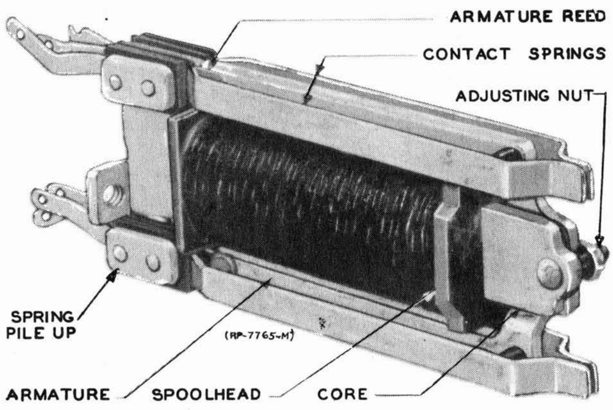


FIG. 5 "A" TYPE RELAY

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 discs are welded to the armature of most E type relays to prevent the armature from sticking as a result of residual magnetism.

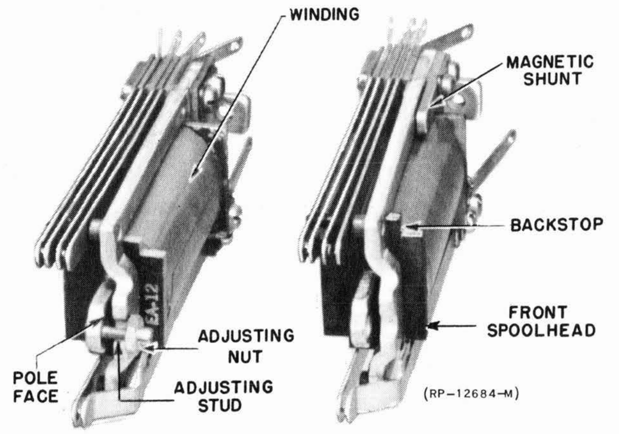


FIG. 6 EA TYPE RELAY

The EA type relay (see Figure 6) 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. The EA type relay shown on the right of Figure 6 is of a later design and

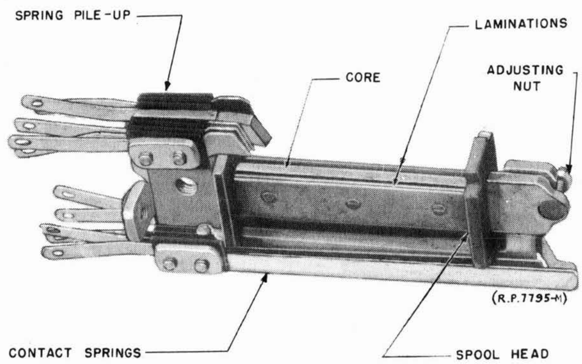


FIG. 7 CORE OF "H" TYPE RELAY

has a fixed armature travel. The armature stud and adjusting nut are omitted on relays of this design and a projection on the spoolhead serves as the backstop. In addition, to restore the magnetic efficiency lost by the use of a non-adjustable armature travel, the relay is provided with a magnetic shunt across the hinge gaps in the rear. Some EA type relays, 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.

The H type relay is an E type relay with 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.

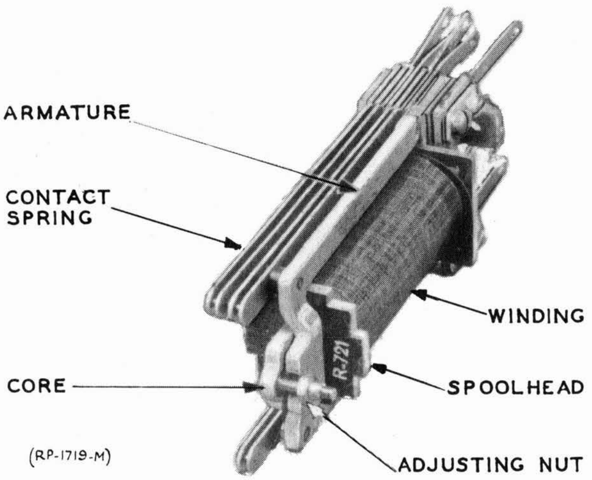


FIG. 8 "R" TYPE RELAY

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, designed to replace the A type, resembles the R type relay, except that the core and armature are made of thinner stock. The swaged core provides for greater winding space and the use of straight springs in place of the old type formed springs simplifies the adjustments for spring tension and contact separation.

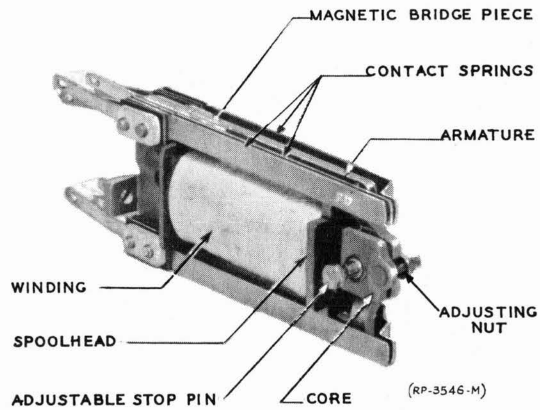


FIG. 9 "F" TYPE RELAY

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 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 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 nonoperate 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 with double or "bifurcated" contact springs, multiple wound (filled) coils and capable of operating heavy spring loads. There may be 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 with 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

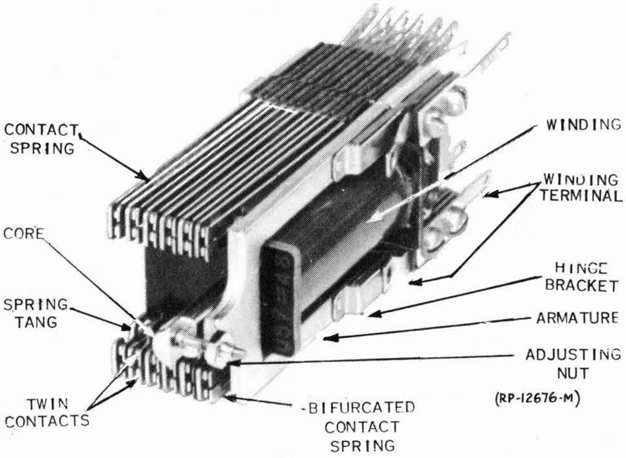


FIG. 10 "U" TYPE RELAY

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 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. The stationary springs are provided with tangs which fit into notches in the spoolhead. 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 core bracket. The armature is held in position by nickel silver reeds attached to each leg of the armature by rivets, located just in front of the armature hinge 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, permalloy shells can be assembled to the relay. These shells consist 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. The effect of the shell is similar to that of the laminations on the core of a G or H type relay. 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.

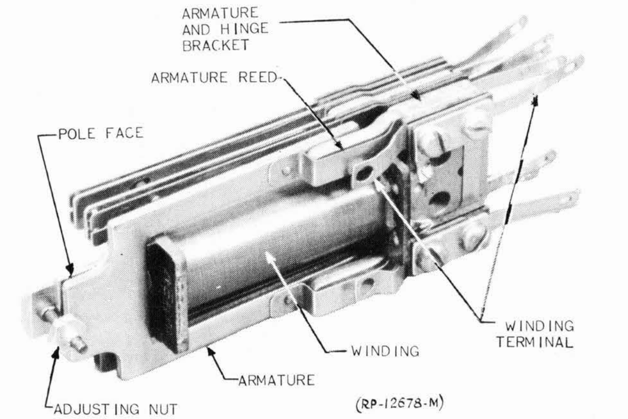


FIG. 11 "UA" TYPE RELAY

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 then the U type. Other differences are 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 some permalloy U type relays. Because of the more reliable contact performance, 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 and is held in position by two springs 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.

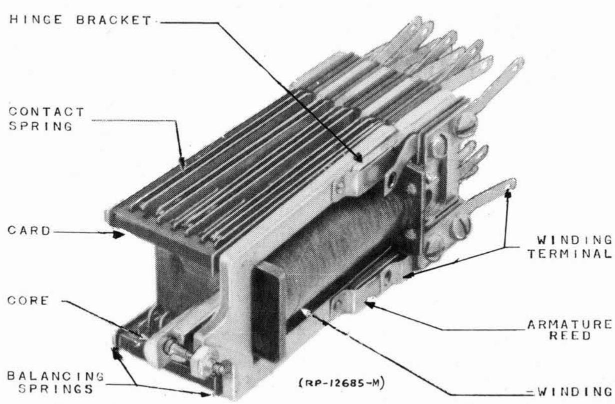


FIG. 12 "UB" TYPE RELAY

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. These modifications consist of the addition of a copper or aluminum sleeve over the core, embossed surfaces on the armature pole face and at the armature pivoting points, and the omission of stop discs. The embossed surfaces provide more definitely controlled operated air-gaps, assuring a uniformity of the manufactured product so far as releasing characteristics are concerned. For the desired time ranges, three sizes of copper sleeves and one size of aluminum sleeve are used. A detailed explanation of the slow operating and slow releasing features in relays is given under the heading of "Slow Acting Relays."

AF, AG and AJ Type Relays (Wire Spring Relays)

AF, AG and AJ type relays are newly developed relays intended to supersede the present U, UA, UB and Y type relays. They are known as wire spring relays, because spring wire instead of the conventional flat stock is used for the contact springs.

The important features that have been incorporated in these relays include the use of pretensioned springs, a fixed armature travel, a single fibre card for actuating the moving twin contact springs, a transparent contact cover and terminals arranged for wire wrapping connections. From an operational standpoint, the relays are capable of faster operate and release times, have reduced contact chatter and armature rebound, and negligible magnetic interference.

The wire spring relay consists essentially of an E shaped core with a filled coil, a U shaped armature, three or four molded contact spring blocks and a contact spring actuating card, held together in rigid alignment by a spring clamp. The magnetic structure, that is the armature and core, are made of silicon steel. Two sizes of armatures are provided, a short armature with 1/2" long legs for AF type relays and a long thicker armature with 1-1/4" long legs for AG and AJ type relays. The armature is supported by a hinge spring assembly and is held in position against the backstop by the tension of a U shaped balancing spring. A non-magnetic core plate, tightly fitted over the ends of the E shaped core, holds the three legs of the core in alignment. The core is zinc plated and the armature and backstop chromium plated to eliminate sticking on the backstop. Figure 13 shows a wire spring relay with the contact cover in place.

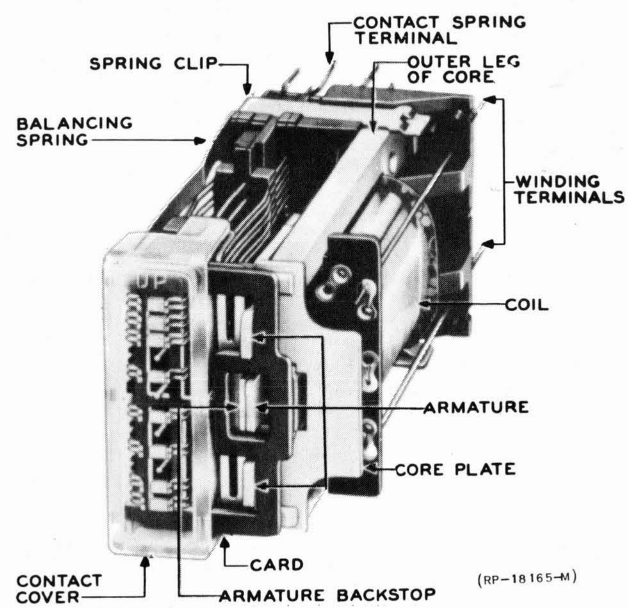


FIG. 13 WIRE SPRING RELAY

Three basic types of molded wire spring blocks or combs are employed, two for the moving nickel silver twin wires for make and break contacts, and one with 12 heavy silicon copper wires for the fixed contacts. No. 2 contact metal is used on the contacting surfaces. The spring wires are actuated by a single phenol fibre card, held against the armature by the tension of the balancing spring. The twin wires that form the make contacts are tensioned against the outer edge of the card, and the twin wires that form the break contacts are tensioned in the opposite direction against the inner edge of the card. As the armature moves toward the core, the card allows the twin wire make contact springs to move forward and make contact with the fixed contacts. As the armature movement continues, the card picks up the twin wire break contact springs to open the break contacts.

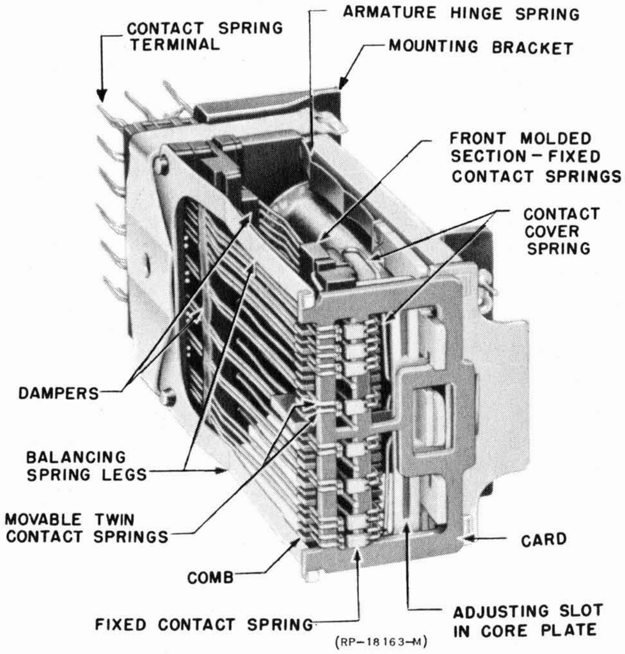


FIG. 14 12 POSITION AF TYPE RELAY

Wire spring relays are equipped with either 12 or 24 contact positions, arranged in two vertical rows of movable twin contact springs and one or two rows of fixed contact springs. The twin wire contact springs are held in position by guide slots in the fixed contact spring block. Figure 14 shows a 12 position AF relay with the cover removed. A 24 position AJ type relay without cover is shown in Figure 15

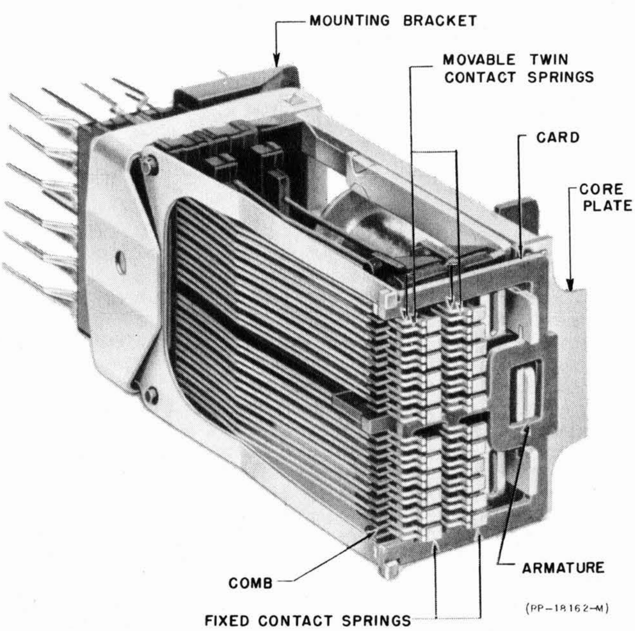


FIG. 15 24 POSITION AJ TYPE RELAY

The twin wire contact springs mounted to the left of the associated fixed contact springs provide the make contacts, and those to the right the break contacts. In addition to ordinary make and break contact arrangements, the make and break contacts can be operated in three stages of the armature travel, designated preliminary, early and late, to meet contact sequence requirements. This is obtained by providing recesses for early makes, and shoulders for early breaks, on the edges of the card which engages with the twin wires. Twin wire contact springs are omitted in any contact position where no contact make or break is required. Although the fixed contact springs are always provided, the entire contact portion is omitted when not required.

In order to meet release requirements, some wire spring relays are provided with a U shaped buffer spring. The pretensioned legs of this spring have notches that engage with the front spoolhead to hold the spring in position on the relay. Wire spring relays operating at high speed, such as pulsing relays, are equipped with dampers to reduce vibration of the movable wires. The dampers consist of a strip of soft material placed between each movable wire spring assembly and the rear molded section of the fixed contact spring assembly. To facilitate the application of electrical requirements, the winding terminals of wire spring relays extend through the front spoolhead.

Each wire spring relay is provided with a molded plastic cover that is held in position by means of a cover spring attached to the front molded section of the fixed contact spring assembly. The cover encloses only the contacts, protects them from dirt and traps the twin wires in the guide slots to avoid displacement and crossing during shipment and pressure cleaning operations.

There are three types of wire spring relays, designated AF, AG and AJ. The AF type relay shown in Figure 14 is a general purpose relay, equipped with a short armature and stop discs. The operate and release times of this relay are approximately one half the time required by a comparable U type relay. The AG type relay is a slow releasing relay to replace the Y type. Like the Y type relay, it is generally equipped with a copper or aluminum sleeve over the center leg of the core, uses a thick armature with long legs, and is provided with a dome shaped embossing on the armature in place of stop discs. The AJ type relay is used for operating the heavier spring loads and also for light loads where greater sensitivity is required. It has a thicker armature with long legs and uses stop discs.

Some AJ type relays are provided with laminations, consisting of a strip of iron on each side of the core to obtain increased impedances at talking current frequencies. A copper sleeve over the core and two copper washers and one iron washer over the front end of the core are used on the AJ 25 relay. This relay is for use as a trip relay in incoming trunk circuits. The action of the copper sleeve and copper washers is similar to the copper sleeve and copper head on 114 type trip relays, described in another section. The iron washer, placed between the copper washers increases the leakage flux between the core and the armature, which makes the relay more insensitive to the ac

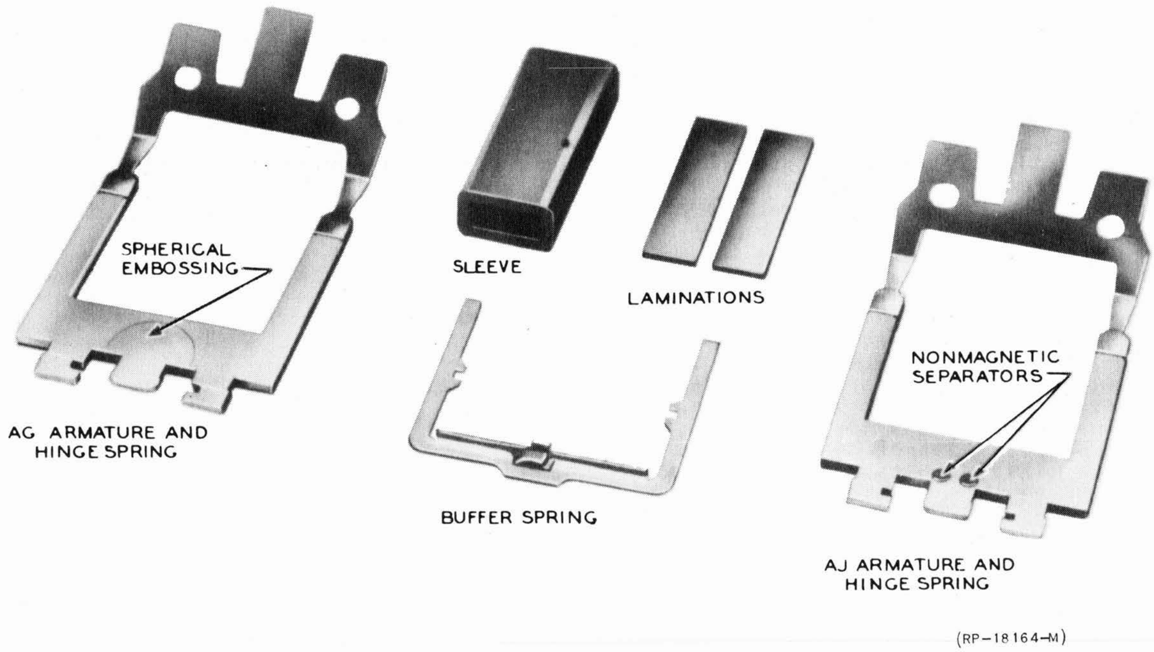


FIG. 16 ARMATURE AND ADDITIONAL PARTS OF AG AND AJ TYPE RELAYS

ringing current. The armatures and most of the additional parts used in the construction of AG and AJ type relays are shown in Figure 16.

Where more than 12 make contacts are required, AJ type relays with 24 make contact positions are provided. The 24 make contact relay uses four molded wire blocks, two with twin wire moving springs and two with fixed contact springs, as shown in Figure 15. To prevent crosstalk between adjacent relays, AJ type relays, when used in transmission circuits and are mounted at close centers, are fitted with a magnetic crosstalk shield. Figure 17 shows an AJ type relay with crosstalk shield.

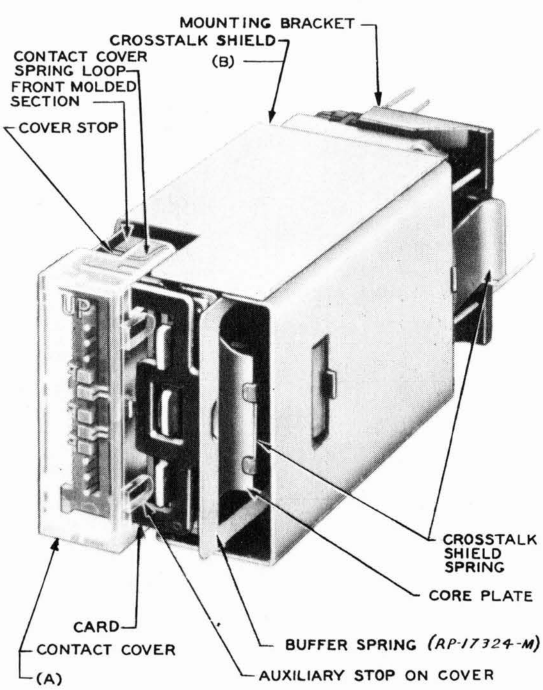


FIG. 17 AJ TYPE RELAY EQUIPPED WITH CROSSTALK SHIELD

The requirements and adjusting procedures for wire spring relays have been reduced to a minimum. Contact spring tension and armature travel requirements have been eliminated, since the relays are equipped with pretensioned springs and use a fixed armature travel. Adjustments are few and include changes in balancing spring tension to meet armature back tension requirements, adjustment of separation between movable and fixed contacts to meet contact make and break requirements, and adjustment of the buffer spring on relays so equipped.

B and G Type Relays

B and G type relays are commonly 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 type of cover used. Figure 18 shows a B type relay of the initial design with the cover removed. A description of B and G type relays of the modified or new design is given in a subsequent paragraph.

The armature of B and G type relays is U shaped, with the closed end extending across the pole piece end of the core. The legs of the armature are riveted at the rear to a thin steel hinge which is assembled in the pileup. The core is enlarged at the front end to form the pole piece, and at the rear end to form the frame for mounting the armature and springs. The assembly is held together in the rear by two iron yokes, equipped with mounting holes and projections for supporting the cover. Three adjusting screws, located in the brass front spoolhead, provide for changes in the positions of the contact springs and the tension of the armature spring.

In order to meet the sensitivity and marginal requirements encountered in supervisory circuits, a core of small cross sectional area is used for B and G type relays. Since the magnetic pull of a small core is necessarily low, the armature and core are made of 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.

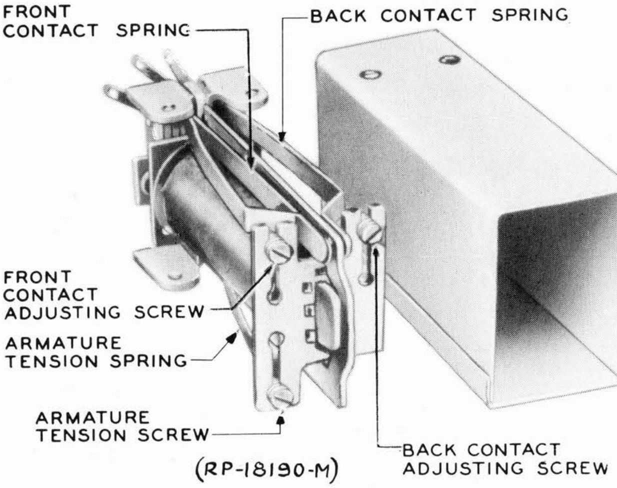


FIG. 18 B TYPE RELAY - INITIAL DESIGN

Most B type relays of the initial design are provided with a thin sheet steel cover with removable cap, which is attached by screws to the yokes of the relay. The purpose of this cover is to protect the relay and to strengthen it. A heavy steel cover is used on some B type relays to avoid transformer action or crosstalk between adjacent relays as explained for the G type relay.

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 acts as a shield against the stray flux from adjacent relays. The principle of shielding against stray flux is illustrated in Figure 19.

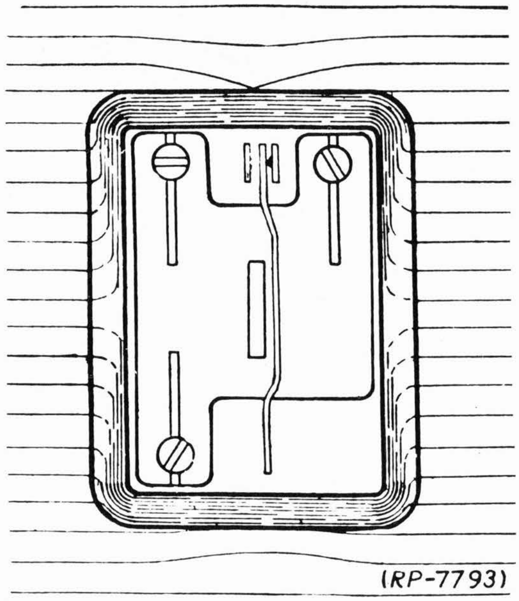


FIG. 19 EFFECT OF COVER OF "G" TYPE RELAY ON EXTERNAL STRAY FIELD

A B type relay of the modified or new design is shown in Figure 20. In this design, intended to improve the stability of adjustments, the following changes have been incorporated. In order to obtain a more rigid support of the relay structure inside the shell, the iron yokes in the rear have been replaced by two comparatively free positioning L shaped brackets attached

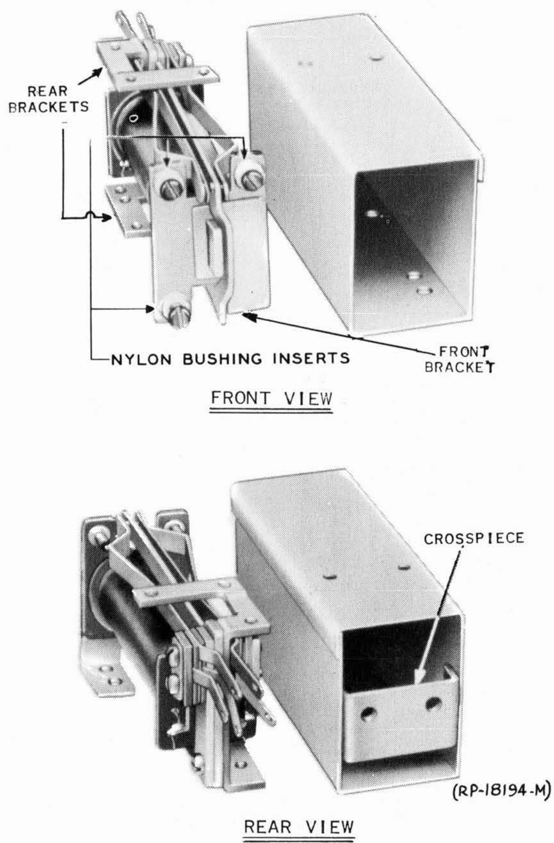


FIG. 20 B TYPE RELAY - MODIFIED DESIGN

to the rear end of the core, and a motion limiting supporting bracket around the front end of the core. The L shaped brackets, which are sufficiently flexible to conform to the shell without distortion of the armature and core alignment, and the supporting bracket in front, are securely attached to a stiff cover, thicker than that previously used. The cover is provided with a very stiff mounting crosspiece, welded across the rear opening for securing the relay to the mounting plate. The adjusting screws are self tapping and fit into nylon bushing inserts in the adjusting plate. The use of self tapping screws provides better thread engagement and facilitates meeting the screw torque requirements in the factory. Other improvements include the use of pretensioned springs for the heavy contact springs to minimize distortion of the relay structure during initial shop adjustment, and a transparent plastic cover for observing the operation of the relay without the need of removing the cover.

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.

209, 215, 218-B, 255, 266 and 280 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.

209, 215 and 255 Type Relays

These relays are of the plug-in type and have no soldering terminals. The windings and contacts are 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 circuit of these relays (see Figures 21 and 22) resemble that of a Wheatstone Bridge. A permanent horseshoe magnet for polarizing the relay is mounted below the coil and is held in position by the pole piece mounting screws. Mounted on top of the ends of the permanent magnet are two pole pieces with pole piece screws. Pole piece extensions to the rear end of the armature provide the return path for the

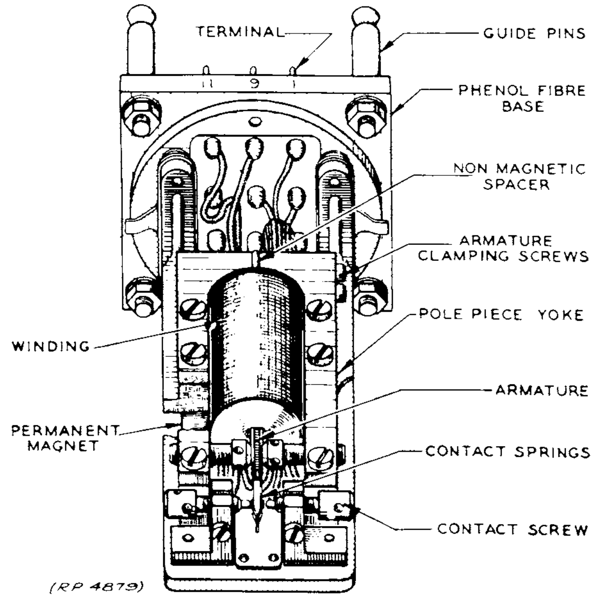


FIG. 21 209 TYPE RELAY

magnetic flux. The armature, which is of the reed type, is rigidly secured at the rear to a mounting block and, on the 209 and 215 type relays, is separated from each of the pole piece extensions, or return pole pieces, by a separator of non-magnetic material. On the 255 type relay a single non-magnetic detail, inserted between the tops of the pole pieces and a U shaped return pole piece, takes the place of the two non-magnetic spacers used on the 209 and 215 types. 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 two gaps of non-magnetic material 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 23), 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, then through the armature, the non-magnetic spacer, return pole piece, to the right hand pole piece (assumed to be a south pole). A movement of the armature to the right causes some of the polarizing flux to flow through

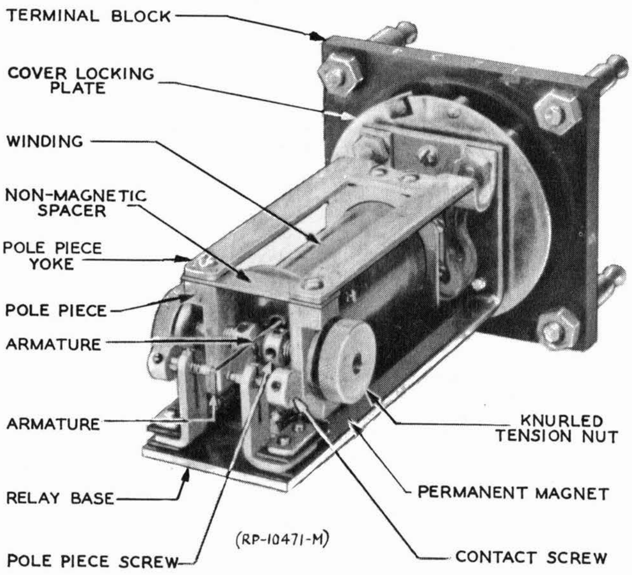


FIG. 22 255 TYPE RELAY

the armature in the opposite direction; that is, from the left hand pole piece and return pole piece through the non-magnetic spacer to the armature, then through the arma-ture, 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 its mid-way position in the air gaps due to its natural stiffness, which opposes the polar-izing force as the armature is displaced.

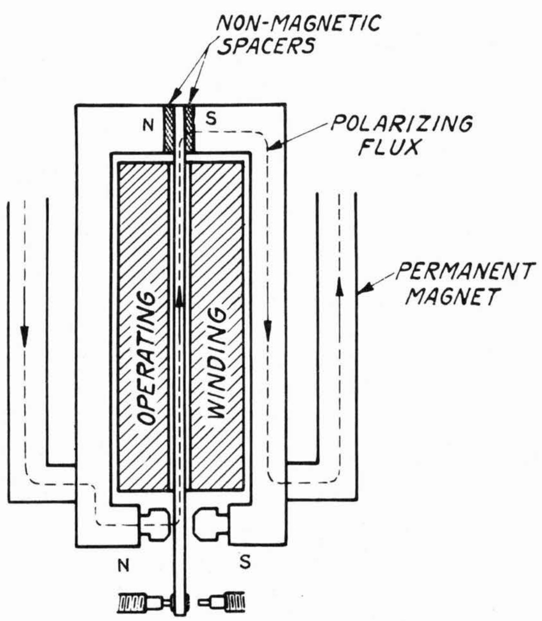


FIG. 23 POLARIZING FLUX THROUGH ARMATURE OF 209 TYPE RELAY

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 suffi-ciently 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 oper-ating current. The application of this oper-ating current causes the free end of the armature to become either a north or a south pole (see Figure 24), depending upon the direction of the current, and it is drawn toward that pole piece which possesses 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, there-fore, more sensitive than the ordinary neu-tral relay.

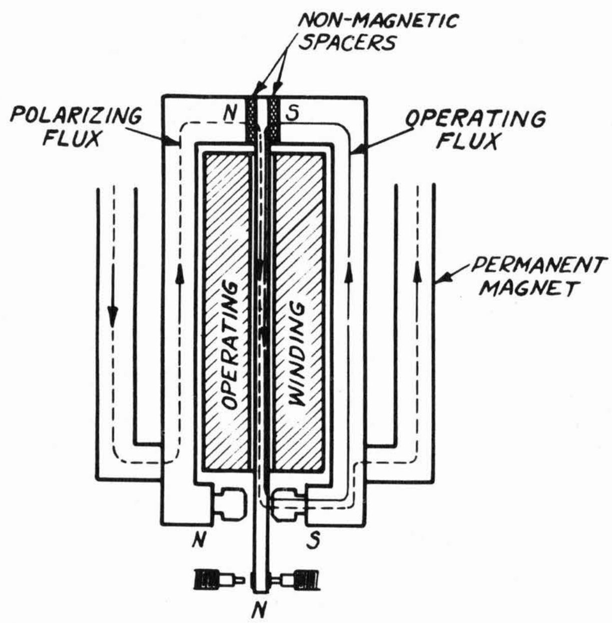


FIG. 24 OPERATING FLUX AND POLARIZING FLUX THROUGH ARMATURE OF 209 TYPE RELAY

209, 215 and 255 type relays are pro-vided with front and back contact screws which, in addition to functioning as con-tacts, also limit the armature travel as stated previously. In order to affect a longer and better contact closure, the relays are equipped with a chatterless arma-ture, 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 pole piece screws are securely held in their adjusted position either by clamping screws or locknuts, except on the 255 type where knurled tension nuts are used for ease of adjustment. 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. Either permalloy or magnetic iron, or both, are used for the magnetic material of these relays. Relays of the 209 type use permalloy only, whereas both materials are used in the construction of the 215 and 255 types. 209, 215 and 255 type relays are principally used for telegraph service. Changes in armature air gap or pole gaps (which also change the strength of the polarizing flux) and contact travel, are the means used in conjunction with the electrical values for adjusting these relays.

280 Type Relays

The 280 type relay shown in Figure 25 is a new improved general purpose polarized relay, replacing the 206 and 239 type relays previously used. The basic arrangement of the parts and the magnetic circuit of this relay are similar to the 255 type, except that it is provided with soldering terminals instead of plug-in contacts. For greater stability of adjustment, as compared with the 206 and 239 types, the new relay incorporates the following features. To minimize the effects of vibration and shock, the relay structure is mounted on a rigid aluminum alloy die-cast frame. A short bar type permanent magnet of remalloy (an alloy of molybdenum, cobalt and iron) is used in place of the relatively long horseshoe

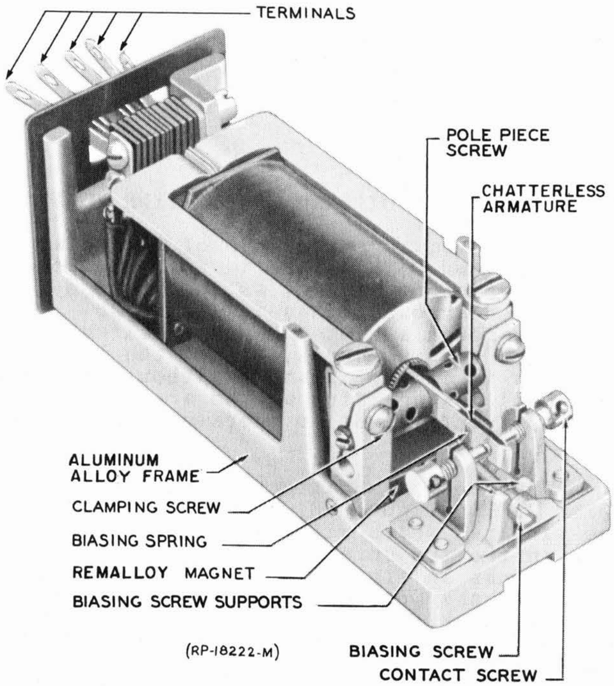


FIG. 25 280 TYPE RELAY

permanent magnet. This provides the relay with more polarizing flux at the working airgaps, permitting the use of bigger airgaps with subsequent ease of adjustment. Mica instead of phenol fibre is used to insulate the contact brackets from the frame, since dimensional changes in mica caused by humidity and temperature are very small. Thus the use of mica insulators for the contact brackets adds to the stability of the contact adjustment. The filled coil provides more uniform impedance and speed characteristics.

The magnetic materials used for 280 type relays are permalloy for the armature, pole piece screws, return pole pieces, and cover; remalloy for the permanent magnet and magnetic iron for the remainder of the magnetic structure. The thicker cover provides additional stability and minimizes magnetic interference. All 280 type relays use a chatterless armature and may or may not be equipped with a biasing spring for holding the armature in its unoperated position against the right hand contact. On relays not equipped with a biasing spring, the armature in its unoperated position may be resting against either the left or right hand contact.

218-B Relay

The 218-B relay (see Figure 26) 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 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. ac 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

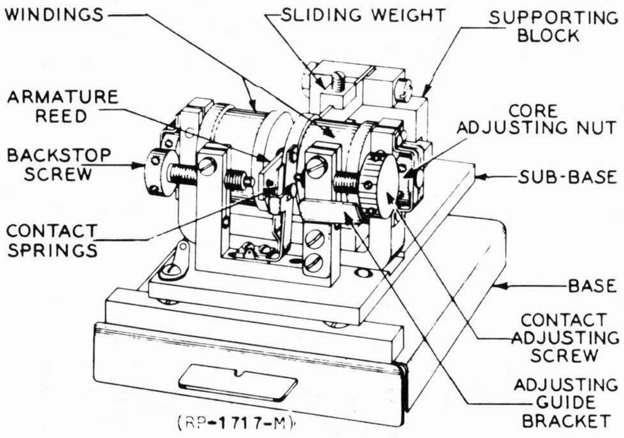


FIG. 26 218-B RELAY

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.

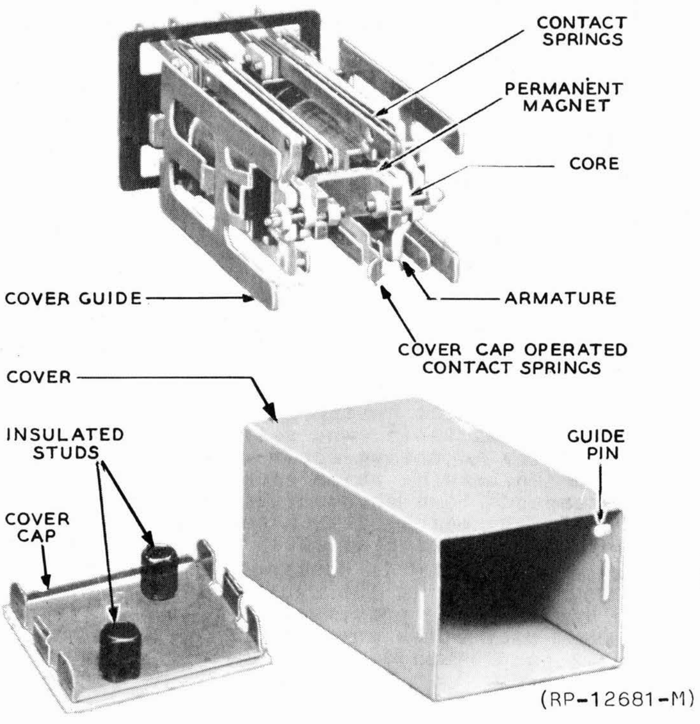


FIG. 27 266 TYPE RELAY

266 Type Relays

The 266 type relay shown in Figure 27 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 steel 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.

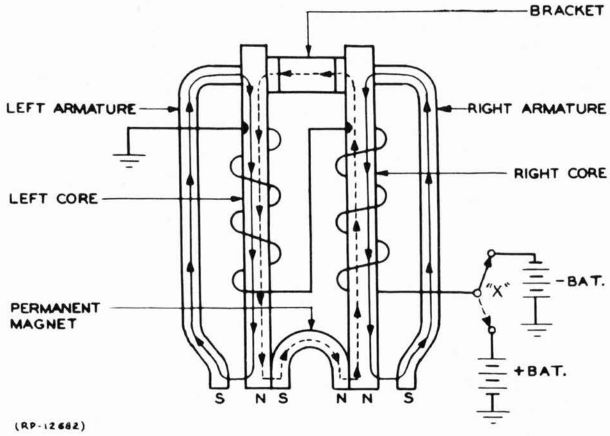


FIG. 28 FLUX DIAGRAM OF 266 TYPE RELAY

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 28, 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 28, 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 28. 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 28, 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.

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

These relays are known as step-by-step relays because they are largely associated with step-by-step equipment. They are equipped with a round core and a short armature. Attached to the core in the rear with a screw is an L shaped bracket, which extends to the front end of the relay. The bracket, known as the heelpiece, forms the return pole piece for the magnetic flux. Attached to the front end of the heelpiece with a yoke set screw is the armature yoke which supports the armature. A phosphor bronze pin attached to projections on the armature and turning in holes in the armature yoke forms a bearing which does not bind, wears very slowly and is practically without side play. A brass screw with a locknut, inserted into 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 29.

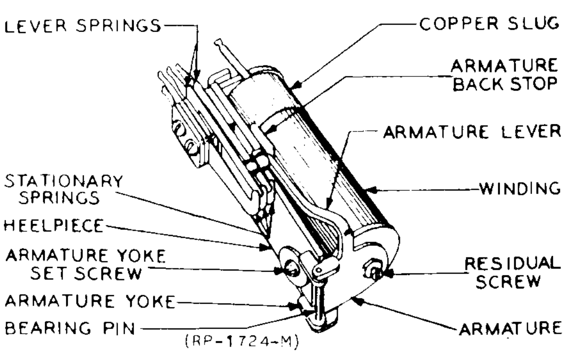


FIG. 29 221 TYPE RELAY

For operating the contact springs, the armature is equipped with either one or two armature levers, or arms, with a hard rubber armature stud at the end. The contact springs are mounted at the rear 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 to 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 switch plates and on relay racks include the 221, 223, 247 and 251 types, while the 222, 224, 248 and 252 types are intended for mounting on the right hand side of switch plates. The magnetic material used for the core, return pole piece and armature of step-by-step relays is magnetic iron. Differences in construction between the various types of relays are given in the following paragraphs.

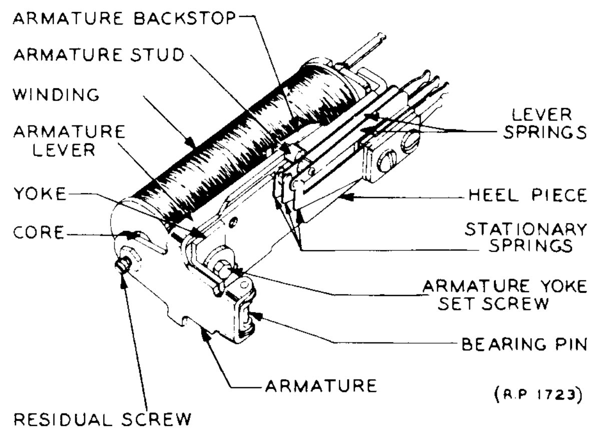


FIG. 30 248 TYPE RELAY

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 2-1/2 : 1 on the relays, except on the 247 and 248 types, which have a ratio of approximately 1 : 1. See Figure 30. 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 2-1/2 : 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 2-1/2 : 1, the contact springs are mounted on the front end of the heelpiece and the contacts are facing the rear.

The 251 and 252 type relays are 3 pole electro-polarized relays. See Figure 31. 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:

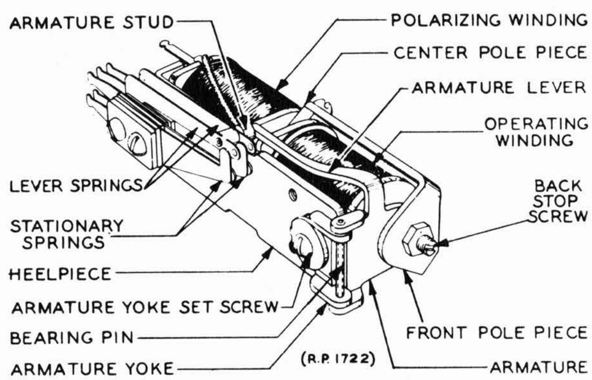


FIG. 31 251 TYPE RELAY

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.

Step-by-step relays are adjusted by changing the tension of the moving springs, the position of the stationary springs and by varying the armature air gap, contact separation and contact follow. The unoperated air gap is regulated by an adjustment of the armature lever and the operated air gap by means of the residual screw.

<u>229, 230, 263, 264, 286, 287 and 288 Type Relays (Multicontact Relays)</u>

Multicontact relays, as the name implies, are relays capable of operating a large number of contact springs. A detailed description of these relays, in the order of their development, is given in the following paragraphs.

<u>229 and 230 Type Relays</u>

These relays 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.

The 229 type relay shown in Fig. 32 is a single unit relay, while the 230 type is a double unit relay having two magnets, each of which operates its own draw bar and contacts. The 229 type is equipped with 50 make contacts and 2 sets of transfer contacts, whereas on the 230 type each unit has

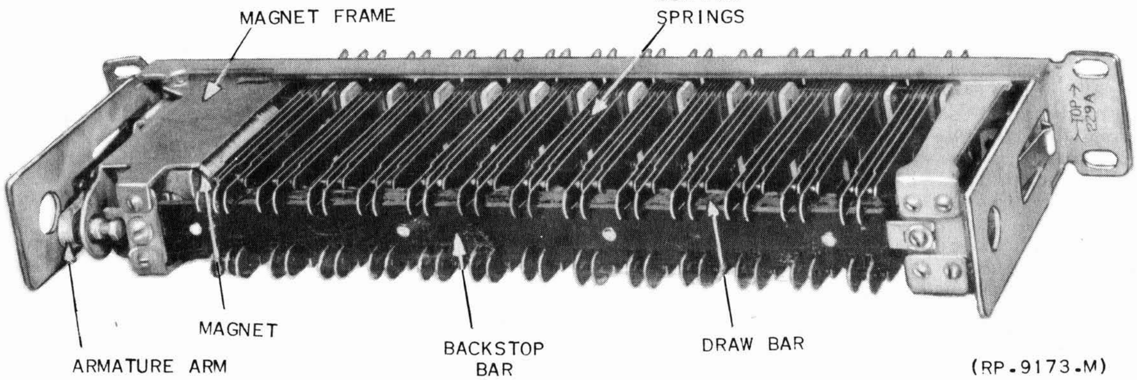


FIG. 32 229 TYPE RELAY

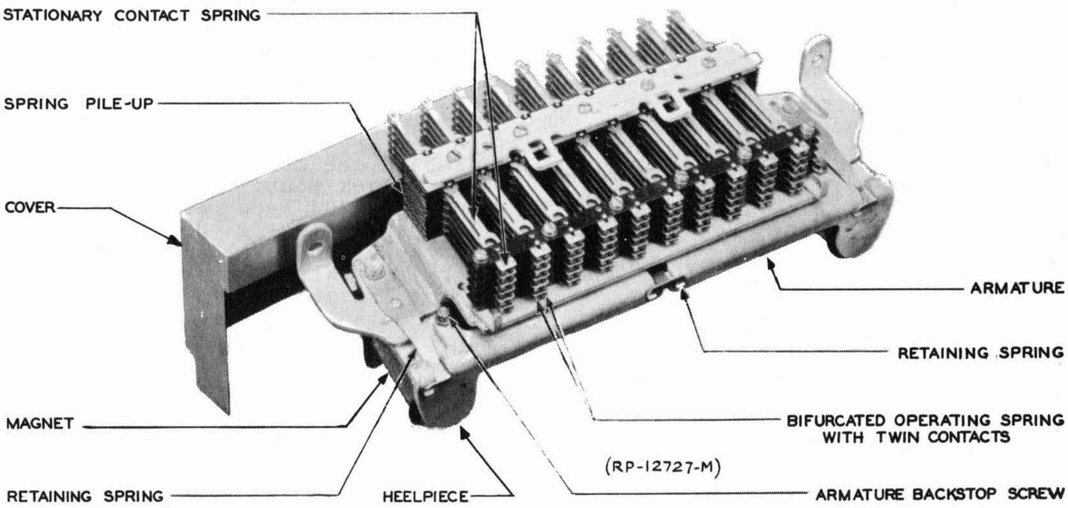


FIG. 33 263 TYPE RELAY

40 make contacts and 2 sets of transfer contacts. 229 and 230 type relays are used in panel dial decoder circuits. The adjustable features for these relays include changes in armature travel, contact separation and spring tension.

263 and 264 Type Relays

The 263 and 264 type relays are multicontact relays used 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 33.

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 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 heelpiece, 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 requirements specified for 263 and 264 type relays include armature travel, contact separation, spring tension, contact make and electrical operate values.

286, 287 and 288 Type Relays

The 286, 287 and 288 type relays are newly developed multicontact relays of the wire spring type and supersede the 263 and 264 types. They employ many of the features of the general purpose wire spring relays (AF, AG and AJ types) such as pretensioned wire springs, molded wire spring blocks, transparent plastic contact cover, an E shaped core, etc. Like the general purpose wire spring relays, they are capable of faster operate and release times and have reduced contact chatter and rebound.

A 286 type relay with contact cover is shown in Figure 34. The relay has 30 make contacts arranged in 2 rows of 15 contacts. Each row again is subdivided into five groups of three contacts. The relay has an E shaped core of silicon steel that is similar but much larger than that of the general purpose wire spring relay. A non-magnetic core plate, tightly fitted over the ends of the E shaped core, holds the three legs of the core in alignment. The magnetic iron armature is U shaped with two short

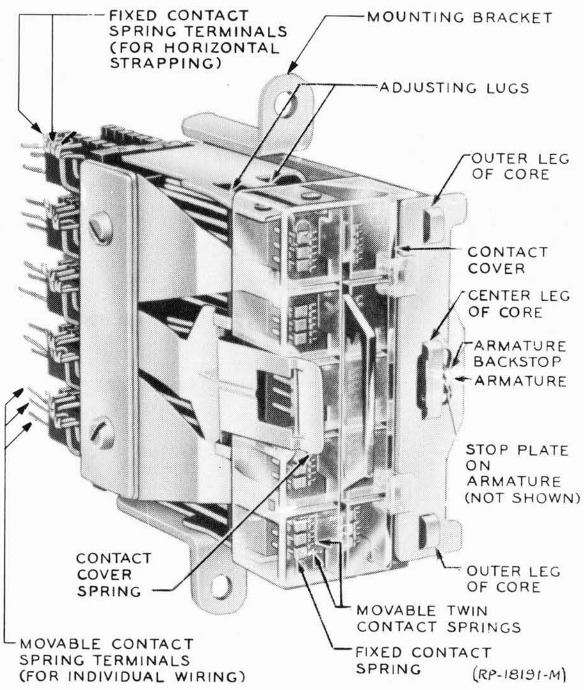


FIG. 34 286 TYPE RELAY

legs that serve as pivot points. It is made thin to obtain a low mass moving element and has a triangular shaped cutout to decrease the pole face area for obtaining the most favorable operating time. The armature is held in place by a retaining or hinge spring which bears against the two legs of the armature to hold them against the core legs. This spring pressure also holds the armature against the actuating card which in turn is being held against the core legs by the balancing spring. Details at the ends of the spring fit into slots in the armature to hold the armature in the proper position.

Multicontact wire spring relays are provided with four molded wire spring blocks, two that contain the moving nickel silver twin wires and two with the heavy silicon copper wires for the fixed contacts. In the unoperated position of the relay, the twin contacts are held away from the single contacts by an actuating card which in turn is held against the two side legs of the core by two prongs of a three-pronged flat balancing spring. The third prong of the balancing spring holds the cover in place. When the relay is energized the armature moves the actuating card forward, allowing the twin-wire contacts to make with the stationary fixed contacts. The operation of the armature differs from the general purpose wire spring relay in that the armature operates from right to left instead of left to right and pushes, rather than pulls, the operating card.

286 type relays are intended for use in new circuits instead of the 263 type, but are not interchangeable with the 263 type. The terminals of the movable twin contact springs on 286 type relays are arranged for individual wiring, while the terminals of the fixed contact springs are arranged for horizontal strapping.

The 287 and 288 type relays consist of an assembly of two units, each similar to the 286 type relay. These units are assembled one above the other on a bracket and the relays mount interchangeably with all 263 and 264 type relays. The 287 type relay, shown in Fig. 35, which replaces the 263 type, has movable twin contact spring terminals arranged for individual wiring and fixed contact spring terminals arranged for horizontal strapping. This arrangement of terminals is the reverse of that on 263 type relays. On 288 type relays, which replace the 264 type, the terminals of both fixed and movable contact springs are arranged for individual wiring, as in the case of the 264 type relay.

287 and 288 type relays are intended as replacements for the 263 and 264 type relays in existing equipment and must therefore match the speed of the 263 type. Since the 286 type is considerably faster operating and releasing than the 263 type, the two 286 type units used on 287 and 288 type relays incorporate the following changes in design to match the speed of the 263 type. To increase the operating time, the 286 type unit is provided with a magnetic shunt across the three legs of the core to increase the leakage flux, a thicker armature to increase the moving mass and a core of magnetic iron instead of silicon steel. Other changes to obtain the required operating and releasing times include an increased number of turns in the winding to retard the flux buildup and a larger armature travel. A core with the magnetic shunt in position is shown in Figure 36.

As in the case of AF, AG and AJ type wire spring relays the requirements and adjusting procedures for 286, 287 and 288 type relays have been reduced to a minimum and relate to contact separation, contact make and electrical requirements.

289, 290 and 293 Type Relays (Dry-Reed Relays)

These relays are known as dry-reed relays because the contacts consist of metal reeds sealed in gas-filled glass tubes. They are fast operating and releasing relays, since the only moving parts are contact reeds of low mass. The relays provide a high degree of contact reliability, as the contacts are enclosed in a glass tube and thus protected from dust and other atmospheric contaminations. In general, dry-reed relay are for use in circuits where they are not required to make or break current. The relays are non-adjustable and their principal use is in AMA assembler computer circuits and in No. 5 crossbar originating register circuits.

The element common to all dry-reed relays is the dry-reed switch shown in Fig. 37. This switch consists of a gas-filled glass tube into each end of which is sealed a magnetic reed whose terminal extends through the end of the tube. The inner ends of the reeds overlap by approximately 1/16

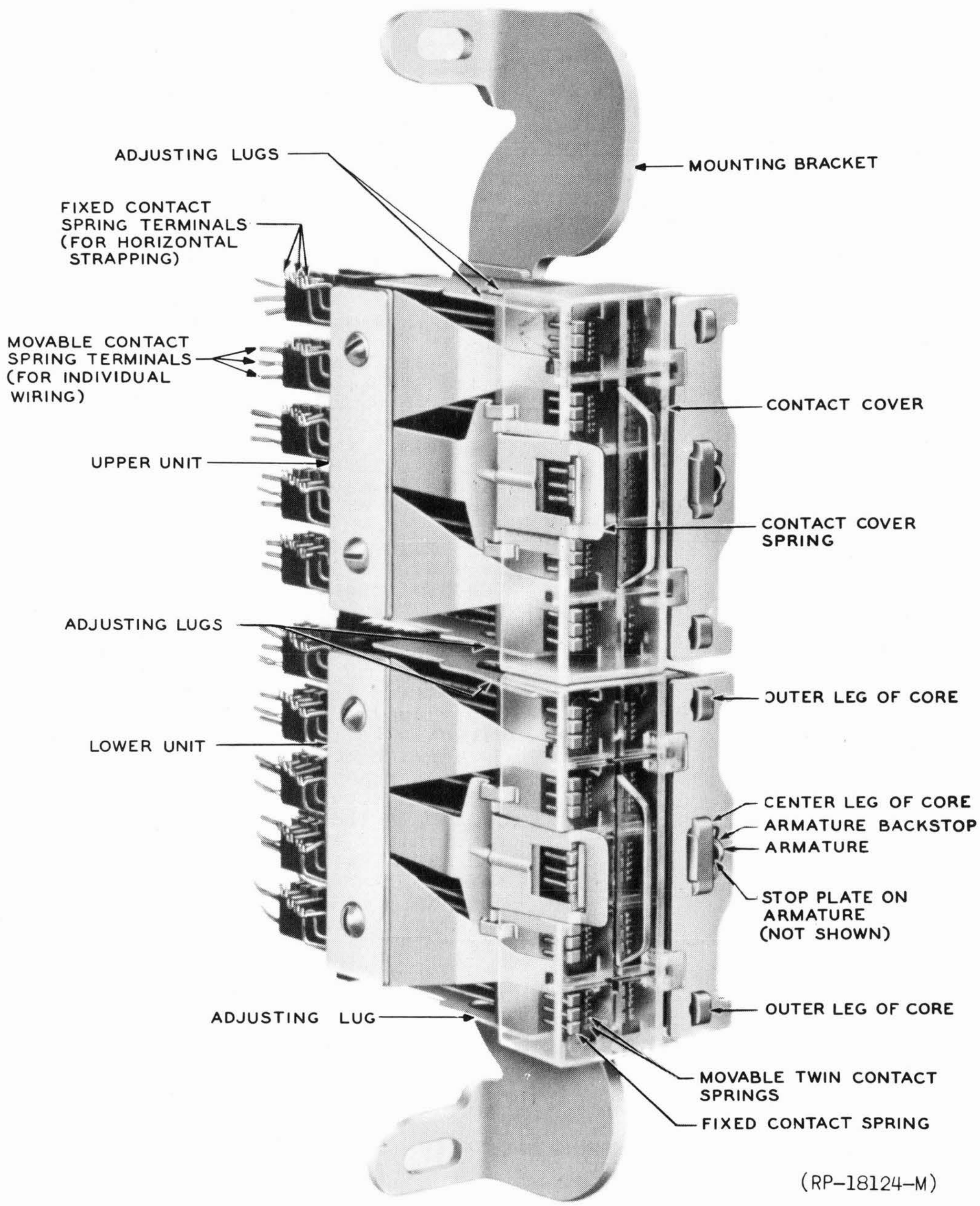


FIG. 35 287 TYPE RELAY

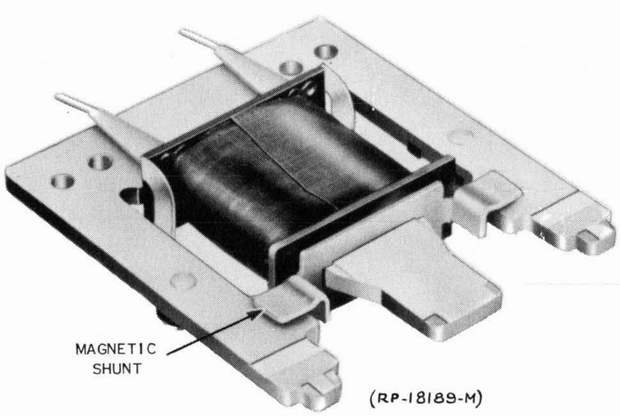


FIG. 36 287 TYPE RELAY CORE WITH MAGNETIC SHUNT

inch and normally are separated by a gap of about 0.010 inch. The gas in the tube is under low pressure which eliminates breakage hazards present where high-pressure gas is used. One or more dry reed switches are placed in the core space of a coil to form a single unit of a dry-reed relay. When current is applied to the coil, a magnetic field is setup which causes the tips of the reeds to come together and make contact.

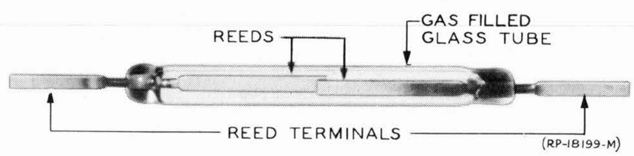


FIG. 37 DRY-REED SWITCH

A 289 type relay is shown in Figure 38. This relay is equipped with five switch units, each unit consisting of a coil with one dry-reed switch. Each coil is provided with a series resistor to limit the current through the coil. The five units of this relay are enclosed in a wrapping of insulating material for protection and are held in position by a spring clip formed from each side of a base shield. The seven leads of the relay are connected to a terminal block in front which is attached to the base shield.

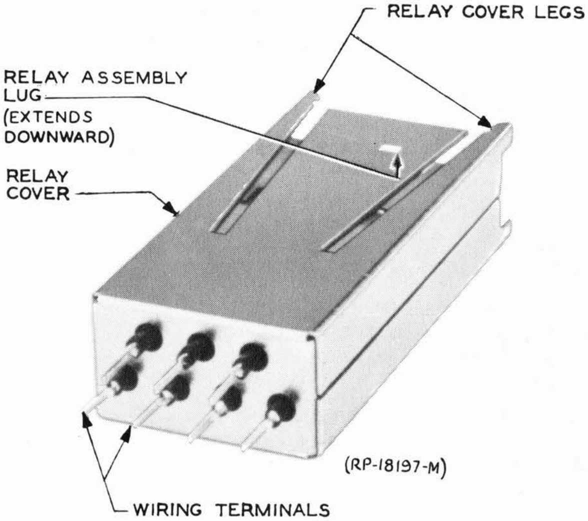


FIG. 38 289 TYPE RELAY

The five series resistors are located between two relay units in a channel shaped portion of the base shield. They are held in position by two small terminal blocks attached to the base shield. A cover shield placed over the relay units and held in position by locking tabs that engage with holes in the base shield, completes the magnetic return path.

The terminals are arranged for solderless wrapped connections and are insulated by sleeving where they pass through the holes in front of the relay cover. The assembly is enclosed in a relay cover with cover legs that engage with holes in the mounting plate. The base and cover shields and the relay cover are made of magnetic material and serve both as magnetic return paths for the coil flux and as shields against magnetic interference from adjacent apparatus. Figure 39 shows the internal arrangement of the parts of a 289 type relay.

Figure 40 shows a 290 type relay. This is a single unit relay consisting of 12 dry-reed switches placed inside of a single flat coil. The coil is held in position in the base and cover shields by projections on the rear spoolhead which fit into positioning slots in the base and cover shields. The coil leads and the contact terminals of the individual dry-reed switches are connected directly to the wiring terminals of two terminal blocks. The terminal blocks are held in place by projections that engage with positioning slots in the base and cover shields. The cover shield fits over the base shield and is held in position by locking tabs that fit into holes of the base shield. Added mechanical protection for the coil is provided by a sheet of insulating material placed between the cover shield and the coil.

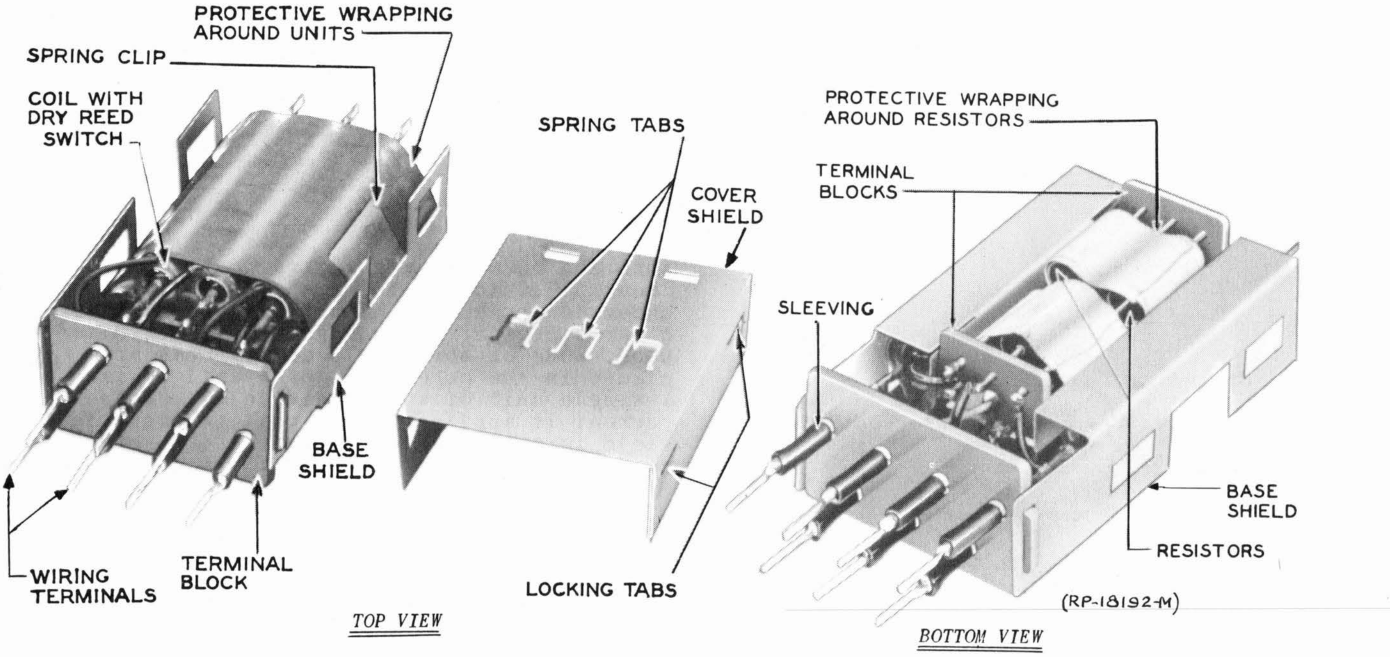


FIG. 39 289 TYPE RELAY WITH COVER AND COVER SHIELD REMOVED

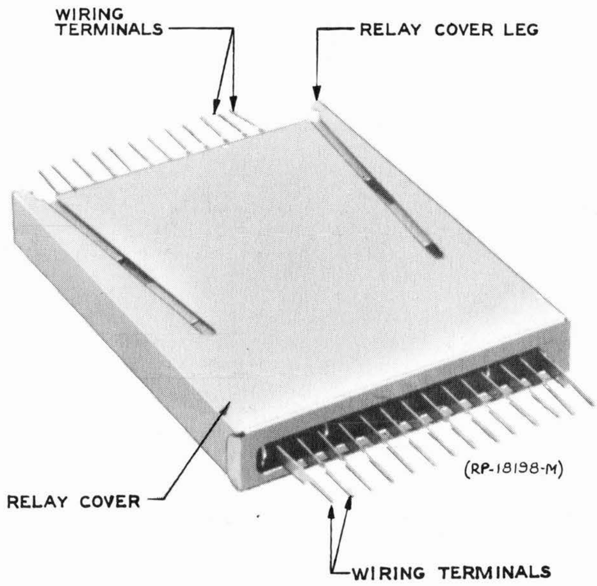


FIG. 40 290 TYPE RELAY

There are 14 wiring terminals in the front and 12 wiring terminals at the rear of the relay, the first and last terminals in the front being those of the coil winding. All wiring terminals are arranged for individual solderless wrapped connections and, with the exception of the two coil winding terminals, are also arranged for vertical strapping. Like the 289 type relay, the assembly is enclosed in a relay cover with cover legs that fit into holes in the mounting plate, and the base, cover shields and the cover are made of magnetic material. The internal arrangement of the parts of a 290 type relay is shown in Figure 41.

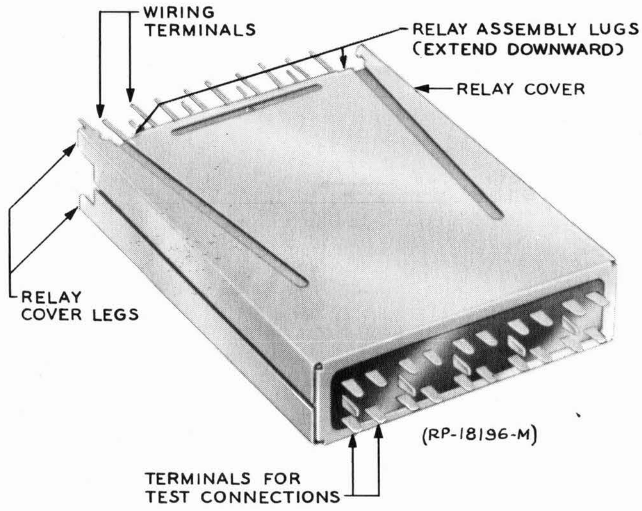


FIG. 42 293 TYPE RELAY

A 293 type relay is shown in Figure 42. The five units of this relay, each consisting of a coil with two dry-reed switches, are supported between two terminal blocks. Each unit has five terminals which extend to the front and rear of the relay. The ends of the terminals in the rear are arranged for solderless wrapped connections and the ends of the terminals in front are formed to permit the application of test connectors.

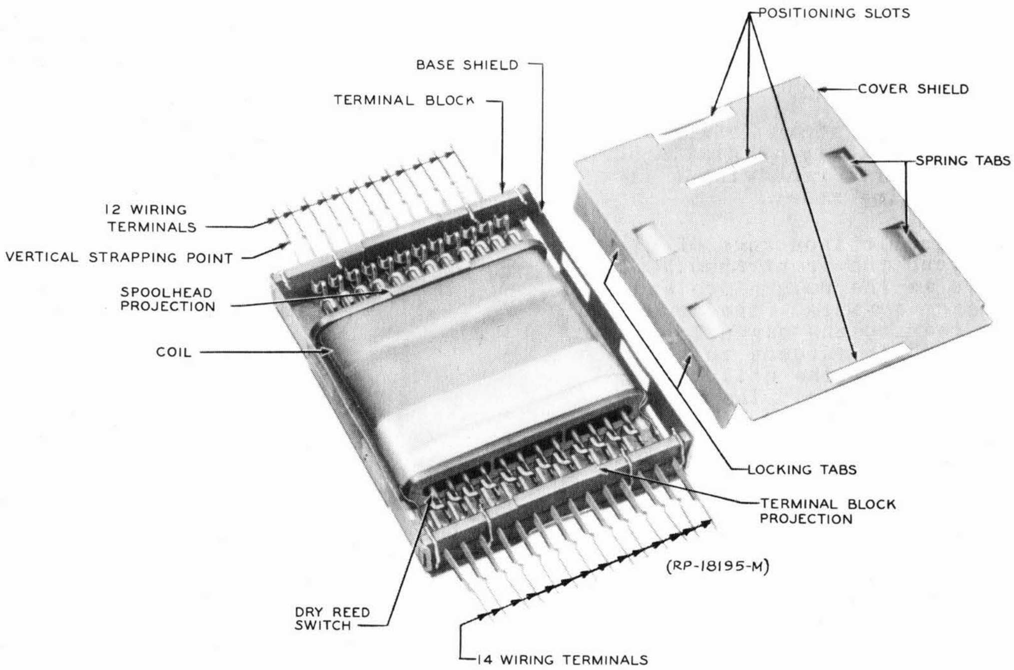


FIG. 41 290 TYPE RELAY WITH COVER AND COVER SHIELD REMOVED

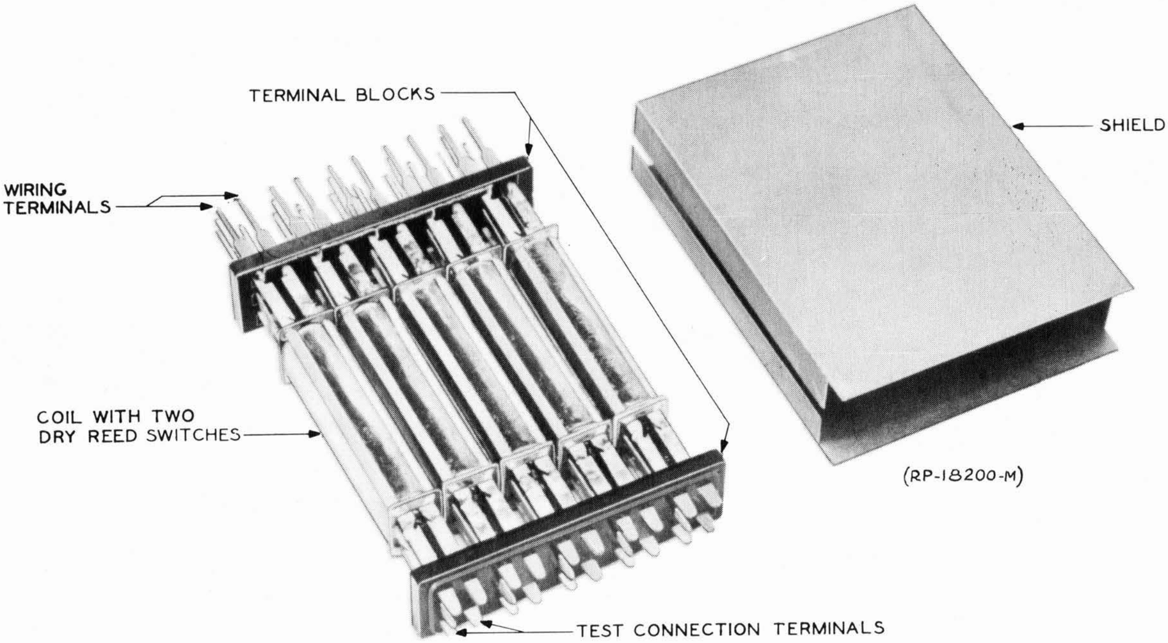


FIG. 43 293 TYPE RELAY WITH COVER AND COVER SHIELD REMOVED

A single shield, slit on one side extends between the terminal blocks, completely enclosing the five units. The unit assembly with the shield in place slides into the relay cover which is equipped with mounting legs for securing the relay to the mounting plate. The shield and relay are made of magnetic material and serve the same purpose as explained for the 289 type relay. A 293 type relay with cover and cover shield removed is shown in Figure 43.

208, 268, L, N and S Type Relays (Pulsing Relays)

The 208 type relay shown in Figure 44 is used as a counting relay in dial sender circuits and in circuits requiring a fast operating and releasing relay.

The round magnetic iron core of this relay extends beyond the front spoolhead of the coil to serve as the pole piece and to support the contact springs. The core is attached in the rear to the magnetic iron return pole piece, which extends to the front of the relay below the coil and supports the armature assembly. The short rectangular armature is provided on the bottom with a bearing pin which turns in holes in the armature support. A spiral retractile spring, stretched between lugs on the armature and the armature support, holds the armature in the unoperated position. Fast operation and quick release are insured by the use of a light weight armature, a small armature travel, and an operated armature air gap to minimize the effects of residual magnetism. Adjustments are made by changing the position of the contact lugs and the tension of the retractile spring.

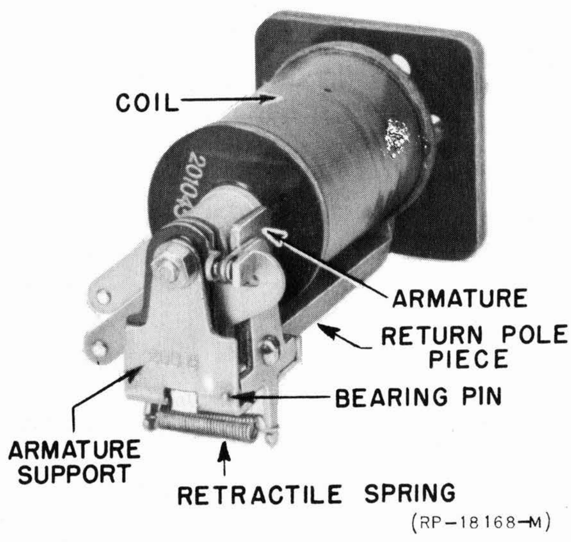


FIG. 44 208 TYPE RELAY

The 268 type relay shown in Figure 45, generally referred to as the "stepper" relay, is of the telegraph relay type and supersedes the 207 type relay previously used. For ease of adjustment, the relay structure is mounted on the relay base so that the armature is at right angles to the base. 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. The magnetic circuit is completed by the armature. The short thick armature moves on a pin in bearings of the armature bracket. Attached to the armature is a flat retractile spring which by means of the retractile spring adjusting screw holds the armature in its normal or unoperated position. The movement of the armature is controlled by the front contact and back stop screws. For fast operation and quick release, the relay uses a small armature travel and an operated armature air gap which minimizes the effects of residual magnetism.

For contact protection purposes a 200 type inductor (retardation coil) is added to the 268A relay. As shown in Figure 45, the inductor is mounted on the relay base in back of the relay structure and is connected in series with the relay contacts. 268 type relays are adjusted by means of the three adjusting screws.

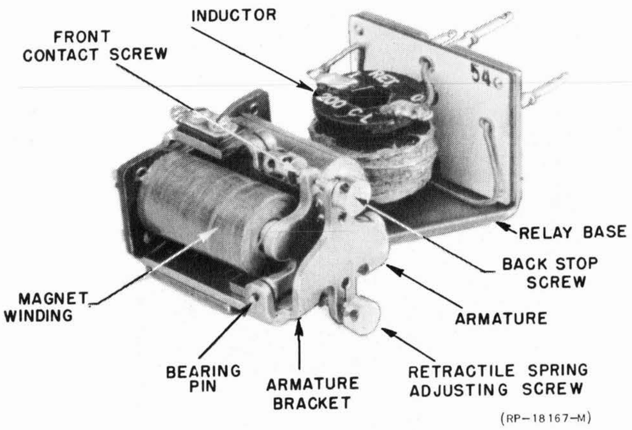


FIG. 45 268 TYPE RELAY

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

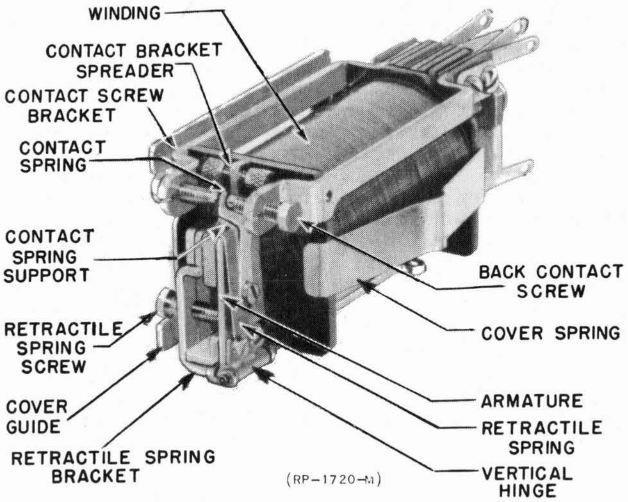


FIG. 46 "S" TYPE RELAY

bracket. The base gap acts in the same 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 spoolhead to avoid changes in adjustment caused by a slight contraction or expansion of the spoolhead with changes in atmosphere. Figure 46 shows an S type relay with the cover removed.

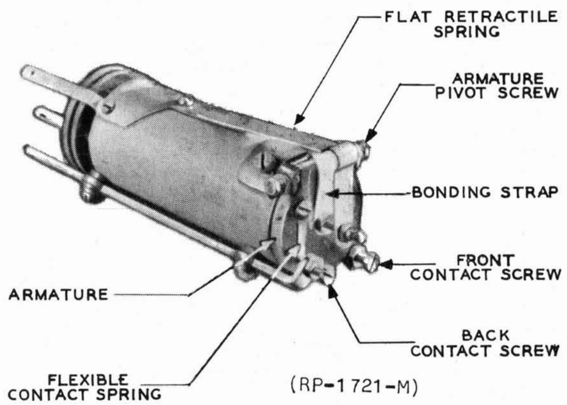


FIG. 47 114 TYPE RELAY

<u>114 and 198 Type Relays (Trip Relays)</u>

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 47.

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, so that the relay becomes insensitive to the ac ringing current. 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 provides the magnetic return path and, prevents magnetic interference with adjacent apparatus.

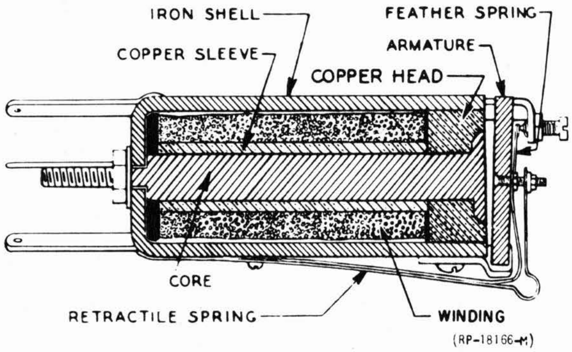


FIG. 48 CROSS-SECTION OF TRIP RELAY

On some codes of 114 trip relays, developed in connection with 1500^W 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 48 shows a cross-section of this 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 nonoperate 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.

For new equipment and circuit designs, the 114 type trip relay is being replaced by an AJ type relay (AJ 25). A description of this relay is given under the heading of AF, AG and AJ type relays.

114 and 198 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 nonoperate requirements.

<u>122, 125, 149, 162 and 178 Type Relays (Barrel or Round Type Relays)</u>

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 are almost identical in construction except for changes in contact arrangement, and in the provision or nonprovision 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. Figure 49 shows a 178 type relay.

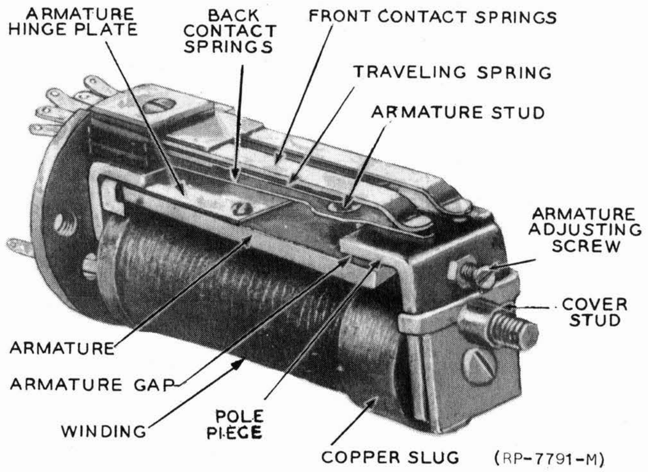


FIG. 49 178 TYPE RELAY

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 adjuting 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 nonfreezing 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.

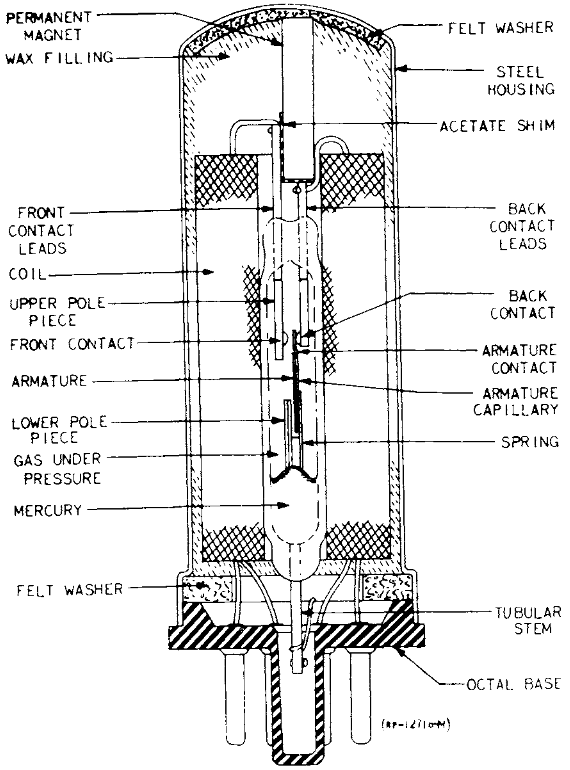


FIG. 50 CROSS-SECTION OF 276 TYPE RELAY

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.

275, 276 and 292 Type Relays (Mercury Contact Relays)

These relays are known as mercury contact relays because the contacts are kept coated with mercury. Each relay consists of a 218A mercury switch surrounded by a solenoidal coil and assembled in a metal electron tube shell equipped with an electron tube base. An eight prong or octal base is used for the 275 and 276 types while the 292 type is equipped with an eleven prong base. In addition, 276 and 292 type relays are provided with a small permanent magnet for biasing the armature. A cross-sectional view of a 276 type relay is shown in Figure 50.

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 nonmagnetic 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 50 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.

The 292 type relay is similar to the 276 type, except that it is provided with one or two additional windings. This results in a somewhat larger relay and the use of an eleven prong base.

Mercury contact relays 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 electron tube socket and are nonadjustable.

267 Type Relays

The 267 type relay shown in Figure 51 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 diammeter 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.

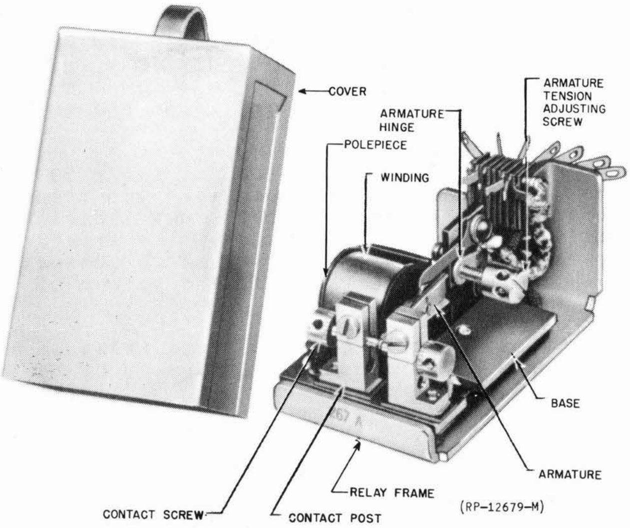


FIG. 51 267 TYPE RELAY

260 and 261 Type Relays (Voltmeter Relays)

The type of relay illustrated in Figures 52 and 53 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.

The 261 type relay is like the 260 type except for the provision of a plastic cover and the addition of a dust cover placed behind the plastic cover.

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 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 and 261 type relays are made for single and double voltage ranges and for differential purposes.

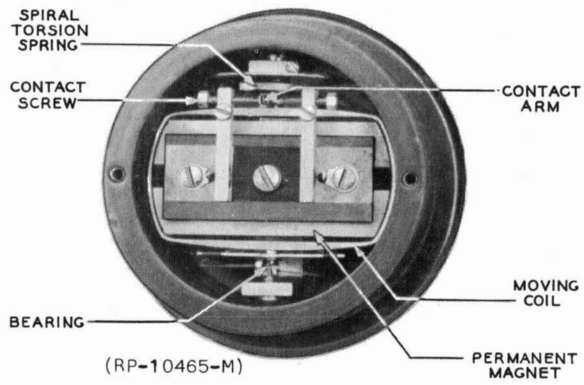


FIG. 53 260 TYPE RELAY - COVER REMOVED

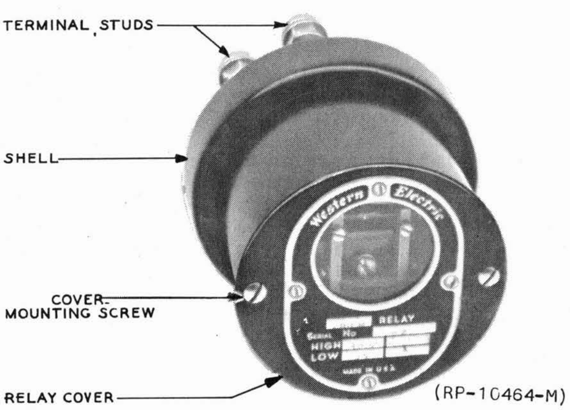
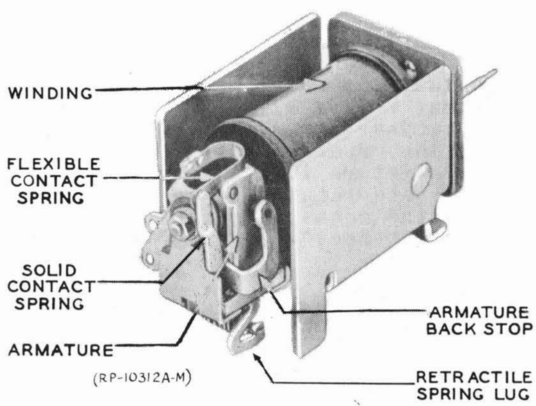
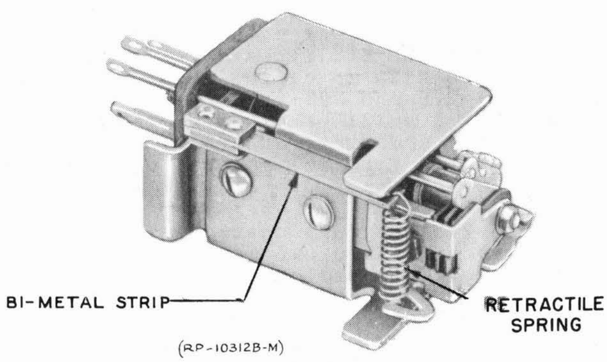


FIG. 52 260 TYPE RELAY



FRONT VIEW



BOTTOM VIEW

FIG. 54 253 TYPE RELAY

253 Type Relays

The 253 type relay shown in Figure 54 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 changes 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 54, 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.

196 Type Relays

The relay shown in Figure 55 is known as the 196 type. It is equipped with a U shaped laminated square core and a very light armature 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 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. 196 type relays of later design are provided with multiple wound (filled) coils and use a cover spring equipped with oval shaped guide springs.

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.

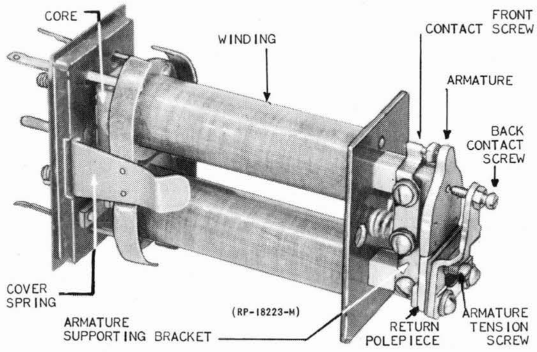


FIG. 55 196 TYPE RELAY

Sensitrol Relays (Weston Model 705)

The sensitrol relay (see Figure 56) 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.

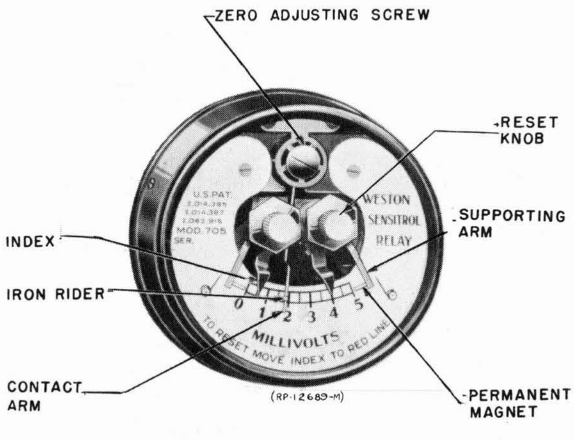


FIG. 56 SENSITROL RELAY

Figure 56 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 setting of the zero adjusting screw.

L1 Carrier Telephone Line Switching Relays per D-178265 and D-178266

The D-178265 and D-178266 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 57 shows four of these relays, two D-178265 and two D-178266, mounted on a line switching relay panel.

In the D-178265 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-178266 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 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 noninductive 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 noninductive 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

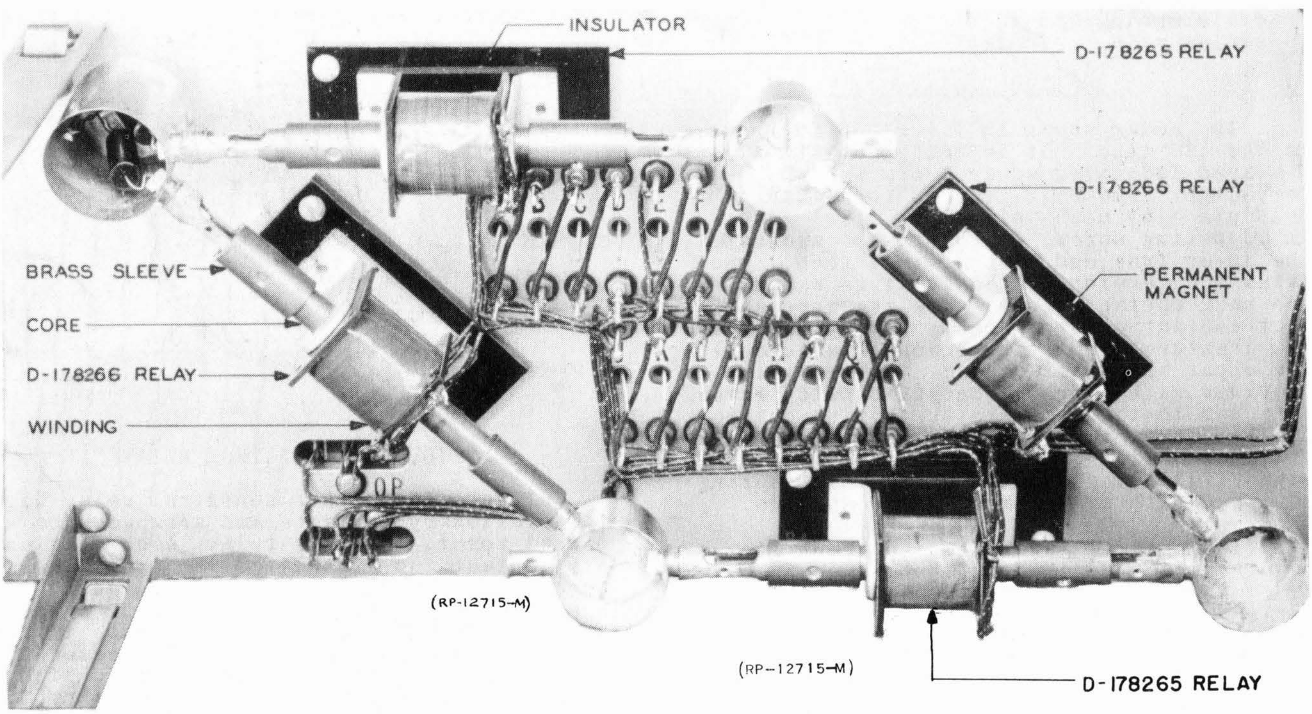


FIG. 57 D-178265 AND D-178266 RELAYS ON LINE SWITCHING RELAY PANEL

may be obtained by a combination of the two. The use of an impedance in series with the relay or a noninductive 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 noninductive 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 noninductive resistances for the purpose of providing a path around the inductive winding for the passage of alternating or talking currents. The supervisory relays in cord and trunk circuits, which have a noninductive 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,Y, and AG 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 condition 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 nonfreezing 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.

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, the relays described in the following paragraphs are used.

235 Type Relay

The 235 type relay shown in Figure 58 is a thermal relay making use of the principle of unequal expansion of metals when heated. It consists of an E type relay structure with one or two bi-metallic contact spring assemblies. Each contact spring assembly consists of two bimetallic contact strips mounted parallel to each other. The two bimetallic contact strips facing each other are arranged so that they will deflect in the same direction when heated. A heater winding, consisting of a single layer of nichrome wire is wound around one of the strips on mica insulation. When current is applied to the heater winding, the associated contact spring is heated, causing the heated spring to deflect toward the mating contact spring and make contact on normally open contacts, or deflect away from the mating contact spring and open the contacts on normally closed contacts. By making the mating contact spring also bimetallic, changes in the surrounding temperature are compensated for, since both springs will be deflected equally and in the same direction.

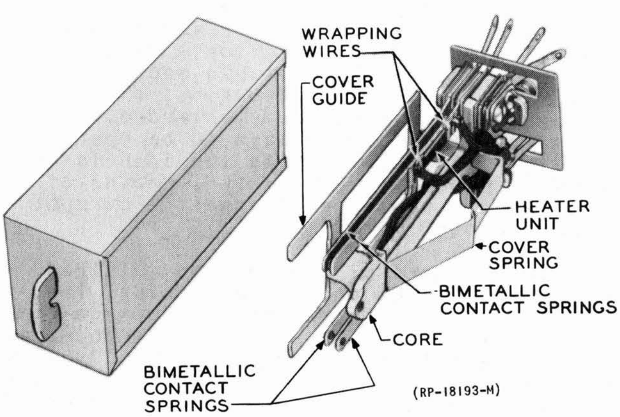


FIG. 58 235 TYPE RELAY

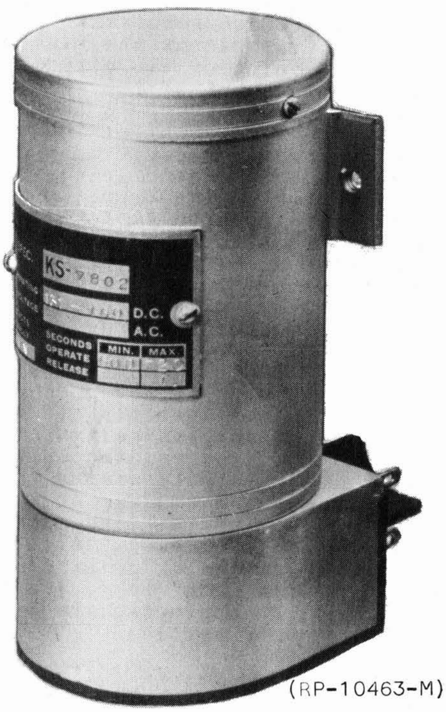


FIG. 59 KS-7802 RELAY

The time of operation on relays with normally open contacts is controlled by the contact separation and on relays with normally closed contacts by the tension of the contact springs against each other. The time intervals that may be obtained with these relays vary from a few seconds to about 25 seconds. A cooling period of several minutes is required between operations to restore the relay to normal. 235 type relays may or may not be equipped with an individual cover.

"Adlake" Relays (KS-7801 to KS-7850)

An external view of an "Adlake" relay per KS-7802 is shown in Figure 59. The operating mechanism 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. See Figure 60.

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.

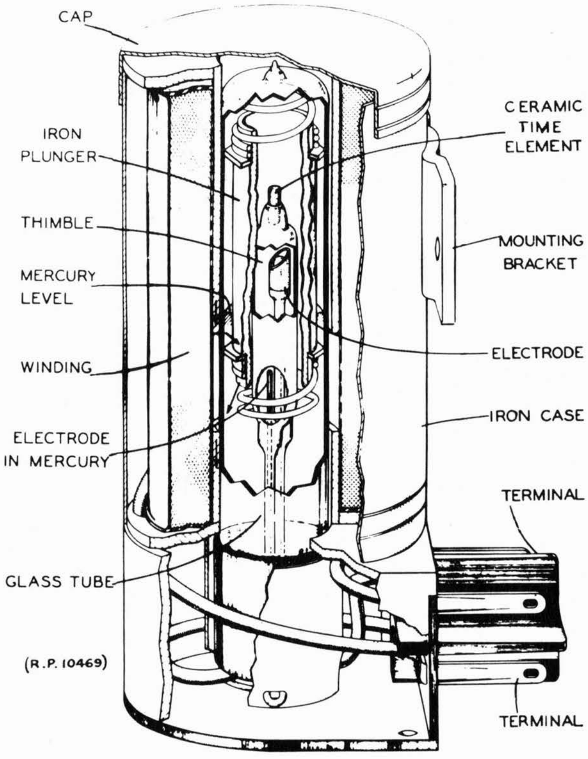


FIG. 60 SECTIONAL VIEW OF KS-7802 RELAY

The relay with the normally closed contacts functions similarly to the relay with the normally open contacts 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 contacts. 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.

Edison and Amperite Relays

These relays are of the thermal type, enclosed in a glass electron tube shell equipped with an octal electron tube base.

An Edison thermal relay, designated KS-13542 is shown in Figure 62. 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. The 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 electron tube.

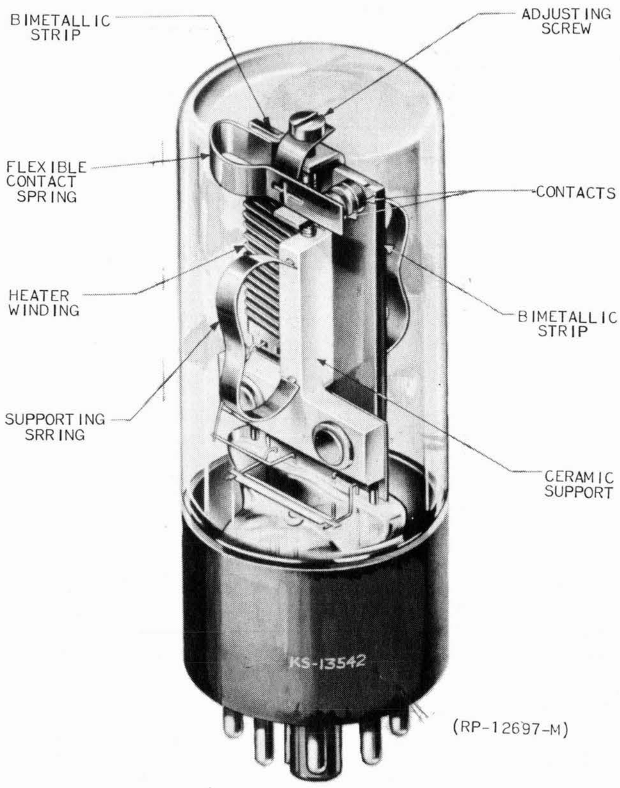


FIG. 61 EDISON THERMAL RELAY

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 Amperite relay is similar to the Edison relay, except for the location of the heater winding and arrangement of the contacts. On this relay, the heater winding is wound on a strip of mica which is positioned parallel and approximately 1/8" from one of the bimetallic strips. The action of the two bimetallic strips, when the heater winding is energized, is the same as on the Edison relay.

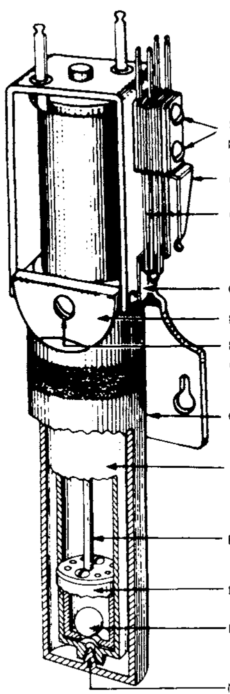


FIG. 62 DASHPOT RELAY

Dashpot Relays

The dashpot relay shown in Figure 62 consists essentially of a solenoid magnet, a plunger arrangement with a ball valve, two cylinders for the dashpot oil and a contact spring assembly. The solenoid magnet consists of a coil mounted in a U shaped iron frame. The core consists of a short piece of iron extending from the top down to about the center of the coil, so that the plunger may be drawn into the coil when energized. A heavy iron front spoolhead with mounting bracket completes the magnetic return path. Attached to the iron plunger is a loosely fitted plunger rod with a dashpot plunger that contains the ball valve. The dashpot plunger, cylindrical in shape, is provided with a number of small holes on top and a steel ball inside, which fits over a larger opening on the bottom of the dashpot plunger. The dashpot plunger moves in a brass inner cylinder with a needle valve opening on the bottom. Surrounding the inner cylinder is a brass outer cylinder equipped on the bottom with a needle point that engages with the hole in the inner cylinder to form a needle valve. Both cylinders are partly filled with a special grade of oil and are held in position by threads that engage with a mounting detail on the front spoolhead.

When the magnet is energized, the iron plunger is pulled into the solenoid magnet, but its movement is retarded by the oil. The suction created by upward movement of the dashpot plunger causes the steel ball to close the opening in the bottom of the dashpot plunger, thus forcing oil gradually into the inner cylinder through the needle valve. Before the solenoid plunger has reached its fully operated position, a collar on the bottom of the solenoid plunger engages with a lever to operate the contact springs.

When the circuit through the winding is opened, the plunger assembly returns to normal by gravity. The downward movement, however, is much faster than the upward movement, because the steel ball over the larger opening in the bottom of the dashpot plunger is raised by the pressure of the oil, thus allowing the oil to pass through the dashpot plunger more freely. A hole in the side of the inner cylinder permits oil to return to the outer cylinder.

The time of operation depends upon the amount of oil passing through the needle valve and is regulated by turning the outer cylinder in or out as required. A friction lock holds the outer cylinder in its adjusted 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 vibration 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 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 63.

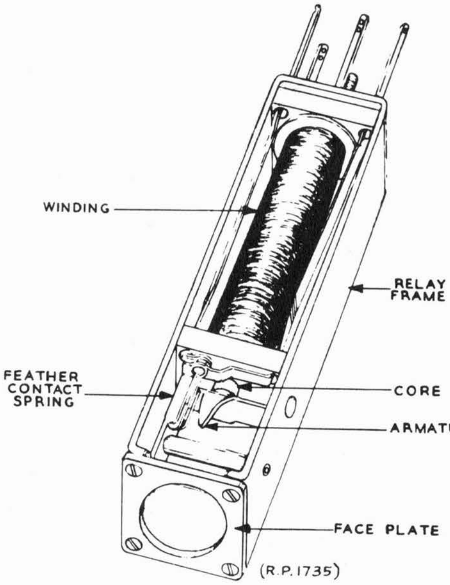


FIG. 63 186 TYPE RELAY

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.

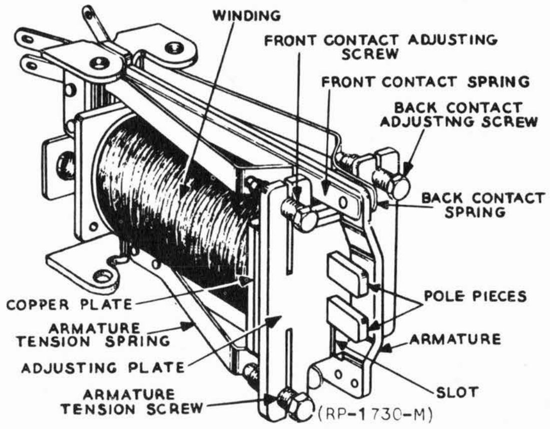


FIG. 64 J TYPE RELAY

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 copper adjusting plate. Another copper plate of the same size as the front spoolhead, is riveted to the rear of the adjusting plate. Figure 64 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 65). Although small, this flux is sufficient to prevent the armature from releasing at the zero points of the alternating current wave.

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 66. The purpose of this weighted contact spring is to prevent the 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

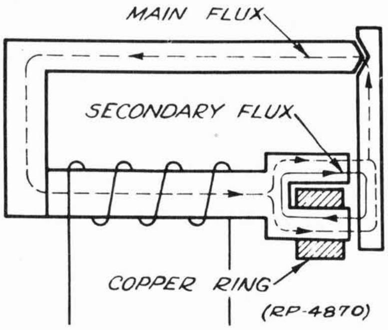


FIG. 65 FLUX DIAGRAM OF J TYPE RELAY

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.

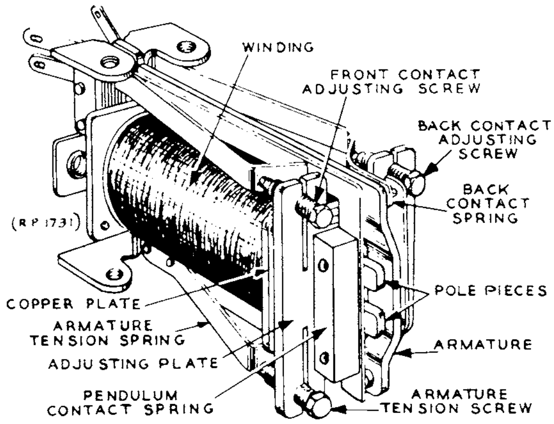


FIG. 66 PENDULUM J TYPE RELAY

QUESTIONS

1. What is the purpose of the stop pins on an armature?
2. What is meant by the "swaged core" of a flat type relay? What is its advantage?
3. Why is a laminated core used on some relays?
4. What is the purpose of a copper head at the armature end of a relay core?
5. What is the object of polarizing a relay? How is this accomplished?
6. What is the purpose of twin contacts?
7. What are the three basic types of wire spring relays?
8. Explain briefly the operation of a wire spring relay.
9. What are the outstanding features of wire spring relays?
10. What are AG type relays used for?
11. What are the principal differences between B type relays of the initial and new designs?
12. How many contacts are on a 286 type multicontact wire spring relay and how are they arranged?
13. What are 287 and 288 type multicontact wire spring relays used for?
14. What element is common to all dry-reed relays?
15. How many switch units are there in a dry-reed relay?
16. Can dry-reed relays be adjusted?
17. Why are J type relays equipped with a copper adjusting plate?
18. Why does an ordinary relay chatter on alternating current?
19. Explain briefly the operation of the 251 type relay.
20. What is the purpose of the weight on the armature of a 218-B relay?
21. Explain briefly the action of the magnetic circuit of a 209 type relay?
22. What are the principal differences in appearance between U and UA type relays?
23. Explain briefly the operation of the 266 type relay.
24. Describe the construction of the 276 type relay.
25. What types of relays are used for obtaining time delays of relatively large duration?
26. Explain briefly the operation of a 235 type thermal relay.
27. How does a dashpot relay operate?

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G	9	19
H	4	7
J	33	64,65,66
L	22	-
N	22	-
R	4	8
S	22	46
T	4	-
U	5	10
Y	5	-
AB	4	-
AF	7	13,14
AG	7	-
AJ	7	13,16,17
EA	4	6
UA	5	11
UB	5	12
Adlake	30	59,60
Amperite	31	-
Dashpot	32	62
Edison	31	61
D-178265	28	57
D-178266	28	57
Sensitrol	27	56
Slow Acting Relays	28	-

SECTION 2

CROSSBAR SWITCHES

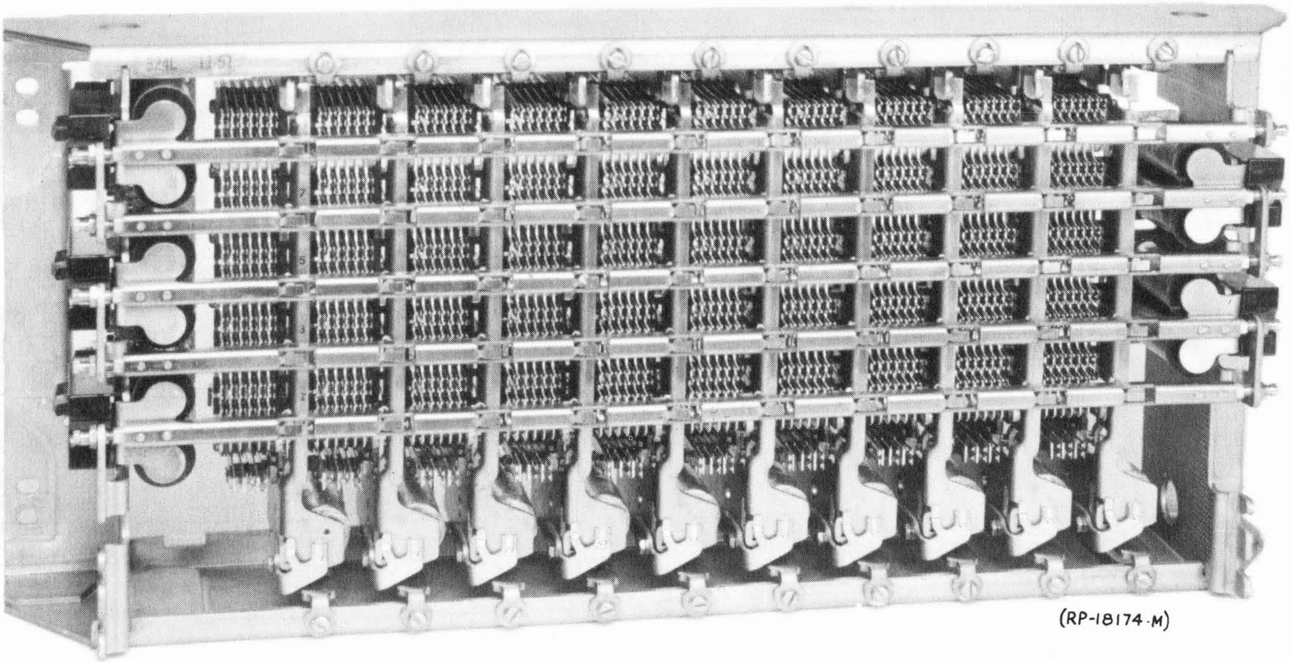


FIG. 67 100 POINT 324 TYPE CROSSBAR SWITCH

The crossbar switch is the principal switching device used in the crossbar system. It consists essentially of a rectangular frame with a number of vertical relay-like units, five horizontal selecting bars and associated selecting magnets and a number of holding magnets with armatures that extend to the top to form holding bars. Figure 67 shows a 100 point 324 type crossbar switch.

As shown in Figure 68, each of the vertical relay-like units consists of 10 contact spring assemblies, having from three to six pairs of normally open or make contact springs. Each pair of contacts, forming a so-called crosspoint, includes a solid fixed contact and a moving contact spring. The fixed contact is formed by a projection on an insulated metal strip that extends from the top to the bottom row of contacts. At the bottom, the metal strip with the fixed contacts is connected to a wiring terminal in the rear by means of a strap. Another projection at the lower end of the metal strip and facing the front serves as a connecting point for testing purposes. The metal strip thus provides a continuous and self-contained multiple within the vertical unit assembly for each alternate vertical row of fixed contacts. The moving contact springs of the assembly are individual and extend to the rear to form wiring terminals. They are clamped in position between strips of insulating material in the vertical spring pile up. Both the common fixed contacts and the individual moving contact springs have forked ends, the prongs of which are equipped with a contact of No. 2 contact metal to provide twin contacts.

Associated with each vertical unit assembly is the holding magnet located at the lower end of the unit. The armature and associated holding bar moves on pivot points at the top and bottom of the unit and is held in the unoperated position by the tension of the holding off-normal spring or balancing springs.

Each of the five selecting bars, rotating on pivot points, is equipped with a number of flexible selecting fingers and a butterfly-like armature on one end. To minimize vibration at the time of release, which may result in double connections, each finger is provided with a dampening spring, consisting of a coiled spring loosely placed over the finger. Facing the armature on the selecting bar are two selecting magnets which when energized impart a rotating motion in either a clockwise or counterclockwise direction to the bar and fingers. The selecting bars are held in the unoperated position by the tension of the selecting off-normal springs or centering springs.

To operate a contact spring assembly, a two stage operation is required, since the operation of either selecting magnet or holding magnet alone does not actuate a contact spring assembly. First a selecting magnet must be operated and kept energized until the holding magnet of the desired vertical unit is operated, after which the selecting magnet may be released. The holding magnet must, however, remain energized throughout the duration of contact closure. A detailed description of what takes place during the operating cycle is given in the following paragraphs.

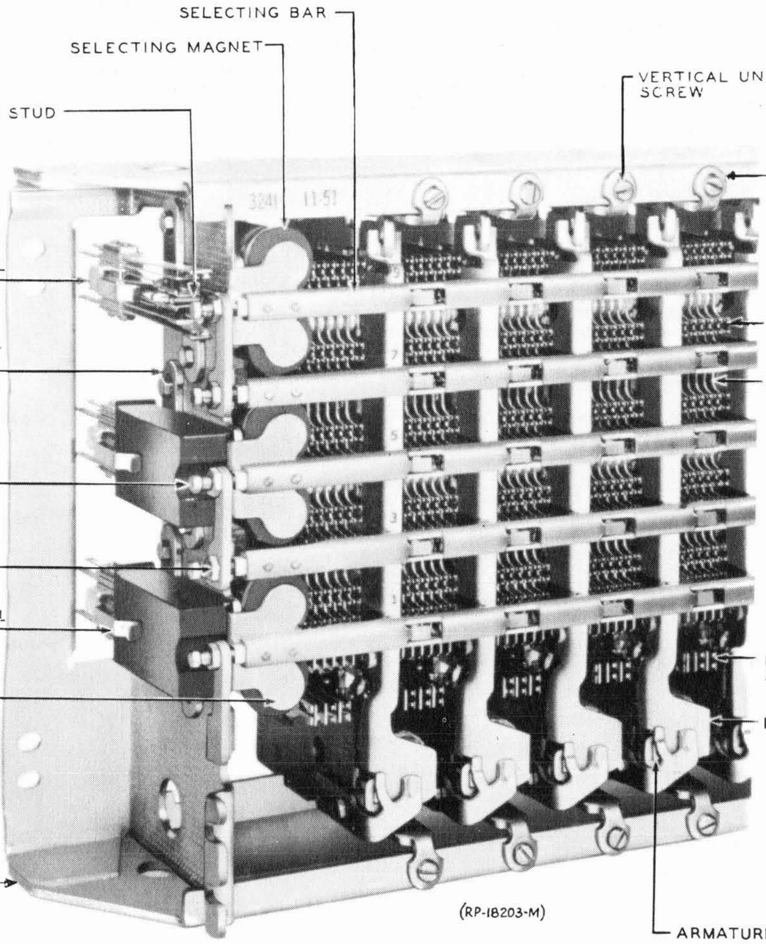


FIG. 68 SECTIONAL VIEW OF 324 TYPE SWITCH

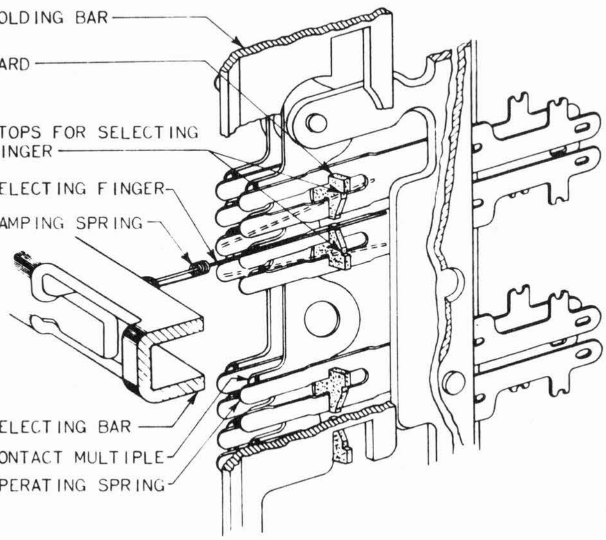


FIG. 69 SKETCH SHOWING ACTION OF SELECTING FINGER

Referring to Figure 69, it will be noted that the end of the fibre actuating card is cut away to form a projection that will act as a stop and limit the travel of the selecting finger. With the switch normal, the selecting finger is in a midway position between the two adjacent contact spring assemblies and free to travel up or down within the limits of the finger stops on the cards. When the selecting magnet is energized, the finger will be deflected toward the stop on the card. In this position, the finger is resting against the stopping face on the card and across an opening in the holding bar. The opening when not blocked by the finger, serves as a clearance hole for the card. With the finger in the operated position, operation of the holding magnet will trap the finger between the card and the holding bar and cause the card to operate the contacts of the selected spring assembly. On release of the selecting magnet the finger remains in its locked position, but due to the flexible nature of the finger, the selecting bar is permitted to return to normal. The same selecting bar may thus again be operated to close the contacts of another spring assembly under control of the selecting bar, with the exception of the spring assembly which is adjacent to the spring assembly already held operated by the holding magnet.

As mentioned previously, crossbar switches are equipped with holding off-normal or balancing springs and selecting off-normal or centering springs. These springs function like those on relays and are operated whenever the associated magnet is energized and are not dependent on the two-stage operating cycle described above.

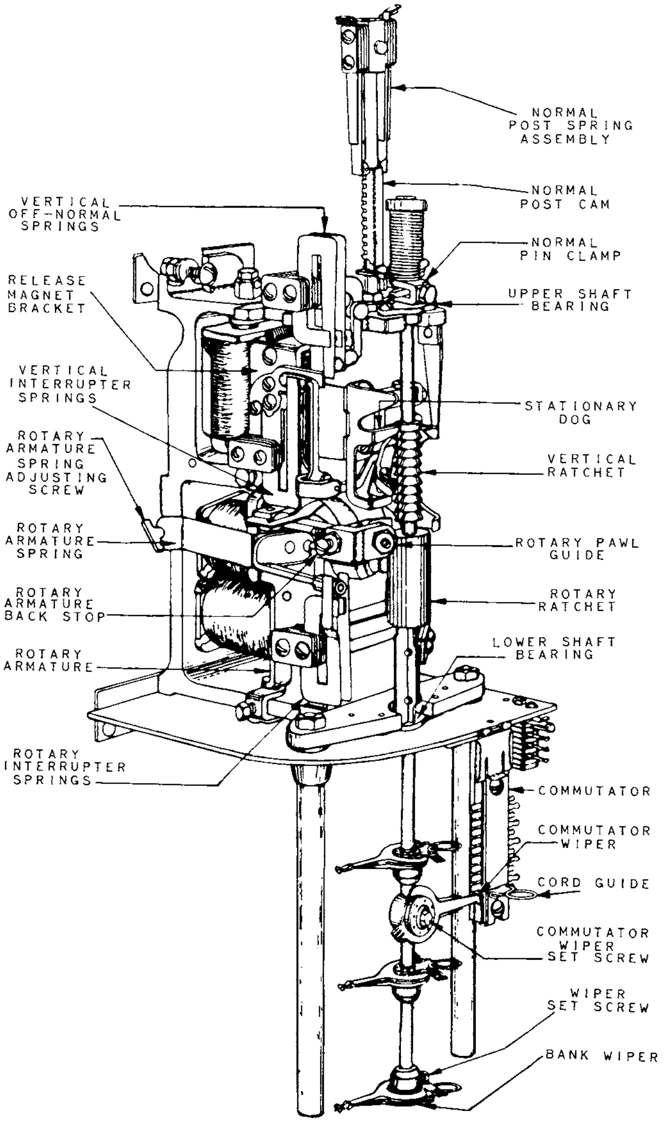
Crossbar switches are made in two sizes, generally referred to as 100 and 200 point switches, having 10 or 20 vertical units, respectively. The switches are also classified as 2, 3, 4, 5 or 6 wire switches, depending upon the number of pairs of springs in each spring assembly.

QUESTIONS

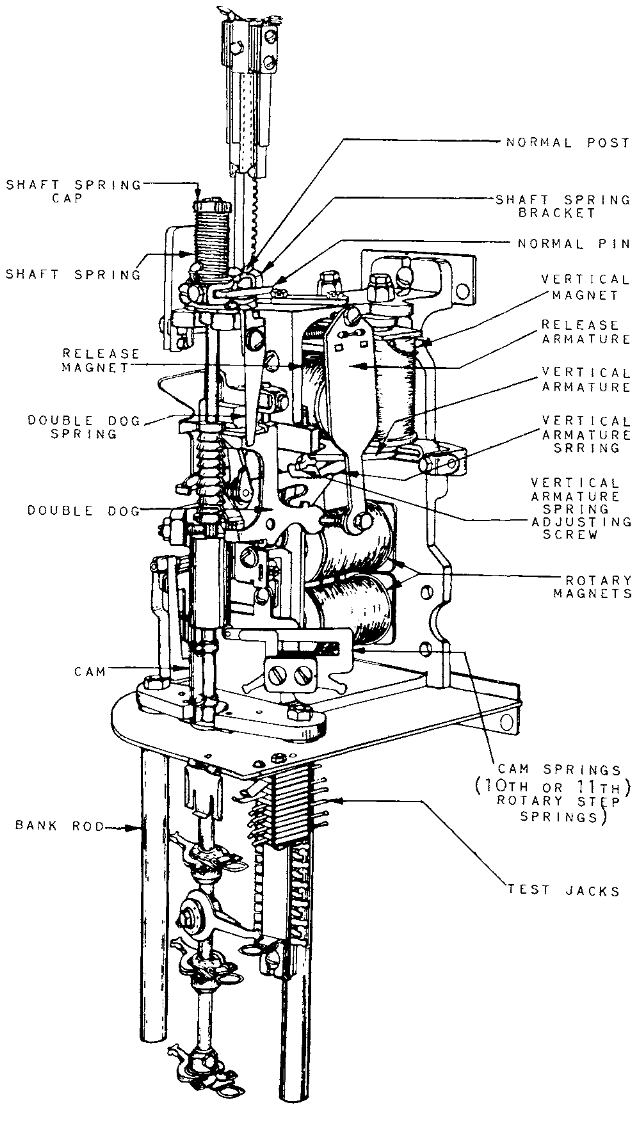
1. How many selecting bars are there on a crossbar switch?
2. What holds the selecting bar in the unoperated position?
3. What is the purpose of the holding bar?
4. Briefly explain the action of the finger on a crossbar switch.
5. If one finger of a given selecting bar is in the locked position, can another finger on the same selecting bar be used for another selection?

SECTION 3

STEP-BY-STEP SWITCHES



PARTS OF 197 TYPE SWITCH AS VIEWED FROM THE LEFT SIDE



PARTS OF 197 TYPE SWITCH AS VIEWED FROM THE RIGHT SIDE

FIG. 70 197 TYPE SWITCH

The step-by-step switch is the principal switching device employed in the step-by-step system. There are two types of switches, designated 197 and 198, used in the Bell System. The 197 type consists essentially of a cast frame on which are mounted a vertical shaft with bank and commutator wipers, a pair of vertical magnets for raising the shaft, a pair of rotary magnets for rotating the shaft, a release magnet for restoring the shaft to normal, and two bank rods accommodating up to four banks. In addition, the switch is equipped with various contact spring assemblies actuated by the vertical, rotary and release mechanisms. The 198 type switch is similar to the 197 type, except that the vertical stepping mechanism is omitted and the switch is, therefore, arranged for rotary stepping only. The various parts of a 197 type switch are shown in Figure 70. A detailed description of these parts and their functions is given in the following paragraphs.

A steel rod, 3/16" in diameter, is used as the shaft for controlling the movement of the bank and commutator wipers. The shaft rotates on two shaft bearings attached to the casting and is held in its vertical normal position by the normal pin clamp located above the upper shaft bearing. Pinned to the shaft are two bronze sleeves with slots or teeth forming ratchets for vertical and rotary movement of the shaft.

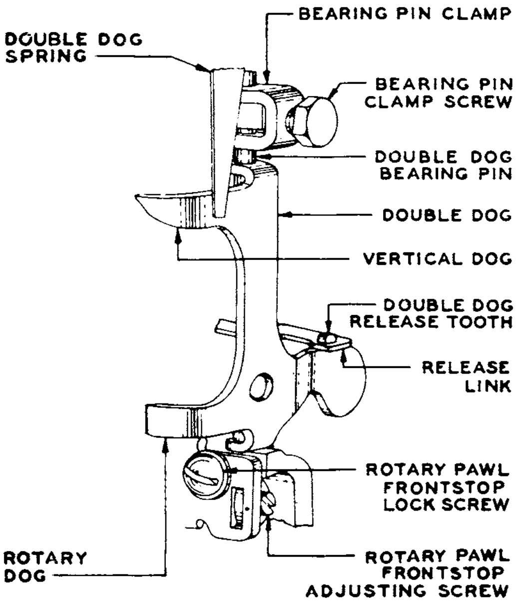


FIG. 71 DOUBLE DOG AND ASSOCIATED PARTS

The upper or vertical ratchet is provided with 10 teeth and the lower or rotary ratchet has 18 teeth.

Associated with the ratchet are the double and stationary dogs, consisting of blanked out pieces of metal with several projections and located to the right and left, respectively, of the vertical ratchet. The double dog, shown in Figure 71, rotates on a bearing pin and is provided in front with two curved projections, called the vertical and rotary dogs, that engage with the ratchet teeth. The vertical dog prevents the shaft from dropping to its normal position during vertical stepping of the switch, while the rotary dog prevents the shaft from returning to the rotary normal position during rotary stepping of the switch. Figure 72 shows the double dog engaging the ratchet teeth. Extending toward the rear is another projection shaped to provide a striking plate for the release pin on the release armature, and a tooth for engagement with a slot in the release link. A flat double dog spring provides the tension for forcing the double dog into the ratchet teeth.

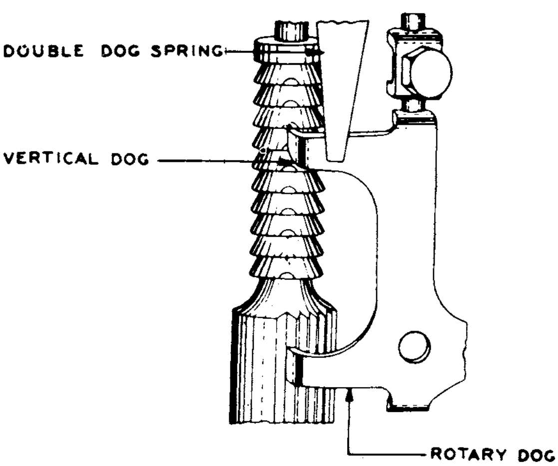


FIG. 72 DOUBLE DOG ENGAGING RATCHET TEETH

The stationary dog is the center projection of a metal detail secured to the casting by two mounting screws. During vertical movement of the shaft, the end of the stationary dog rides in a slot in the vertical ratchet and in one of the teeth on the vertical ratchet when the shaft is rotating. In the unoperated position the stationary dog is engaging the collar on top of the vertical ratchet, thereby preventing rotary movement of the shaft until the shaft is up at least one step. During subsequent vertical movement of the shaft, the stationary dog performs no function, but during rotary movement it supports the shaft. The triangular projection on top of the metal detail and extending forward (see Figure 70) acts as a stop for the cover. The bottom projection on the metal detail, called the vertical pawl guide, acts as a guide and rest for the vertical pawl. Figure 73 shows the position of the stationary dog during vertical and rotary stepping.

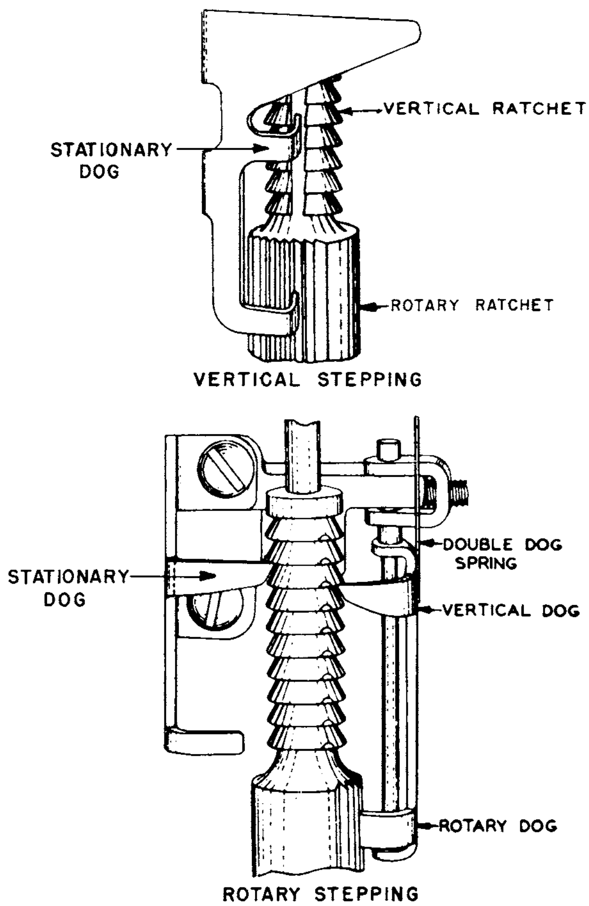


FIG. 73 POSITION OF STATIONARY DOG DURING VERTICAL AND ROTARY STEPPING

Attached to the top of the shaft is a spiral shaft spring. The top end of this spring is fitted with a shaft spring cup and a crossbar that engages with bayonet slots in the shaft extension sleeve for tensioning the spring. The bottom end of the spring hooks onto a lug on the shaft spring bracket, held to the shaft by the shaft spring bracket bearing. The rear end of the shaft spring bracket is provided with a guide hole for up and down movement on the normal post attached to the casting. The shaft spring winds up during rotary movement of the shaft and returns the shaft to its unoperated position when the shaft is released by the double dog. The shaft, when returning to normal, is prevented from swinging past the rotary normal position by the normal pin engaging with a stopping tab on the shaft spring bracket. The normal pin is secured to the shaft by means of the normal pin clamp. Figure 74 shows the shaft spring and associated parts.

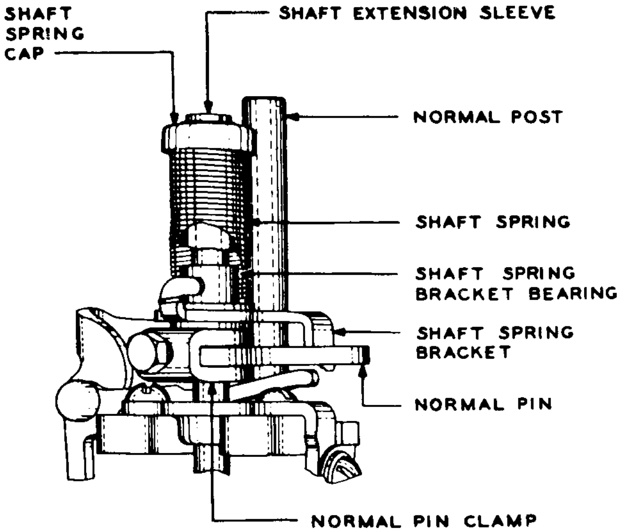


FIG. 74 SHAFT SPRING AND ASSOCIATED PARTS

Three magnets known as vertical, rotary and release are required in the operation of the switch. The vertical and rotary magnets are made up of two coils connected in series aiding, whereas the release magnet has a single coil. Both the vertical and rotary magnets are held in position on the casting by means of adjusting and locking screws so that the position of each magnet may be adjusted for proper alignment with the associated armature. The release magnet and associated return pole piece is secured to the casting by mounting lugs on the return pole piece and its position is fixed. The three magnets, when operated, cause the shaft and associated wipers to be elevated, rotated or released.

The armature of the vertical magnet moves on a bearing pin and extends toward the front of the switch. In the unoperated position, it is held against a projection on the casting by the tension of the vertical armature spring. Attached to the end of the armature, and located just behind the vertical ratchet, is the vertical pawl which is tensioned toward the vertical ratchet by means of a coiled spring. In the unoperated position, an arm on the vertical pawl, called the vertical pawl finger, is resting against the vertical pawl stop on the bottom of the stationary dog, and the vertical pawl is not engaging the vertical ratchet. When the vertical magnet is energized, the armature is pulled upward, allowing the coil spring to push the pawl into the vertical

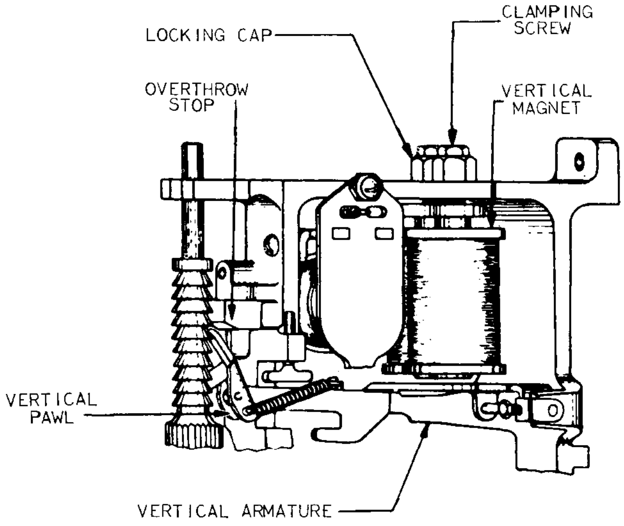


FIG. 75 VERTICAL MAGNET AND ASSOCIATED PARTS

ratchet teeth with an upward thrust, thus raising the shaft. Operation of the armature also causes the vertical arm on the bottom of the armature to pick up the release link to release the double dog. Upon release of the vertical armature the shaft is held in the raised position by the vertical dog on the double dog. Figure 75 shows the vertical magnet and associated parts, with the double dog and part of release armature omitted.

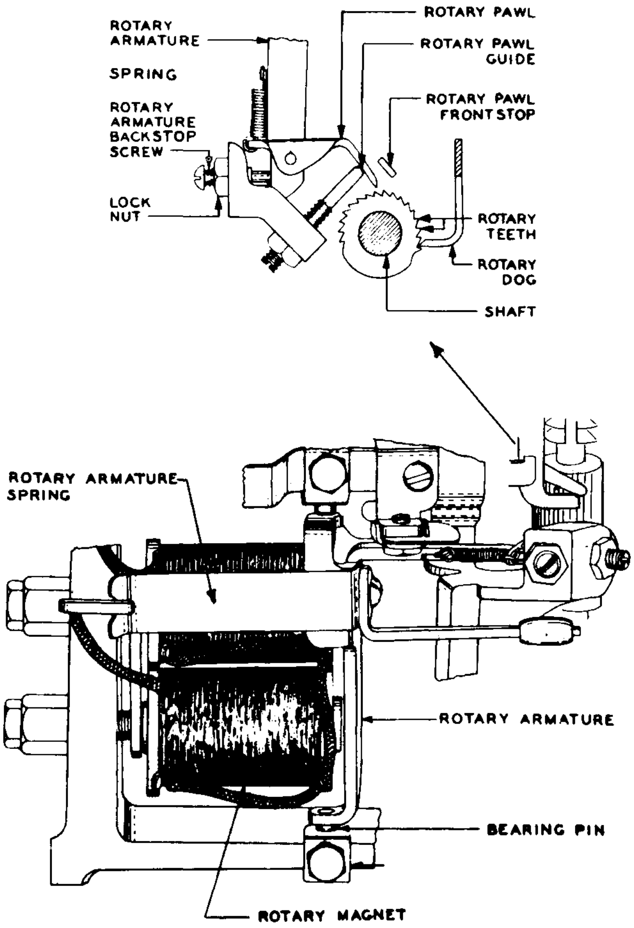


FIG. 76 ROTARY MAGNET AND ASSOCIATED PARTS

The armature of the rotary magnet moves on bearing pins and extends towards the front of the switch. In the unoperated position, the tip of the armature is held against the rotary armature back stop screw by the tension of the rotary armature spring. A pawl attached to the outer end of the armature is tensioned toward the rotary ratchet by a coiled spring. In the unoperated position, the pawl is resting against the tip of the rotary pawl guide screw which holds it away from the rotary ratchet teeth. When the rotary magnet is energized the armature pushes the pawl into the rotary ratchet teeth and moves the shaft around. A rotary pawl front stop limits the travel of the pawl in a forward direction to prevent overstepping. The rotary dog on the double dog prevents the shaft from rotating back to normal when the rotary armature is released. Figure 76 shows the rotary magnet and associated parts.

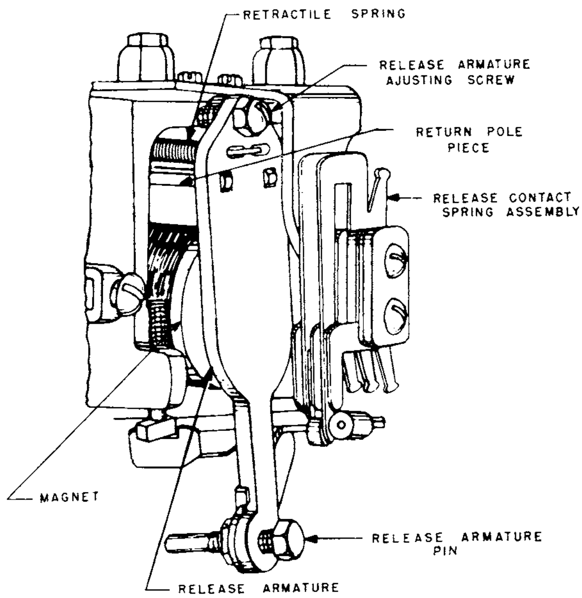


FIG. 77 RELEASE MAGNET AND ASSOCIATED PARTS

The armature of the release magnet is supported on two projections of the return pole piece and is held in the unoperated position by the tension of a coiled retractile spring. A release armature adjusting screw on top of the armature and resting against the casting, acts as a back stop for regulating the armature travel. Attached to the lower end of the armature is a long screw, known as the release armature pin. When the release magnet is energized, the release armature pin strikes a projection on the double dog, causing disengagement of the double dog from the vertical and rotary ratchets, return of the shaft to its unoperated position by the shaft spring and a reengagement of the tooth on the double dog with the release link. The release magnet and associated parts are shown in Figure 77.

Actuated by the vertical, rotary and release mechanisms are various contact spring assemblies that serve as control elements in the operation of the switch or associated circuits. All 197 type switches are equipped with vertical off-normal contact spring assemblies and most of these switches have rotary interrupter spring assemblies. Other contact spring assemblies used on 197 type switches include vertical interrupter springs, cam springs (10th or 11th rotary step springs), release contact springs and normal post springs. A description of these contact springs is given in the following paragraphs.

Mounted on top of the casting to the left of the upper shaft bearing is the vertical off-normal contact spring assembly. It is operated by the off-normal lever that extends below the normal pin. With the switch normal the weight of the shaft causes the normal pin to hold the off-normal lever finger down, thus actuating the contact spring assembly. When the shaft is raised to the first level the normal pin releases the off-normal finger, operating the contact springs to the vertical off-normal position. See Figure 70.

Located on the lower right hand side of the switch just below the rotary ratchet, and mounted on a bracket attached to the casting, are the rotary off-normal and/or the cam springs. They are operated by a cam clamped to the shaft. On the first rotary step, the stud on the actuating spring of the rotary off-normal contact spring assembly becomes disengaged from the cam and operates the contact springs to the rotary off-normal position. When the shaft is rotated to the 10th or 11th rotary position, the cam engages with the stud on the actuating spring of the cam springs to operate the contacts of this spring assembly. Figure 70 shows the cam springs on a 197 type switch. When the switch is equipped with rotary off-normal and cam springs, the spring assemblies are combined, forming one spring pile-up, with the rotary off-normal springs in front.

Attached to the lower left hand side of the casting (see Figure 70) is the rotary contact spring assembly. The interrupter springs of this spring assembly consist of a thick stationary spring normally in contact with a moving spring. When the rotary magnet is energized, and just before the rotary armature has fully operated, an extension arm on the rotary magnet armature engages with the moving spring to open the contacts, thus causing the shaft to rotate under control of the interrupter contacts.

The vertical interrupter contact spring assembly used on some 197 type switches is located on the left hand side of the switch, attached to the back of the release magnet return pole piece, as shown in Figure 70. Like the rotary interrupter contact spring assembly, the interrupter springs of this assembly consist of a thick stationary spring normally in contact with a moving spring. One end of the associated operating lever is positioned above the vertical armature, just in back of the vertical pawl, by the back stop in the contact spring assembly. When the vertical magnet is energized, and just before the vertical armature has fully operated, the lever engages with the vertical armature, causing the other end of the operating lever to open the interrupter contacts and the shaft to step under control of the interrupter contacts.

As shown in Figure 77, the release contact spring assembly is mounted on a bracket adjacent to the release armature. It is actuated by a detail attached to the end of the release armature when the release magnet is energized.

Mounted on the normal post, located on top of the switch, is the normal post contact spring assembly, consisting of from 1 to 4 spring pile ups on a mounting block clamped to the normal post. See Figure 70. The actuating springs of this contact spring assembly are provided with rollers that engage with teeth-like projections on the normal post cam, attached to the shaft spring bracket, to operate the contacts at the required levels as the shaft steps vertically.

Among the items located below the cover plate are a test jack and sometimes a sleeve cutoff jack, both fastened to the underside of the cover plate; two bank rods, bolted to the casting, for mounting the banks and a number of bank wipers on the shaft. The bank wipers are positioned on the shaft by set screws and engage with the bank contacts during rotary stepping of the switch. There are two kinds of bank wipers, single conductor wipers for 100 point or sleeve banks and two conductor wipers for 200 point or line banks. In addition to the above items, line and trunk finder switches are provided with a commutator, attached to either the banks or the cover plate, and a commutator wiper mounted on the shaft. The commutator wiper is in contact with the commutator only during vertical stepping of the switch.

Associated with, but not forming a part of the 197 type switch mechanism, are the mounting plate and cover, the step-by-step relays that control the operation of the switch, the banks, the multicontact plug, capacitors and networks for contact projection purposes, and the commutator if it is mounted on the banks. The relays are located on top of the mounting plate, except the 225 type, used in some selector connector circuits and usually designated "Z", which is mounted in the lower right hand corner of the casting adjacent to the rotary magnets. The number of relays associated with a switch depends on the circuit in which the switch is used.

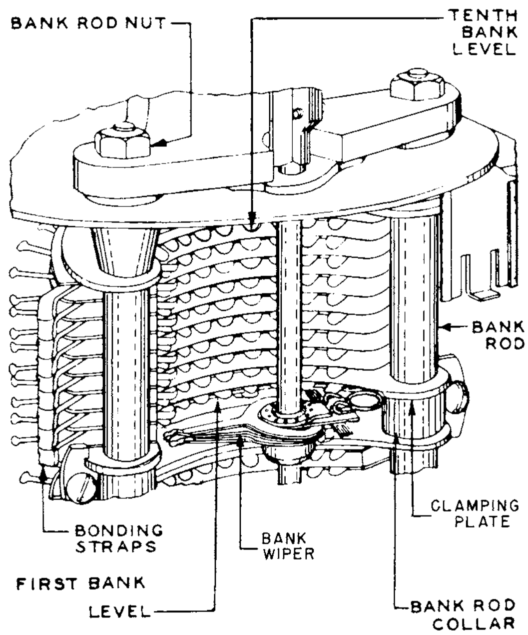


FIG. 78 200 POINT BANK AND MOUNTING

As mentioned previously, there are 100 point and 200 point banks. In the 100 point bank, one hundred terminals, arranged in a semi-circle, are assembled in ten horizontal rows, one above the other. Each row consists of ten brass contact terminals placed between insulators and separated from the next row by a metal spacer. The assembly is held together between clamping plates by three bolts. The clamping plates are provided with mounting holes on both ends for slipping the bank over the bank rods, where it is held in position by bank rod collars. The 200 point bank is assembled in the same manner, but instead of single contact terminals it is provided with pairs of contact terminals, separated by an insulator that extends beyond the edge of the contacts. In this type of bank, the metal spacers are connected together by bonding straps to prevent crosstalk. Figure 78 shows a 200 point bank mounted on a switch.

Mounted in back of the mounting plate is the multicontact plug that engages with the shelf jack springs when the switch is in position on the shelf. This plug and jack arrangement permits removal of the switch from the shelf without disconnecting the associated wiring. The cover, enclosing the switch mechanism and the relays completes the assembly.

QUESTIONS

1. What is the principal difference between 197 and 198 type switches?
2. What are the functions of the vertical and rotary dogs?
3. What is the purpose of the stationary dog?
4. Where is the normal pin located and what is its purpose?
5. What happens when the release magnet is energized?
6. Briefly explain what happens when the vertical magnet is energized.
7. What prevents the shaft from rotating when it is in its unoperated position?
8. Name the various contact spring assemblies that may be found on a 197 type switch.
9. What operates the rotary off-normal springs?
10. What kind of banks are used on 197 type switches?

SECTION 4

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 a preceding section, and consequently will be covered very briefly in the following paragraphs.

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 attatched 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 79.

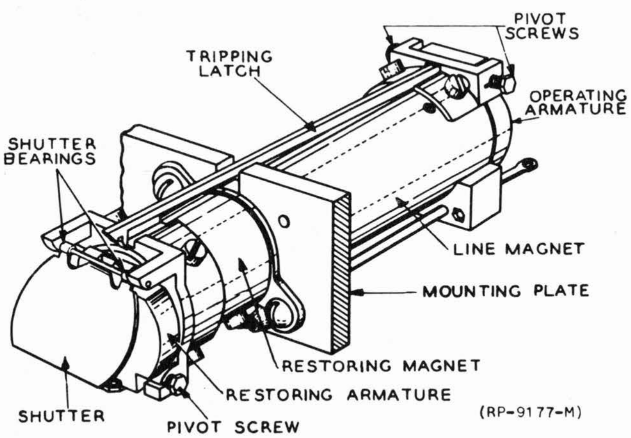


FIG. 79 22 TYPE DROP

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.

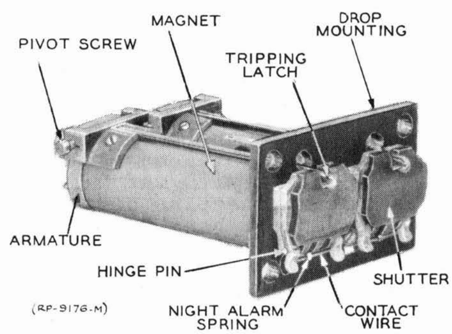


FIG. 80 56 TYPE DROP

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 80 shows two 56 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 because an aluminum signal ball 7/8" in diameter is visible in the window when the armature is operated. See Figure 81. The armature and signal ball are pivoted at the front end of the magnet core. The armature being heavier than the signal ball, keeps the ball raised up and 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.

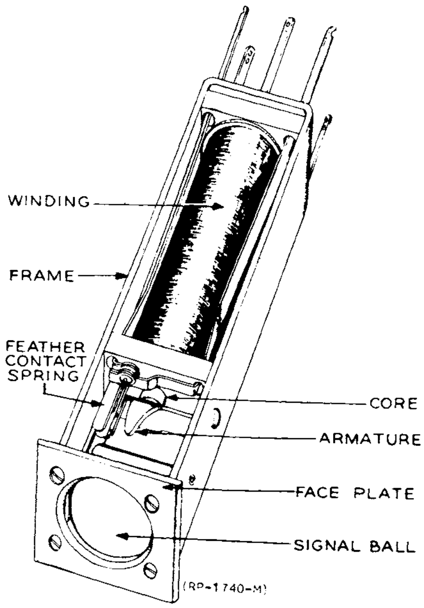


FIG. 81 34 TYPE SIGNAL

42 Type Signals

These signals are used as busy signals to mark a busy line on toll boards and are multipled 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 82, 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.

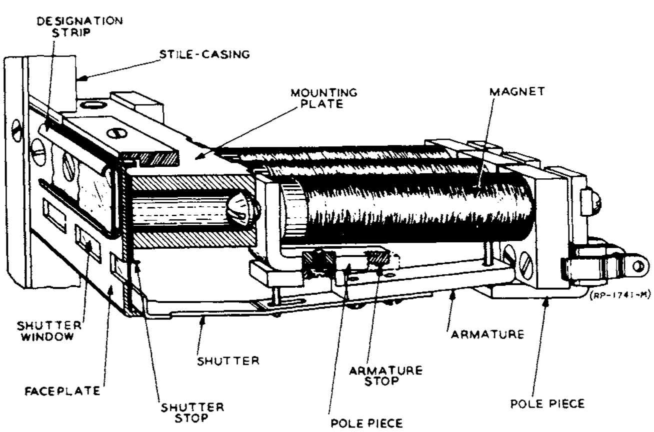


FIG. 82 42 TYPE SIGNAL

RINGERS

Ringers may be classified as biased and unbiased ringers. They generally consist of two electro-magnets wound in series aiding 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. 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 south polarity, and the ends of the armature a north polarity. The diagram shown in Figure 83 illustrates the polarizing action of the permanent magnet.

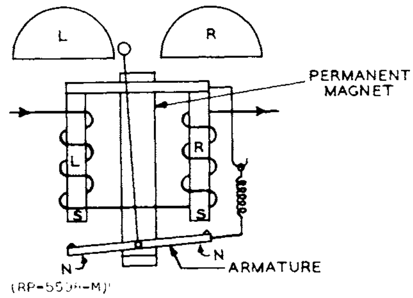


FIG. 83 DIAGRAM ILLUSTRATING ACTION OF A RINGER

Unbiased Ringers

The unbiased ringer, infrequently used today, is intended to operate 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

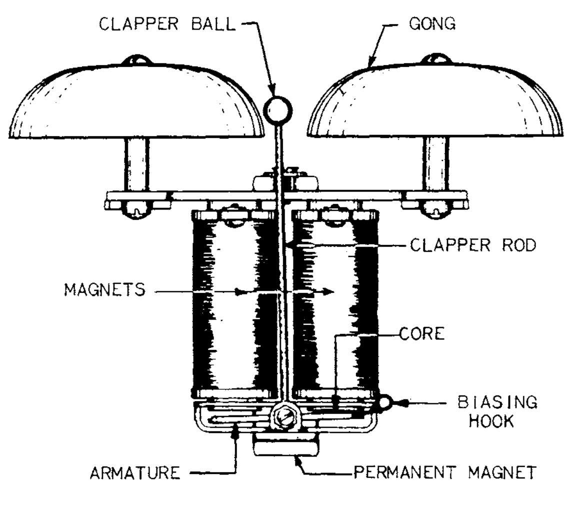


FIG. 84 UNBIASED RINGER

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 84 which shows an unbiased ringer of the 38 type.

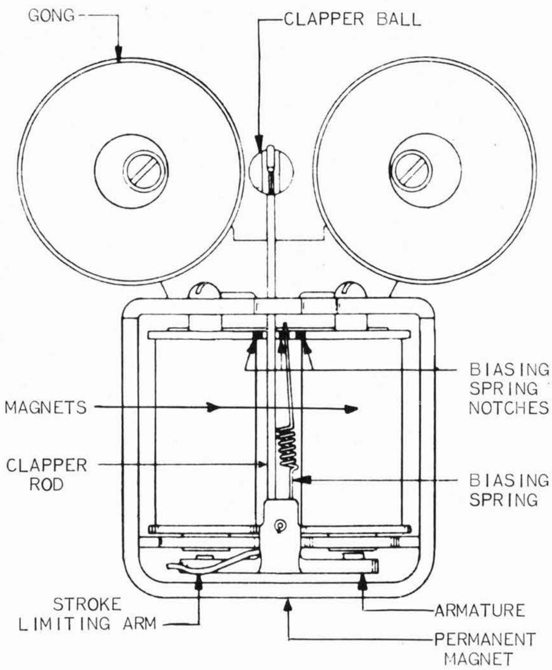


FIG. 85 BIASED RINGER

Biased Ringers

The biased ringer is intended to operate on superimposed or ac-dc ringing current used in present day ringing plants. In a biased ringer, a biasing spring is used to hold one end of the armature against one of the magnet cores. A pulse of the proper polarity will overcome the tension of the biasing spring and pull the armature against the other core, thus ringing first one gong and then the other as the armature is released and returned to the biased side. Pulses of the opposite polarity, 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.

Figure 85 shows a biased ringer of the B type. 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. B type ringers are principally used in telephone set mountings and in telephone sets.

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 86. 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 single coil type, and the armature itself acts as the return pole piece for the magnetic flux. The armature moves on a knife edge bearing and is tensioned against the back stop screw by a retractile spring attached to a movable slide for tension adjustment. 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 follows the reversals in current, returning to normal at the zero point on each half wave.

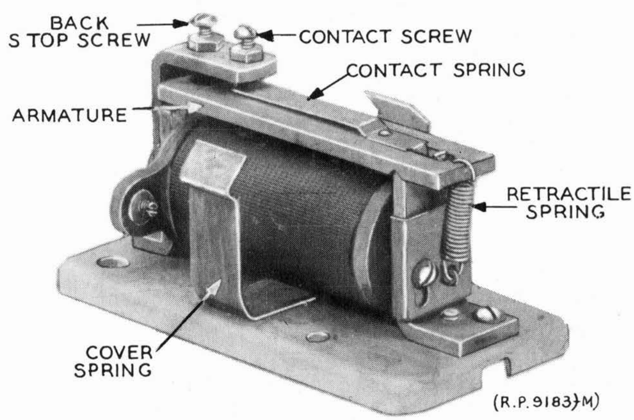


FIG. 86 4 TYPE BUZZER

7 Type Buzzer

This is a general purpose buzzer and its design is similar to that of the ordinary commerical buzzer. It is arranged for either direct current, or 50-60 cycle alternating current 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 silver 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 87 shows a 7 type buzzer with the cover removed.

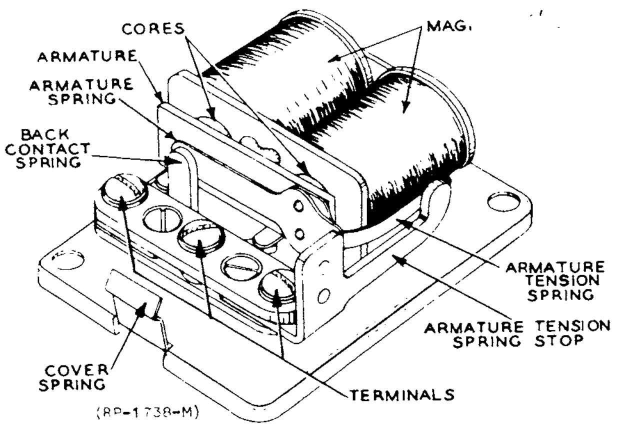


FIG. 87 7 TYPE BUZZER

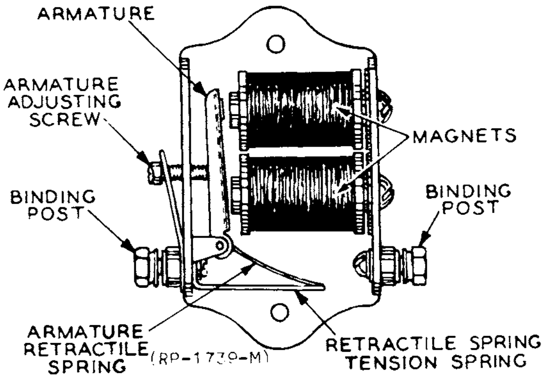


FIG. 88 12092 TYPE BUZZER

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 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 most 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 88.

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 5

LINE, TRAFFIC AND PEG COUNT REGISTERS AND SWITCHBOARD CLOCKS

LINE, 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.

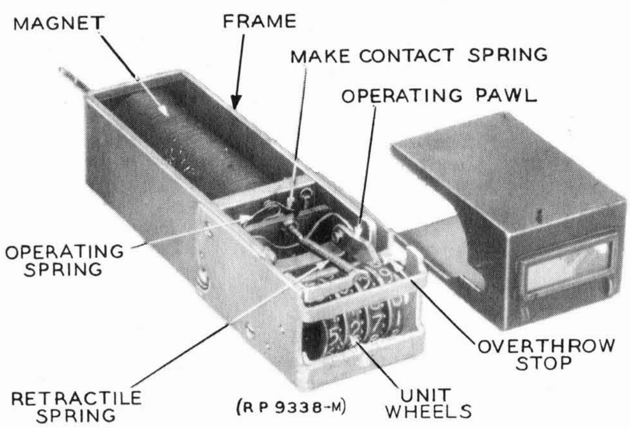


FIG. 89 5 TYPE REGISTER

The registers used in the central office include 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 89. 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 removeable 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 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, shown in Figure 90 with the cover removed, is a high speed register intended for use in the line and traffic register circuits of dial 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. To prevent the operation of the register from being affected by vibrations of the retractile spring upon release of the armature, the retractile spring is provided with a damping detail. 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.

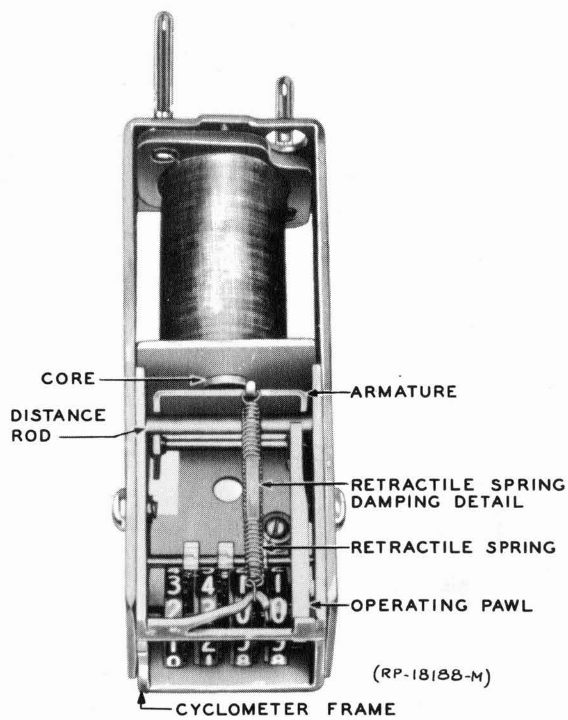


FIG. 90 14 TYPE REGISTER

A 13 type register is shown in Figure 91. This is a manually operated portable register, having a counting mechanism similar to the one used for 5 type registers. Instead of an electromagnet, however, this register uses a plunger,

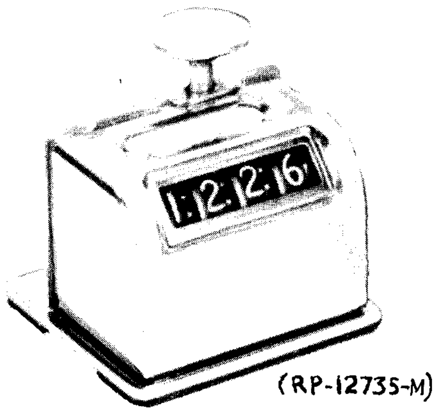


FIG. 91 13 TYPE REGISTER

which when depressed, causes the associated operating pawl to engage the ratchet wheel of the units wheel, and moves 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.

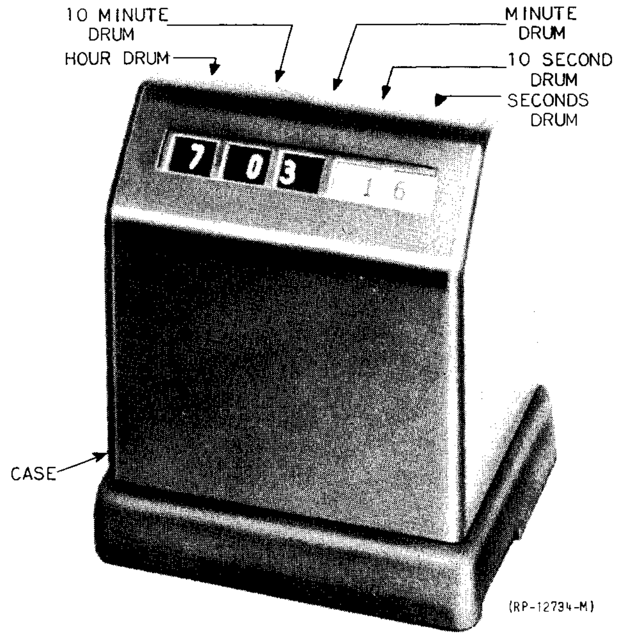


FIG. 92 KS-14156 CLOCK

SWITCHBOARD CLOCKS

Switchboard clocks are timing devices used by telephone operators for the timing of calls. Figure 92 shows a synchronous motor-driven switchboard clock, designated KS-14156 arranged for surface mounting. 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 molded plastic 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, 10 second drum and a continuously rotating second drum. For easy removal and replacement, the clock is provided on the bottom with two plugs that engage with jacks in the connecting block. An adjusting screw on the bottom permits the clock to be slightly titled to minimize light reflections from the clock window. By using different escutcheons, KS-14156 clocks may be arranged for surface and subsurface mounting.

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 KS-14156 clock indicate time?

SECTION 6

204, 206, 209 AND 211 TYPE SELECTORS

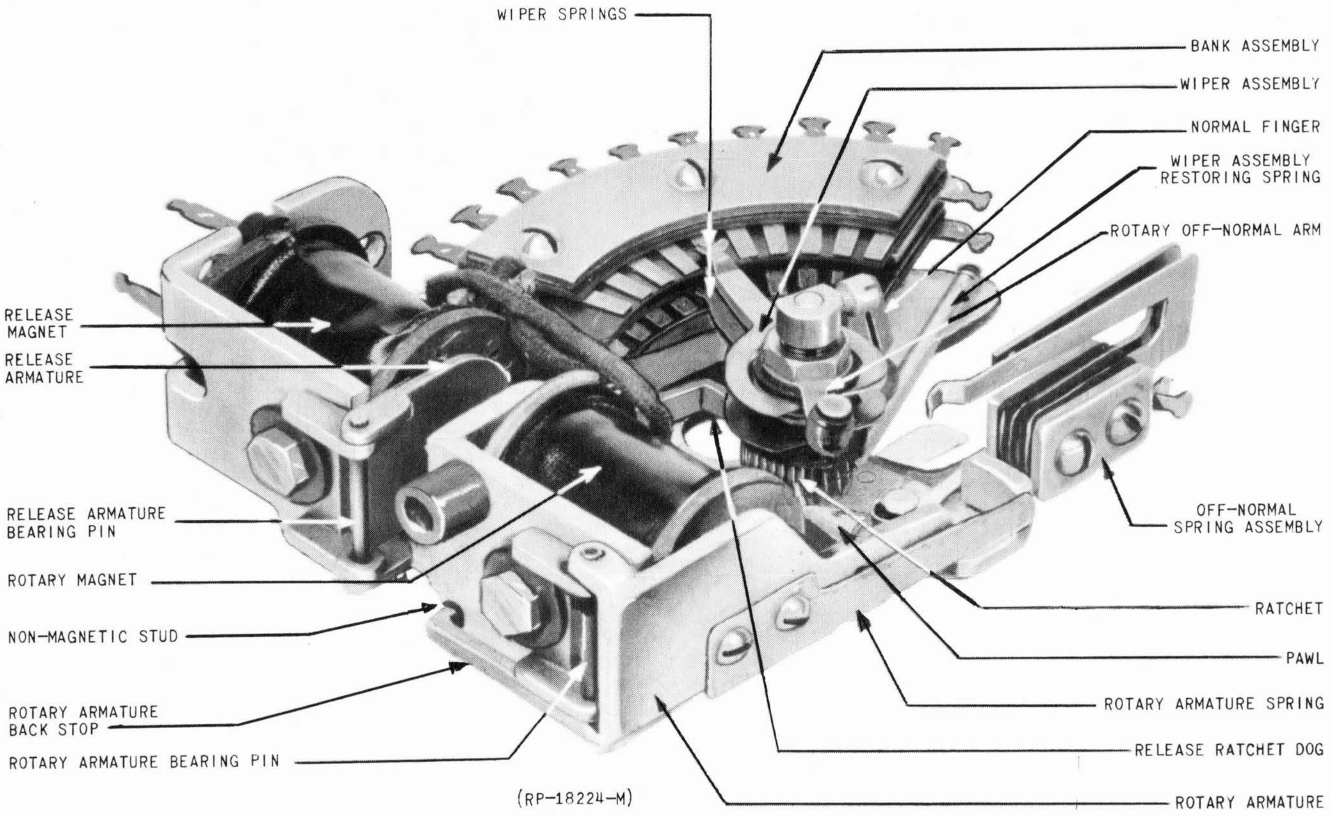


FIG. 93 204 TYPE SELECTOR

204 Type Selector

The 204 type selector shown in Figure 93 consists essentially of a metal frame on which are mounted a rotating wiper assembly with two wipers, an associated bank assembly, a rotary magnet, a release magnet and a contact spring assembly.

The wiper assembly rotates on a bearing shaft attached to the frame and includes a ratchet, a normal finger, two bank wipers insulated from each other and the frame, a rotary off-normal arm and a wiper assembly collar to hold the assembly in position on the bearing shaft. A restoring spring provides the tension for holding the wiper assembly in, or restoring it to, the unoperated position, where the normal finger is resting against a stop on the frame.

The bank assembly consists of two rows of terminals, insulated from each other and held together between clamping plates. Each row is provided with 10 brass terminals on top and a common terminal plate on the bottom, separated by an insulator that extends beyond the edge of the contacts.

The rotary magnet armature is attached to the bearing yoke by a bearing pin and is held in the unoperated position by the tension of the rotary armature spring. An extension arm on the bottom of the armature, that engages with a non-magnetic stud on the underside of the return pole piece serves as a back stop. Attached to the upper end of the armature is a pawl for rotating the wiper assembly. When the rotary magnet is energized, the pawl engages the ratchet teeth to rotate the wiper assembly one step. When the rotary armature releases, the release ratchet dog on the release magnet, engaging the ratchet teeth, holds the wiper assembly in the operated position.

The armature of the release magnet, attached to the frame like the rotary armature, is provided with an arm that extends to the ratchet to form the release ratchet dog. A release armature spring provides the tension for keeping the release ratchet dog engaged with the ratchet teeth. When the release magnet is energized, the release ratchet dog is disengaged from the ratchet and the wiper assembly is returned to normal by the tension of the restoring spring.

Associated with the wiper assembly is the rotary off-normal arm. When the switch is in the normal position, the roller on the off-normal arm holds the off-normal spring assembly in the off-normal position.

206, 209 and 211 Type Selectors

206, 209 and 211 type selectors are rotary switches that operate from pulses received from such source as a dial or a relay, or may be made to hunt for the proper connection. The three types are almost identical in construction, except for the addition of a pawl guide on the 209 type to guard against overstepping, and the use of precious metal contact surfaces on certain brushes of the 211 type associated with talking circuits.

The selector consists of a metal frame equipped with a number of rotary brushes, a magnet that operates a ratchet wheel and a set of interrupter springs. Associated with the selector, but not forming a part of it, is a bank having from 2 to 6 arcs with either 22 or 21 phosphor bronze terminals and a phosphor bronze feeder brush in each arc. A 206 type selector is shown in Figure 94.

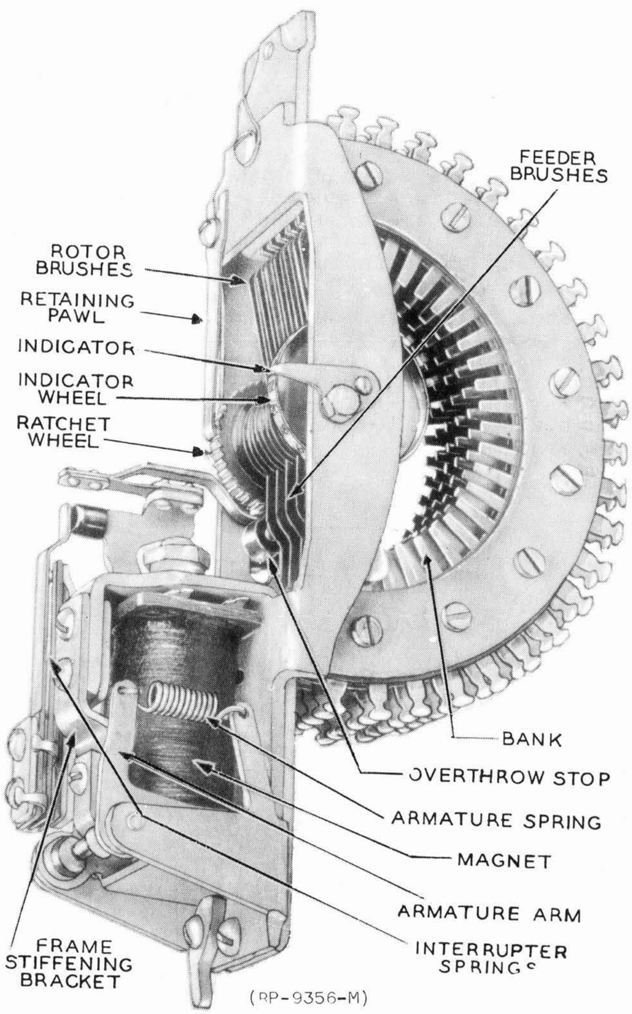


FIG. 94 206 TYPE SELECTOR

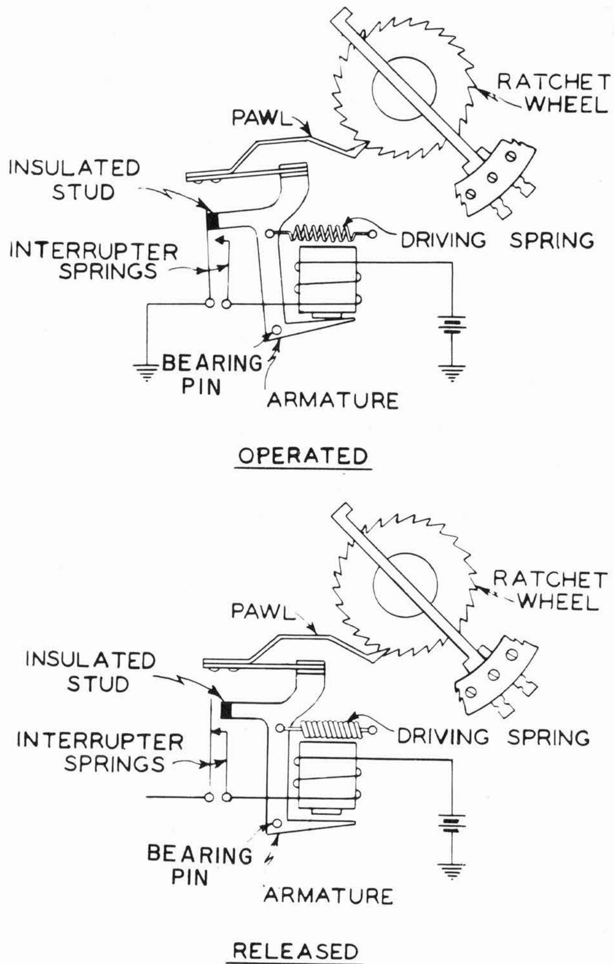


FIG. 95 OPERATION OF ROTARY SELECTOR

The rotor brush assembly includes a number of rotor brushes, numerically corresponding to the number of arcs in the associated bank, mounted on a hollow shaft together with a 44 tooth ratchet wheel on one side and an index wheel on the other side. The assembly rotates on a bearing pin and is made to revolve by a driving pawl attached to 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 magnet is de-energized, the retractile spring pulls the armature away from the core, causing the driving pawl to engage with a tooth on the ratchet wheel and the brushes to step from one terminal to the next. A retaining pawl engaging the ratchet wheel holds the rotor brushes in position on the bank terminals. Also actuated by a stud on the end of the armature extension are the interrupter springs. The contacts on the interrupter springs open each time just before the armature has fully operated and they close again when the armature is released. This 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 95.

The magnet is attached to the frame by means of an adjusting bushing with lock nut and a magnet clamping screw. This permits the magnet to be raised or lowered, as needed, for adjustment purposes. The armature moves on a thick bearing pin secured to projections on the bottom of the frame and is provided with bent up sides to reduce the magnetic reluctance. In front of the magnet is a brass stiffening bracket, attached on top to a projection on the frame and on the bottom to the thick bearing pin. The purpose of this bracket is to prevent a movement of the magnet toward the armature when energized.

The rotor brushes form a connection between the feeder brushes and the bank terminals. They have two types of contacting surfaces, bridging and non-bridging, as shown in Figure 96. Bridging brushes are in continual contact with a terminal of the bank at all points in the rotation of the selector. Non-bridging brushes have only a line contact face. Both types of brushes consist of two equal sections for making contact with both sides of a bank terminal. The object of using double contacts is to reduce contact failure to a minimum, similar to the use of twin contacts on relays.

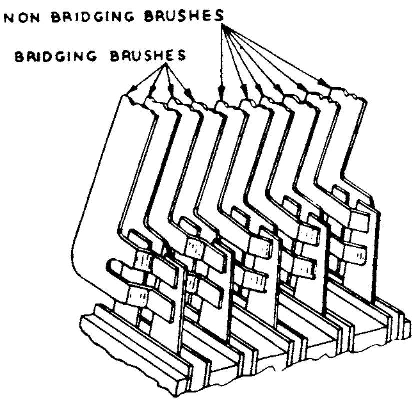
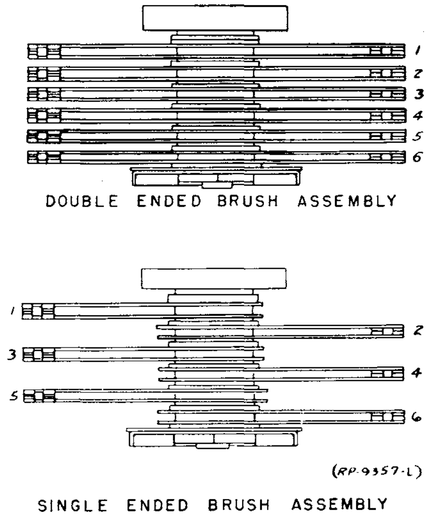


FIG. 96 BRIDGING AND NON-BRIDGING BRUSHES

Aside from the various combinations of bridging and non-bridging brushes there are several brush arrangements. 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 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 ordinary double ended brush arrangement and one of the single ended brush arrangements are shown in Figure 97.

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 con-



FIG, 97 BRUSH ARRANGEMENTS

tacts 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. The unit is wired in parallel with the regular feeder brushes of the selector. A selector equipped with such a unit is shown in Figure 98. 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.

When 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.

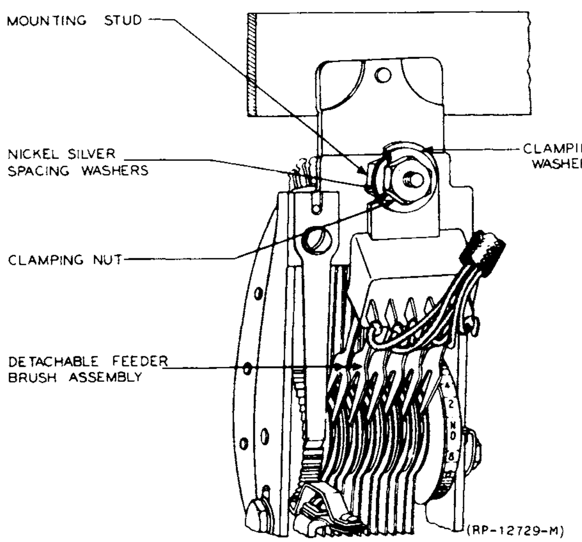


FIG. 98 SELECTOR EQUIPPED WITH DETACHABLE FEEDER BRUSH UNIT

QUESTIONS

204 Type Selector

1. How many bank terminals are there on a 204 type selector and how are they arranged?
2. What happens when the rotary magnet is energized?
3. What happens when the release magnet is energized?

206, 209 and 211 Type Selectors

4. Do the rotor brushes advance when the armature operates or when it releases?
5. What is the function of the interrupter springs?
6. What is the function of the brass stiffening bracket?
7. What happens when the magnet is energized?
8. What is the difference between a bridging and a non-bridging brush?
9. Why are single ended rotor brushes used?
10. What are detachable feeder brushes used for?
11. When are felt mounting pads furnished?

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 to 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 99. 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 spring is used whenever a non-locking spring combination is desired. All contact springs with the exception of the crook

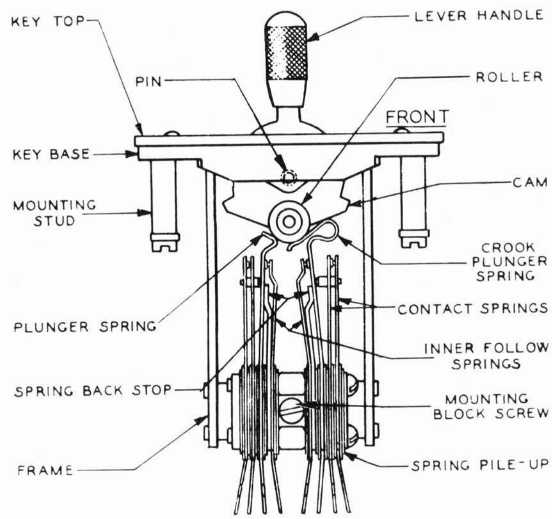


FIG. 99 C-1 TYPE KEY

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 100 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.

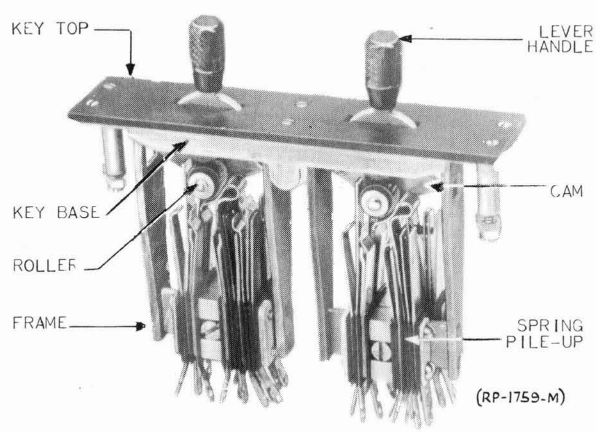


FIG. 100 B-1 TYPE KEY

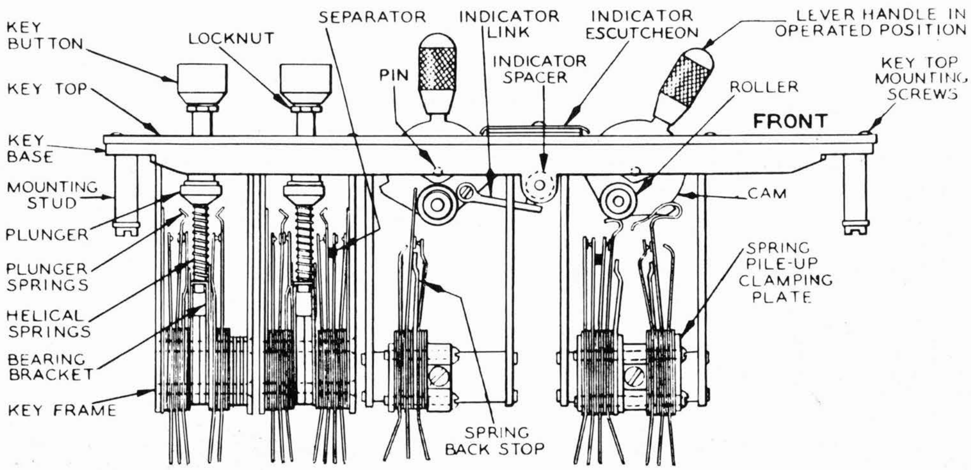


FIG. 101 A-2 TYPE KEY

Another universal type key is shown in Figure 101. 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.

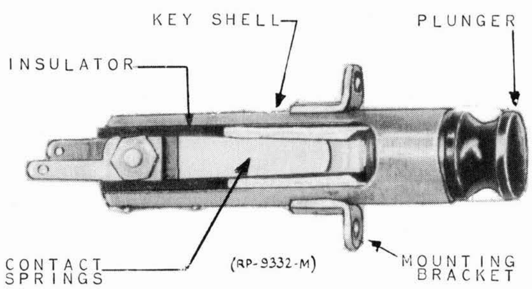


FIG. 102 92 TYPE KEY

PLUNGER TYPE KEYS

Among the most commonly used plunger type keys is the 92 type shown in Figure 102. 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.

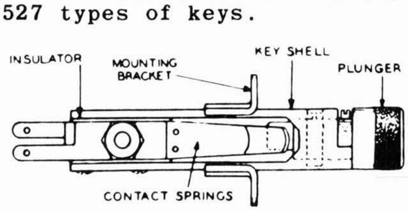


FIG. 103 498 TYPE KEY

Figure 103 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.

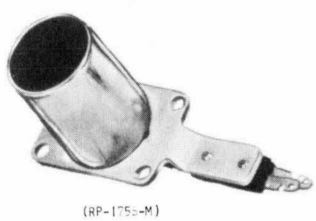


FIG. 104 520 TYPE KEY

Another plunger type key, known as the 520 type is shown in Figure 104. 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 105. 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

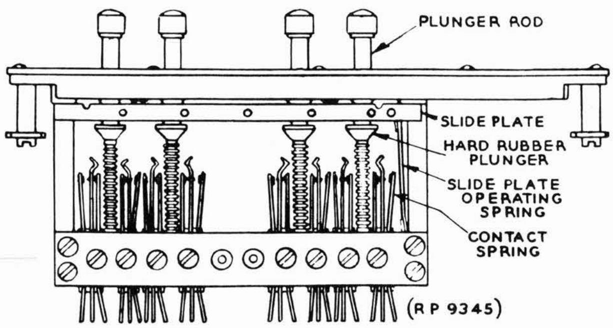


FIG. 105 A-6 TYPE KEY

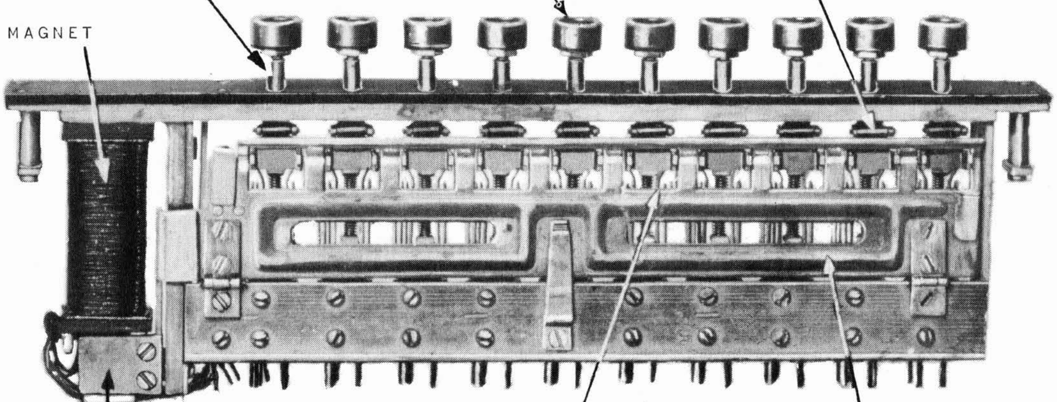


FIG. 106 E-1 TYPE KEY

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 106. 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

JACKS, LAMPS, LAMP SOCKETS AND MOUNTINGS

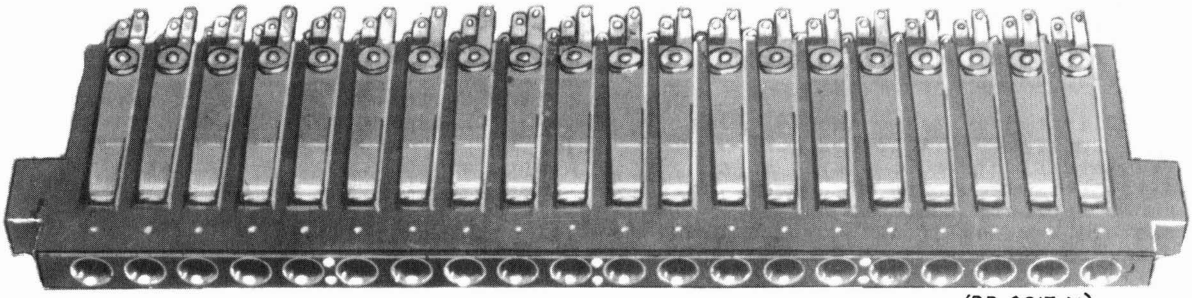


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FIG. 107 114 TYPE JACK MOUNTING EQUIPPED WITH 49 TYPE JACKS

JACKS

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.

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 metal 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.

49 Type Jack

This is a three-conductor jack usually mounted in strips 10 or 20 and is used on small manual and toll switchboards. Figure 107 shows twenty 49 type jacks assembled on a 114 type jack mounting. The 49 type jack 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.

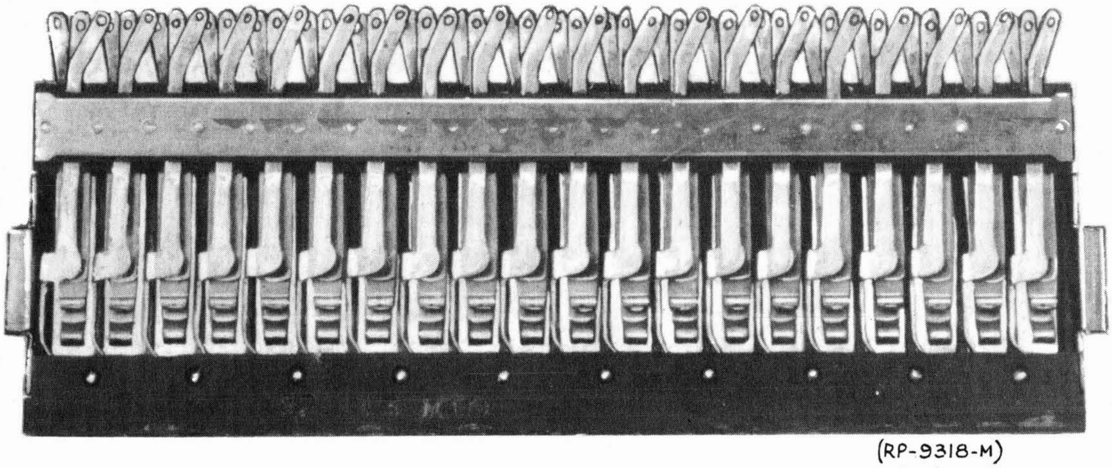

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FIG. 108 113 TYPE JACK MOUNTING EQUIPPED WITH 92 TYPE JACKS

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 of twenty 92 type jacks assembled on a 113 type jack mounting is shown in Figure 108.

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 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.

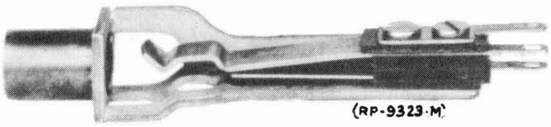

FIG. 109 218 TYPE JACK

218 Type Jack

This is a typical individually mounted two conductor jack, having an auxiliary break contact spring and used with the 347 and similar type plugs. It is provided with either one or two mounting lugs and mounts with the springs in a vertical plane. See Figure 109.

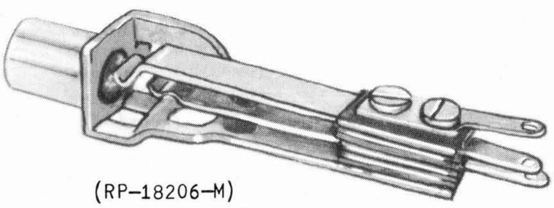

FIG. 110 238 TYPE JACK

238 Type Jack

A typical three conductor jack, designated 238, is shown in Figure 110. The tip and ring springs of this jack are tensioned against a hard rubber stud to hold them in proper alignment. Like the 223 type, this jack is also provided with either one or two mounting lugs and mounts with the springs in a vertical plane.

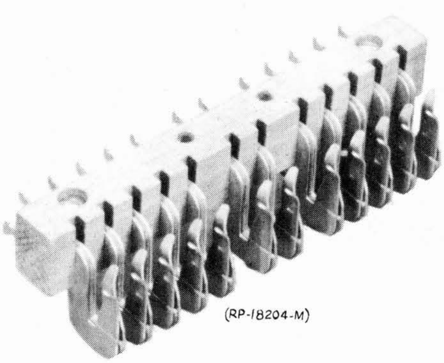

FIG. 111 346 TYPE JACK

346 Type Jack

This is a multicontact jack used in step-by-step offices and is shown in Figure 111. It consists of a wooden strip with 12 pairs of contact springs. It mounts on the shelf framework of step-by-step switch equipment and engages with the prongs of a 242 type plug mounted in the rear of the step-by-step switch assembly. The U shaped contact springs are flared on the ends to facilitate engagement with the plug.

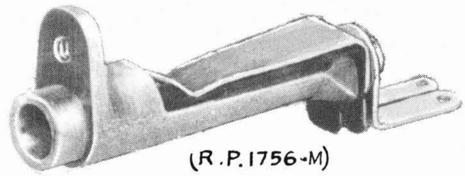

FIG. 112 364 TYPE JACK

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 112.

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 107.

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 107 and 108. 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 jack mounting equipped with 49 type jacks is shown in Figure 107. 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 108. These jacks are also separated into groups of five by pairs of small white dots on the face of the strip.

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 withstand a considerable increase in current 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.

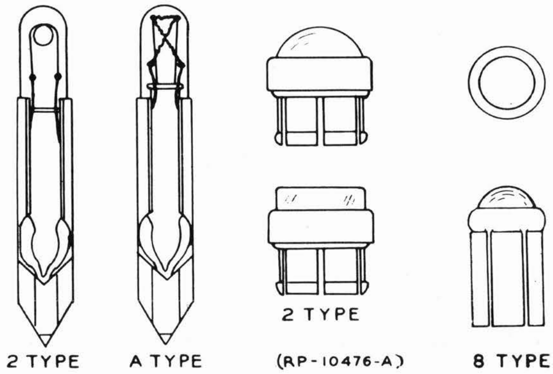

FIG. 113 SWITCHBOARD LAMPS AND LAMP CAPS

Switchboard lamps use either a carbon or a tungsten filament. See Figure 113. They vary in voltage from 4 to 48 volts and in current consumption from .018 to .310 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-Y lamp has a carbon filament and an A-3 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.

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.

FIG. 114 278 TYPE LAMP SOCKET MOUNTING EQUIPPED WITH 43 TYPE LAMP SOCKETS

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 then the one directly in front of the lamp. See Figure 113.

LAMP 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 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 jackstrip. 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 sockets is shown in Figure 114.

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 115.

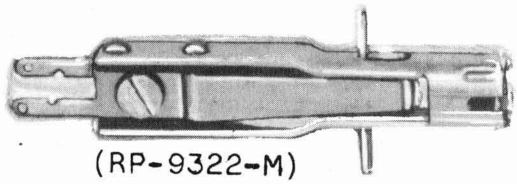

FIG. 115 13 TYPE LAMP SOCKET

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. What is the purpose of the sleeve on a lamp cap?
8. How is a lamp mounting secured to the switchboard?

SECTION 9

PLUGS AND CORDS

Although there are many different kinds of plugs, only a few of the most commonly used types will be considered in this section. These include the two conductor plug, the double plug, the small three conductor plug, the large three conductor plug, and the multi-contact plug associated with step-by-step switches.

A good example of a two conductor plug is the 347 type plug shown in Figure 116. 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.

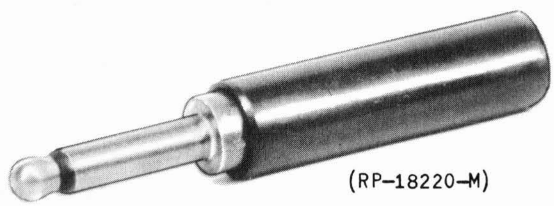

FIG. 116 347 TYPE PLUG

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 117, 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 parts, 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 placed. Inside the sleeve, and separated from each other and the sleeve by molded-in insulation, are the ring and tip conductors,

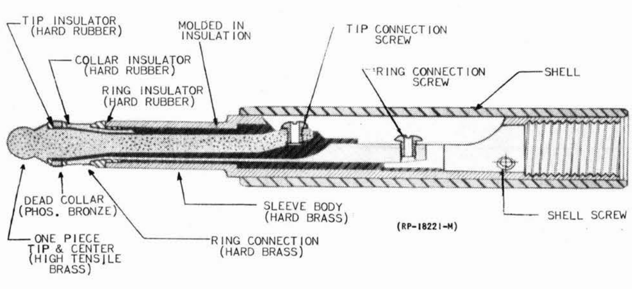

FIG. 117 CROSS SECTION OF 310 TYPE PLUG

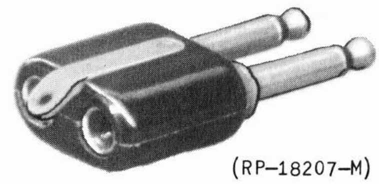

FIG. 118 289 TYPE PLUG

also made of brass. Placed between the tip and ring conducting surfaces and insulated from the tip and ring is the phosphor bronze dead collar. The purpose of this collar is to prevent the tip and ring from shorting on the ring spring or sleeve of the jack during insertion or removal of the plugs.

The double plug connected to the operator's breast transmitter and head set and shown in Figure 118 is the 289 type plug. It consists of 2 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.

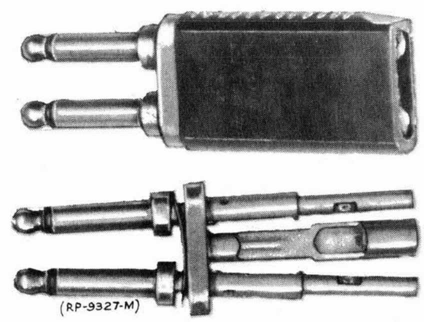

FIG. 119 241 TYPE PLUG

The twin plug shown in Figure 119 is the 241 type plug which is used at toll test boards. This 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 into 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.

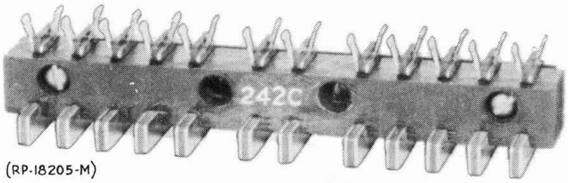

FIG. 120 242 TYPE PLUG

The 242C plug shown in Figure 120 is used on step-by-step switches and mounts in back of the switch. It consists of a wooden strip with 12 pairs of contact springs. When the switch is in position on the shelf, the contacts of the plug engage with the contact prongs of the shelf jack.

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 arbitarily 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 121 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 cotton knitting is then wrapped around the conductor followed by a coating of rubber to insulate it. The rubber is of a different color for each conductor, the tip being white, the ring blue and the sleeve red. The conductors are twisted together and cotton filler threads are wound in the crevices so that the cord will be smooth and round when the nylon braid is applied.

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.

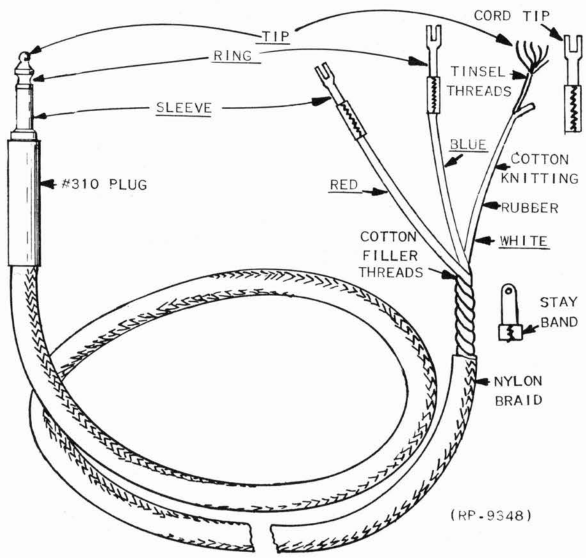

FIG. 121 SWITCHBOARD CORD

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 10

CAPACITORS

A capacitor 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.

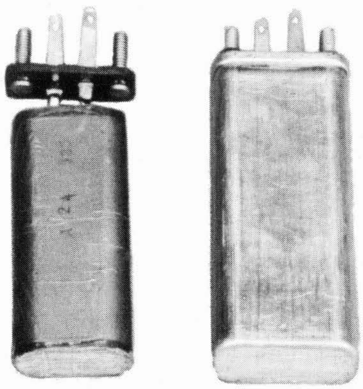

FIG. 122 439 TYPE CAPACITOR

The majority of capacitors used in the telephone plant are of the paper insulated type. In these capacitors, the conducting material consists of long strips of aluminum foil, approximately .0003" thick, and the insulators are strips of very thin high grade tissue paper about .0004" thick. To make a paper condenser, two strips of aluminum 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 middle 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 capacitor is flattened to remove excess wax and to raise the capacity. The capacitor is next tested for breakdown strength and capacity and then sealed into a aluminum container with an asphalt or wax preparation. A 439 type paper capacitor before and after it is sealed into the aluminum container is shown in Figure 122.

Among the typical types of paper capacitors commonly used in the telephone plant are the 437, 438, 439 and 441 types. These capacitors 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. See Figures 122 and 123.

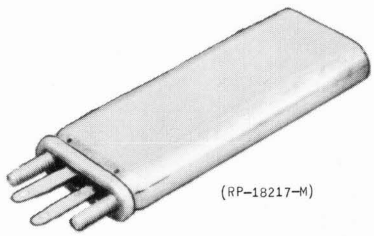

FIG. 123 441 TYPE CAPACITOR

Capacitors not intended for mounting plate use, are generally of the 447 and 449 types. See Figure 124. These capacitors have the terminals in front and are mounted by means of a mounting strap.

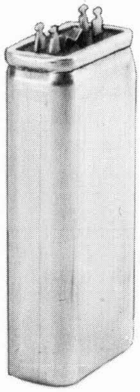

FIG. 124 447 TYPE CAPACITOR

The 187 type capacitor shown in Figure 125 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 capacitor 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.

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

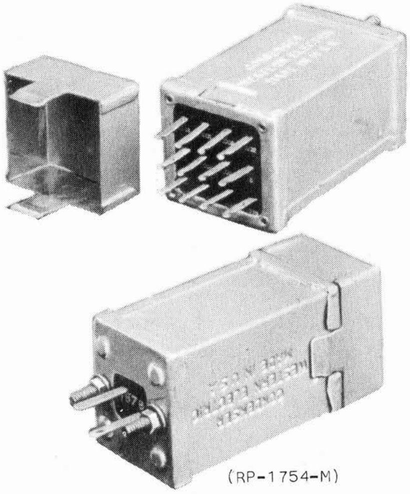

FIG. 125 187 TYPE CAPACITOR

While paper capacitors have the advantage of being inexpensive, there are certain limits to the accuracy with which they can be commercially produced. Where closer limits are required, particularly on the lower values, mica is used as the dielectric. Instead of being rolled, silvered mica laminations are assembled with very thin lead foil looped-in to make electrical contact between the silvered

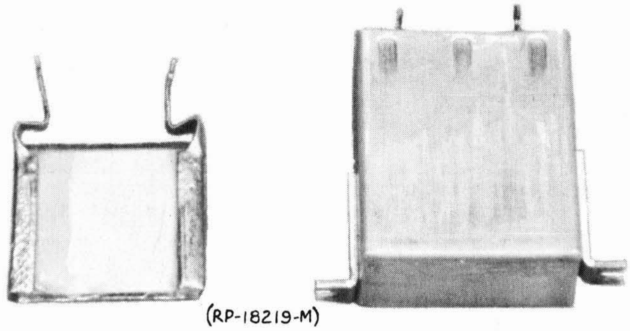

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FIG. 126 AR TYPE CAPACITOR

coatings and the terminals. The purpose of looping-in the foil is to permit a continuous electrical connection between the stack and a capacitance meter during assembly. After stacking, the capacitor units are dried at atmospheric pressure and adjusted within final capacitance limits by scraping off small portions of the silver coating from the top lamination. The assembly is then potted in metal or molded cases, or hermetically sealed cans. The assembled stack of silvered mica laminations for an AR type capacitor and the finished capacitor are shown in Figure 126.

QUESTIONS

1. What are the component parts of a paper capacitor and how is it made?

2. What types of capacitors are most commonly used?

3. Why do some capacitors use mica instead of paper for the dielectric?

SECTION 11

TRANSFORMERS AND INDUCTORS

Among the many kinds of transformers and inductors found in the telephone plant, only a few typical types used in transmission circuits will be described in this section. The term transformer includes apparatus previously designated repeating coils, induction coils, input and output transformers. Likewise, the term inductor refers to apparatus previously designated retardation or choke coils.

According to their mechanical construction, transformers may be of the shell, toroidal or core type. The core of a shell type transformer consists of a number of silicon steel or permalloy laminations of E, I and L shapes, as shown in Figure 127. The assembled sections of laminations are butt-jointed after the filled or spool wound coil has been placed over the center leg of the core. The completed assembly is then encased in an extruded aluminum case lined with sheet iron for crosstalk shielding purposes.

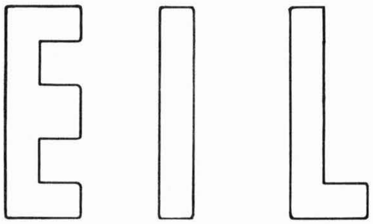


FIG. 127 TRANSFORMER LAMINATIONS

A typical shell type transformer used in telephone central offices is the 94 type shown in Figure 128. One of these transformers 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. Transformers used in this manner are referred to as battery supply transformers, because the direct current required for the operation of the transmitter passes through its windings. Battery supply transformers prevent shortcircuiting of the voice currents by the battery.

The core of a toroidal type of transformer consists generally of a ring of silicon steel or permalley 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. 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 metal can.

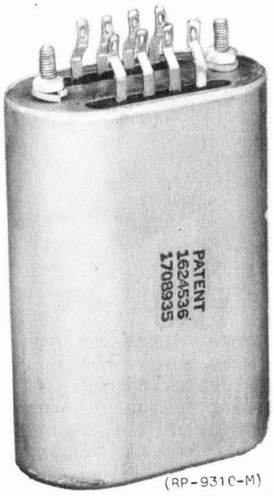


FIG. 128 94 TYPE TRANSFORMER

Figure 129 shows a 62 type transformer consisting of two toroidal type transformers mounted on a common metal base. The two units of this transformer are provided with balanced windings for use in deriving phantom circuits. The term phantom refers to an additional telephone channel obtained by utilizing the two conductors of each of the two principal or "side" circuits as a conductor for a third circuit.

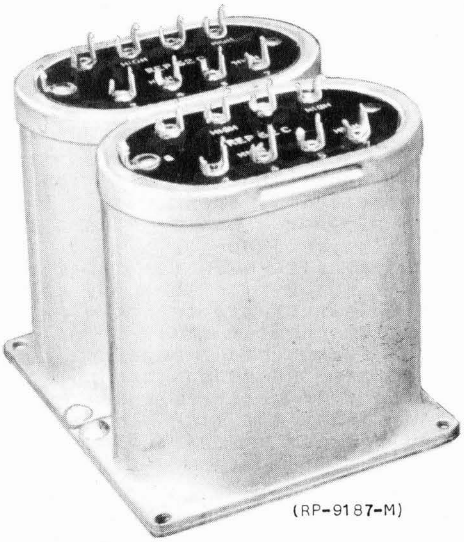


FIG. 129 62 TYPE TRANSFORMER

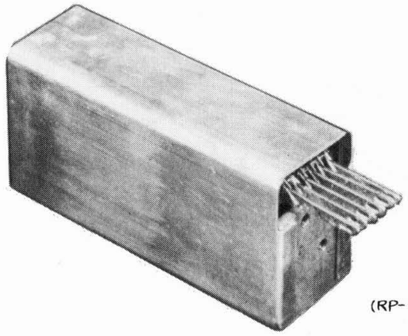


FIG. 130 178 TYPE TRANSFORMER

A transformer used in operator's telephone circuits is shown in Figure 130. This is a core type transformer using two butt-jointed stacks of L shaped laminations, with the coil placed over the long leg of one of the L shaped stacks. Like in a shell type transformer, the completed assembly is encased in an extruded aluminum case lined with sheet iron for crosstalk shielding purposes.

Another core type transformer similar in appearance to, and partly superseding the 178 type, is the 181 type. The core of this transformer, however, consists of a single stack of I shaped laminations placed inside of a filled coil. The assembly is held in position inside the sheet iron lined aluminum case by the tension of a flat spring inserted between the core and front of the case.

Inductors are used to retard or choke the flow of alternating or rapidly varying currents but allow the comparatively free passage of direct current. Like transformers, inductors for general transmission purposes may be of the shell, toroidal or core type.

Typical among the inductors having a shell type core and used in central office equipment is the 149 type. In construction and external appearance the 149 type inductor is practically identical with the 94 type transformer shown in Figure 128. Another shell type inductor used on toll lines, which are also used for telegraph purposes, is the 158 type shown in Figure 131. It consists of two separate units each potted in a rectangular sheet steel can and mounted 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.

Inductors with a toroidal type of core include the 91 and 167 types. Both types are arranged for relay rack mounting and differ primarily in mounting and terminal arrangement. The 91 type is provided with a base plate with mounting holes and the windings terminate at a phehol fibre terminal strip in front. The 167 type is arranged for stud mounting and the winding terminals are located on the wiring side. A 167 type inductor is shown in Figure 132.

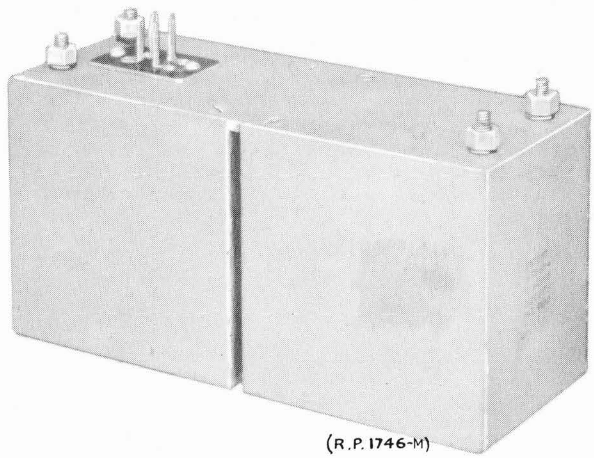


FIG. 131 158 TYPE INDUCTOR

Typical core type inductors include the 274 and 307 types. In appearance and construction they are identical to the 181 and 178 type transformers, respectively.

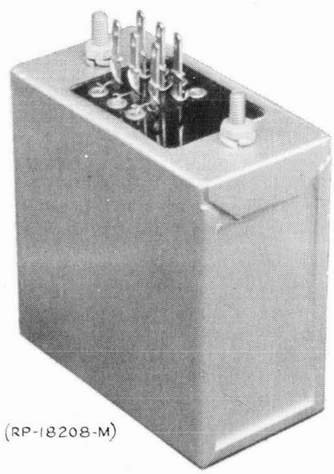


FIG. 132 167 TYPE INDUCTOR

In addition to the above mentioned types, relay cores are also used as inductors. The 85 type inductor for example is similar to an "H" type relay with the armature and contact springs omitted. See the section on relays for a description of the "H" type relay.

<u>QUESTIONS</u>

1. What materials are used for the cores of toroidal type transformers?
2. What is meant by battery supply and phantom transformers?
3. What are inductors used for?
4. What is the purpose of the sheet iron lining inside the aluminum case of a transformer or inductor?

SECTION 12

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.

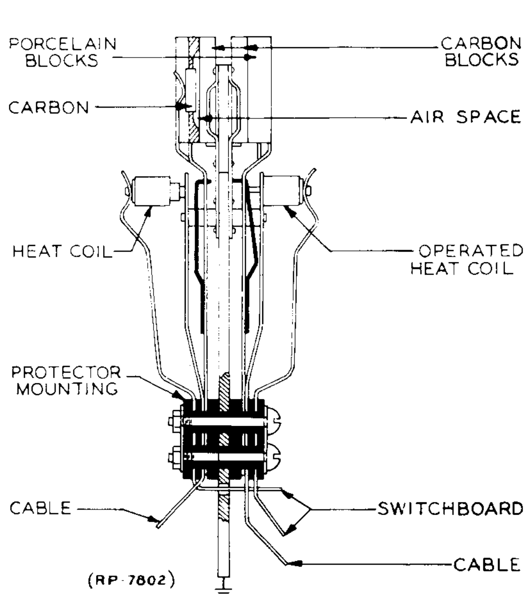


FIG. 133 DIAGRAM OF A PROTECTOR

A diagrammatic view of such a protector unit with protector blocks and heat coils is shown in Figure 133. 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 134, consists essentially of a winding of fine alloy wire on a copper sleeve which is

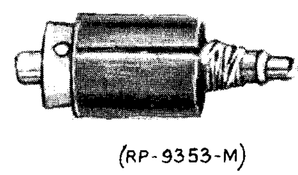


FIG. 134 76 TYPE HEAT COIL

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 133. A cross-sectional view of a heat coil mounted in a protector is shown in Figure 135.

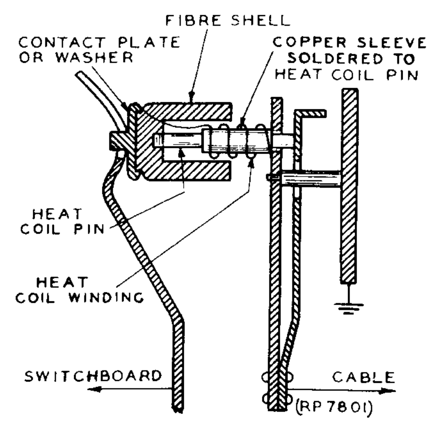


FIG. 135 CROSS-SECTION OF HEAT COIL

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 136 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.

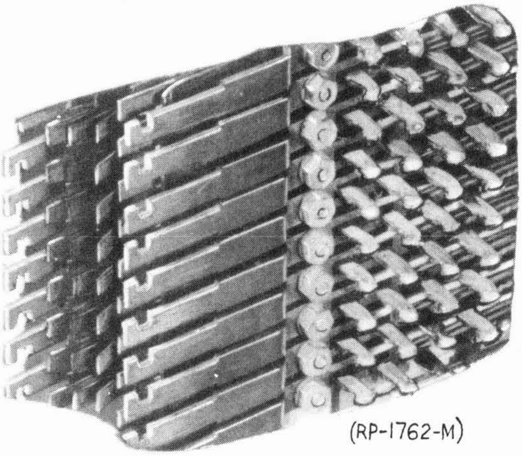


FIG. 136 SECTION OF 444 TYPE JACK

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.

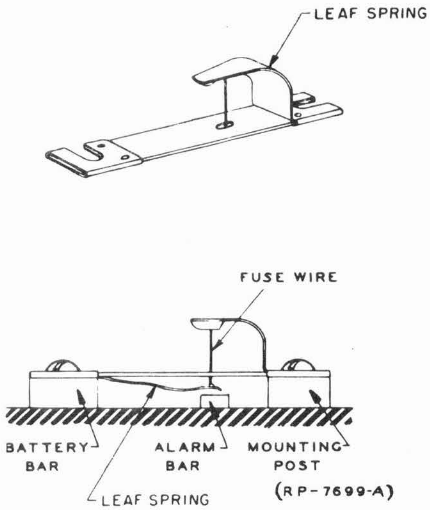


FIG. 137 35 TYPE FUSE

Fuses used for local telephone circuits are either of the open or enclosed type. Figure 137 shows a fuse of the open type, 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 phenol fibre with slotted tinned terminals at each end. The fuse wire is held taut between two leaf springs.

When the fuse blows, the springs are released and take up a position shown in Figure 138. 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. When the fuse blows, the leaf spring on top projects beyond the line of the other fuses so that it can be readily located. 35 type fuses are made in various capacities and use differently colored insulating strips for each separate capacity. A glass or porcelain tube enclosing the fuse wire is provided on fuses operating on voltages above 90 volts.

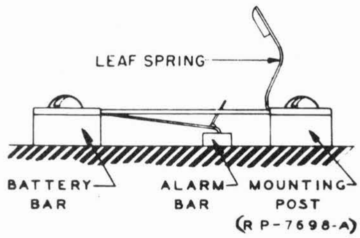


FIG. 138 35 TYPE FUSE BLOWN

Another open type fuse 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.

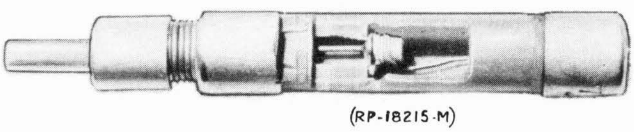


FIG. 139 70 TYPE FUSE

A closed type of fuse of the 70 type, with cut-away section to indicate the fuse wire, is shown in Figure 139. This fuse consists essentially of a fibre tube containing a fuse wire which is attached to a metal cap on one end and to a coil spring with metal cap at the other end. When the fuse operates, the spring is released, forcing the metal cap against the alarm terminal of the fuse block. Like the 35 type, 70 type fuses are made in various capacities and are provided in front with different colored beads that project through a hole in the cap of the fuse holder to facilitate selection and location of a blown fuse.

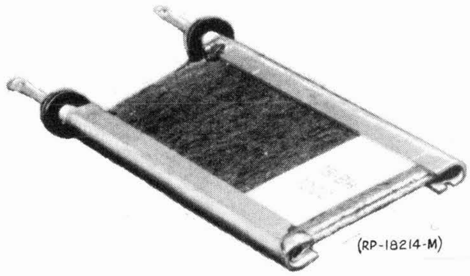
<u>QUESTIONS</u>

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. Why are 70 type fuses equipped with different colored beads?

SECTION 13

RESISTORS, RESISTANCE LAMPS, BALLAST LAMPS AND VARISTORS

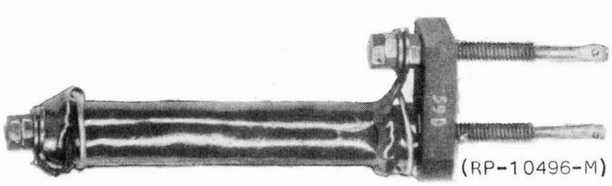
Resistors are one of the most commonly employed devices in the telephone plant. In the majority of cases they are used to control the flow of current in a circuit, such as lighting of switchboard lamps, regulating current values through relay windings, etc. There are a number of different types of resistors,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



(RP-18214-M)

FIG. 140 **18 TYPE RESISTOR**

Two types of resistors, similar in construction and used very extensively, are known as the 18 and 19 types. The 18 type shown in Figure 140 is a single resistor, while the 19 type has a third connection to an intermediate point of the resistance winding. These resistors 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 steel mounting plate. 18 and 19 type resistors are made with resistance values from less than one ohm to nine thousand ohms and have a safe carrying capacity of approximately five watts.



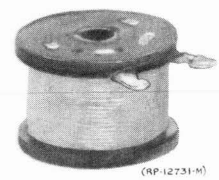
(RP-10496-M)

FIG. 141 **59 TYPE RESISTOR**

Another type of resistor used in cases where the required current carrying capacity is above the maximum rating of the 18 or 19 type is shown in Figure 141. This is a vitrohm resistor of the 59 type, consisting of a porcelain spool and a resistance winding which is completely covered with vitreous enamel. The resistor 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 resistors. Other examples of resistors 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.

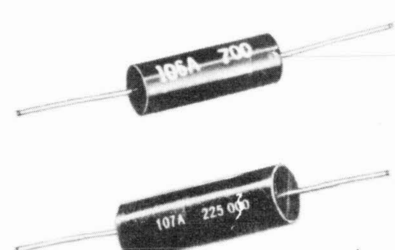
A spool type resistor of the 63 type is shown in Figure 142. It consists of a non-inductive winding wound on a hollow brass spool equipped with phenol fibre spoolheads. Two winding terminals attached to one of the spoolheads serve as connecting points. The 3/16" diameter hole through the center of the core facilitates mounting by means of a screw, either singly or several mounted one above the other.



(RP-12731-M)

FIG. 142 63 TYPE RESISTOR

Resistors 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. The 106 and 107 types (See Figure 143) are examples of this kind. They consist essentially of a resistance winding on a phenolic spool enclosed in a phenolic tubular shell. Short pieces of tinned wire extending from both ends serve as terminals and, are also used to support the resistor.



(RP-18212-M)

FIG. 143 **106 AND 107 TYPE RESISTORS**

Other pig-tail type resistors include the 144 and 145 types. The resistance element of these types consists of a **ceramic** core with a coating of deposited carbon, terminating in end caps with axial leads. The completed assembly is covered with a baked enamel finish. The 144 type, about 1" long and 9/32" thick, has a power rating of 1 watt, while the 145 type, which is slightly smaller, is rated at 1/2 watt. See Figure 144.

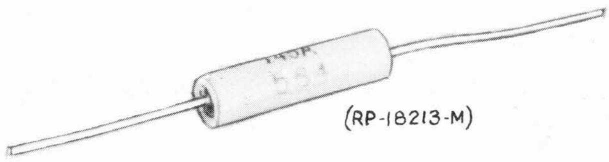


FIG. 144 145 TYPE RESISTOR

In order to facilitate the mounting of resistors on relay mounting plates, 40 type resistors 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 resistor 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.

Two of the most commonly used types are shown in Figure 145. 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.

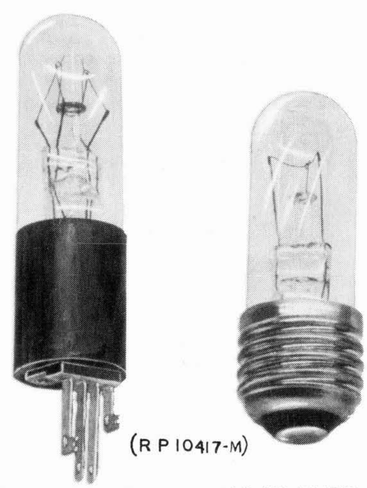


FIG. 145 11 AND 12 TYPE RESISTANCE LAMPS

Two other types of resistance lamps known as ballast lamps are shown in Figure 146. Ballast lamps are used as current regulators to maintain an approximate constant current within a rated voltage range. The filament of the 8 type is made of iron while tungsten is used for the 120 type. The resistance of the filament increases quite rapidly at certain temperatures and by arranging operation of the filament where this action takes place, the current through the filament, in series with the device to be controlled, is held nearly constant even through the applied voltage may increase considerably.

Ballast lamps are usually equipped with either a screw base or a four prong electron tube base as indicated in Figure 146.

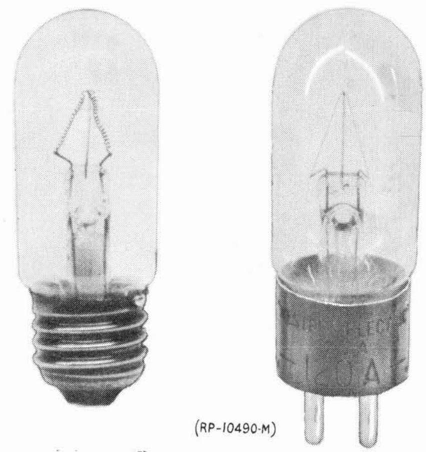


FIG. 146 8 AND 120 TYPE BALLAST LAMPS

While the above mentioned resistors and lamps have a definite specified resistance value, except for changes due to temperature variations, variable resistors, called varistors are used in the Telephone Plant. The four types of varistors to be discussed in this section are the copper oxide, selenium, germanium and silicon carbide. These types may be further classified as asymmetrical and symmetrical varistors. In an asymmetrical varistor, the resistance to one polarity of applied voltage is greater than to the other and in a symmetrical varistor, the resistance change to applied voltage is the same with either polarity. Copper oxide, selenium and germanium are asymmetrical varistors, while the silicon carbide varistor is of the symmetrical type. Both types possess the characteristic of decreasing in resistance with an increase in voltage, thus permitting an increase of several times the normal current flow with but a small increase in potential. Copper oxide, selemium and germanium varistors, in addition, permit the ready flow of current in one direction and very little in the other direction. This characteristic permits these types to be used as rectifiers.

A typical varistor of the copper oxide type used for the reduction of clicks in operator's telephone circuits is shown in Figure 147. 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 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. Although asymmetrical in type, this arrangement of the two sets of discs is equivalent to the action of a symmetrical varistor.

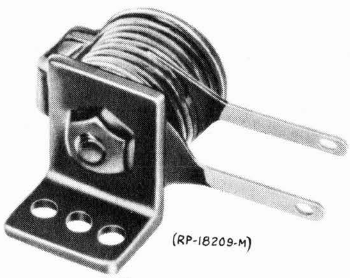


FIG. 147 3 TYPE VARISTOR

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.

Another copper oxide varistor of the 33 type is shown in Figure 148. The copper oxide discs of this varistor are bolted to a phenol plastic base with the wiring terminals extending to the rear. An enveloping gray lacquer finish protects the unit against moisture. 33 type varistors vary in size and are made with one or more stacks of oxide discs arranged in several different ways.

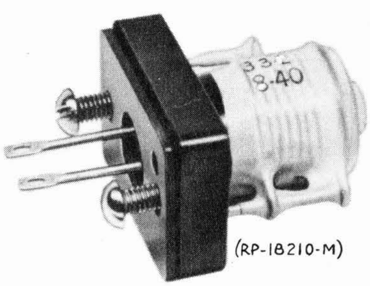


FIG. 148 33 TYPE VARISTOR

Selenium varistors consist of a number of selenium cells assembled on an insulating tube and held together under pressure by means of studs or bolts. Metal spacer washers placed between the cells allow the free passage of air for cooling the unit. Each cell consists of a back plate or electrode of steel or aluminum, coated on one side with a very thin layer of metallic selenium, and a front or counter electrode in direct contact with the selenium coating. The change in resistance or rectifying action occurs in the so-called "barrier" layer where the selenium is in contact with the front electrode. Current flows readily from the back electrode to the front electrode, while very little current will flow in the opposite direction. Selenium varistors are primarily used in power rectifiers for converting ac to dc.

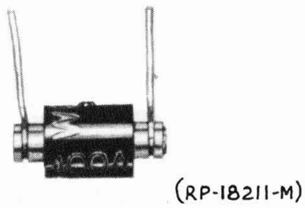


FIG. 149 400 TYPE VARISTOR

A typical germanium varistor of the 400 type is shown in Figure 149. It consists of a molded phenolic assembly of the varistor elements with bare wire connecting leads, similar in size and shape to a 1/2 watt pigtail resistor. The varistor elements are a pointed tungstem spring in contact with a processed germanium wafer. The outstanding characteristic of a germanium varistor is the ability to withstand a much higher reverse voltage than the copper oxide type.

A silicon carbide type varistor is shown in Figure 150. 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.

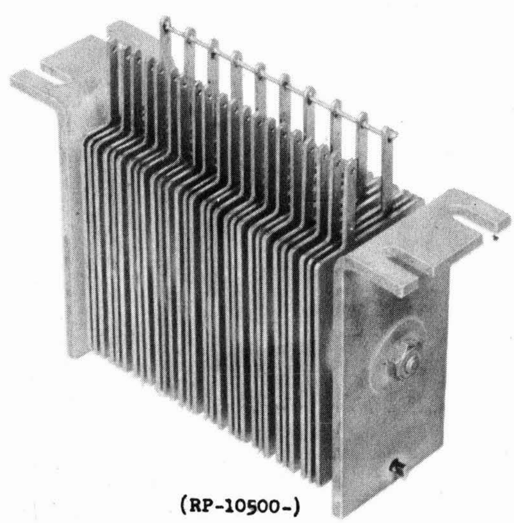


FIG. 150 300 TYPE VARISTOR

QUESTIONS

1. What are resistors used for?
2. What is the approximate safe carrying capacity of 18 and 19 type resistors?
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?