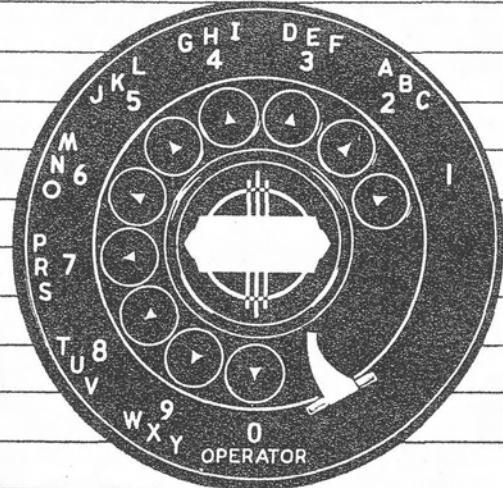


MECHANICAL PRINCIPLES OF TELEPHONY

**STROWGER AUTOMATIC
TELEPHONE SYSTEMS**



AUTOMATIC  ELECTRIC

ORIGINATORS OF THE DIAL TELEPHONE

This is one of the helpful booklets in the
AUTOMATIC ELECTRIC TRAINING SERIES
on
STROWGER AUTOMATIC TELEPHONE SYSTEMS

- 800 Electrical Principles of Telephony
- 801 Mechanical Principles of Telephony
- 802 Fundamentals of Apparatus and Trunking
- 803 Distributing Frames
- 805 The Plunger Lineswitch and Associated Master-Switch
- 806 The Rotary Lineswitch
- 807 The Connector
- 808 The Selector
- 810 Pulse Repeaters
- 812 Power and Supervisory Equipment
- 813 Party-Line Connectors and Trunk-Hunting Connectors
- 814 Reverting-Call Methods
- 815 The Test and Verification Switch Train
- 816 Toll Switch Train
- 817 Switching Selector-Repeater
- 818 Private Automatic Exchanges with PABX Appendix
- 820 Manual Switchboards
- 821 Linefinder Switches

May we send you others
pertaining to equipment in your exchange?

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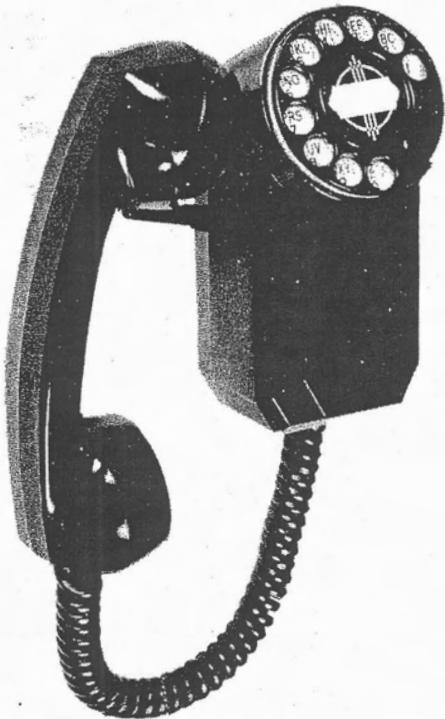
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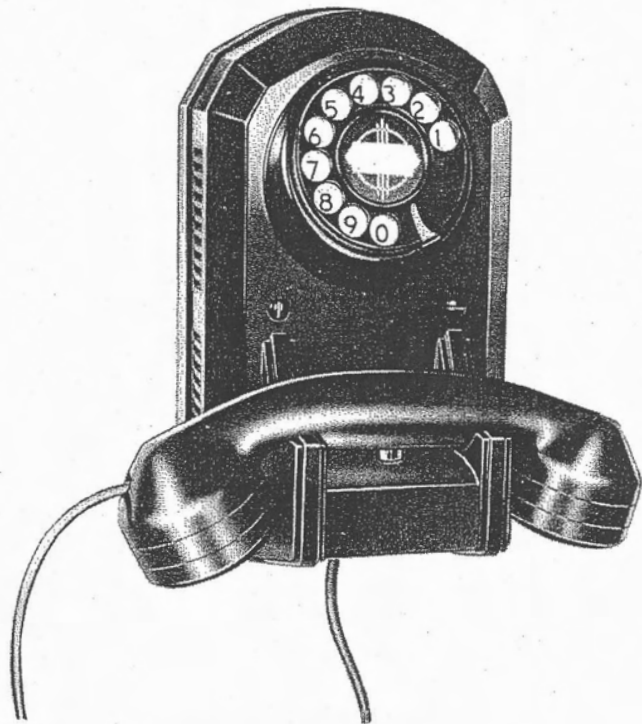
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Type 80 desk Monophone.



Type 83 compact Monophone.



Type 50 wall Monophone.

Figure 1. Three types of automatic telephone.

TELEPHONES

1. TELEPHONES

A telephone is a combination of parts assembled into a complete unit having facilities for voice transmission, voice reception, signaling, and switching. In this discussion, telephones regularly supplied by Automatic Electric Company are used as examples. Telephones of other makes may vary in general design and in details of their components.

The components usually comprise a handset, including the transmitter (voice transmission) and receiver (voice reception), a base assembly on which are mounted the telephone signal (ringer), induction coil, capacitors, cradle switch, and terminals; the interior wiring; the handset cord; and, in the case of a desk telephone, the desk-set cord and terminal block.

Telephones may be classed as to service requirements; for example, telephones ordinarily supplied for commercial and domestic uses are desk or wall handset types. Automatic Electric Monophones Types 43, 50, and 80 shown in Figure 1 are typical examples. Other designs for more specific purposes include operators' telephones, test telephones, weatherproof telephones, and telephones for hazardous locations.

Telephones may also be classed as local battery or common battery. In the former type, the transmitter of each telephone receives its current from a local source such as a pair of dry cells. Common-battery telephones receive transmitter current from a central-office storage battery which serves all telephones in the exchange.

Telephones may be further classed as automatic or manual. Each automatic telephone has in addition to the components already listed a dial-type calling device to control automatic switching equipment in the central office.

2. DIAL

The dial (see Figures 2 and 3) is a pulse-sending calling device which, when wound up and then released, interrupts the electric current to control switching mechanisms at the central office. To operate the dial the calling subscriber inserts a finger in the appropriate hole in the finger plate and turns the plate clockwise until the finger strikes the finger stop. The finger plate is then

released and is returned to its normal position by a coiled spring, its speed of return being controlled by a worm-driven governor.

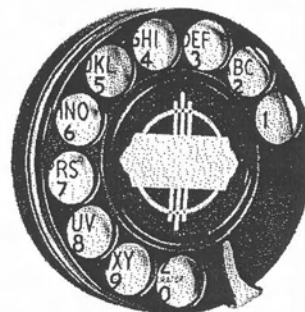


Figure 2. Type 51 dial with letters and figures on number plate.

As the dial finger plate returns to its normal position, it successively opens and recloses the telephone line circuit a number of times corresponding to the figure dialed. For example, if the finger plate is turned from the figure "5" on the number plate and then released, the line circuit will be opened five times in quick succession, by a small fibre cam geared to the main dial shaft and acting against the pulse springs. Each circuit interruption lasts about 1/16 second. These brief interruptions operate central-office switches.

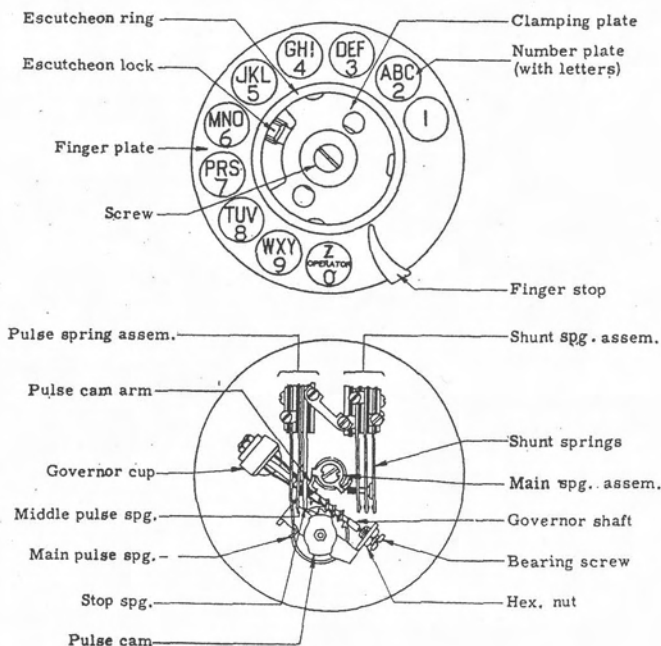


Figure 3. Type 51 dial assembly (front and rear views).

The dial consists essentially of:

- (a) The finger plate which is rotated and released by the caller for each letter or digit dialed.
- (b) The number plate which bears the figures "1" to "9" and "0" (and often the alphabet too) under the ten holes in the finger plate.
- (c) The governor and its driving mechanism.
- (d) The pulse cam which, as it rotates, opens and recloses the pulse springs.
- (e) The pulse springs, which open and reclose the line circuit.
- (f) The shunt springs, which short-circuit the transmitter and receiver of the telephone while the dial is off-normal.

The governor assembly consists of a worm wheel which is on the same shaft as the pulse cam and which drives the governor shaft through a worm. Attached to the governor shaft are two wings, each with a weight on the end. During rapid rotation of the worm shaft, centrifugal force causes the wings to move outward and causes friction between the governor weights and the inside of the governor cup. The pulse speed of the dial is adjusted by positioning the flyballs with respect to the governor cup. During operation, the speed is controlled by the friction resulting from the centrifugal force of the flyballs against the inside of the governor cup. The governor is adjusted so the pulse springs send about 10 pulses per second.

Our modern dials provide a delay between the final circuit interruption of the series and the completion of the return motion of the finger plate. A cam attached to the main dial shaft moves the two pulse springs out of engagement with the pulse cam during the last $\frac{1}{2}$ revolution of the cam. This delay allows time for central-office equipment to perform switching functions between successive pulls of the dial.

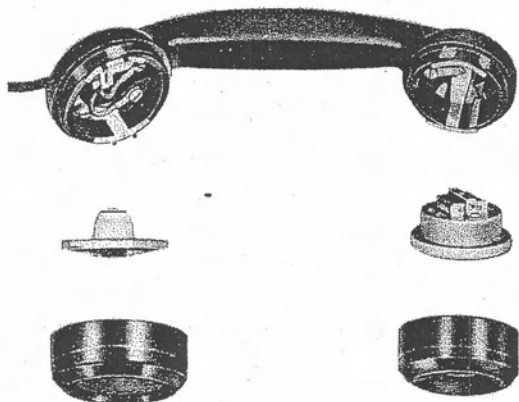


Figure 4. Handset components.

3. HANDSET

The handset (Figure 4) houses the transmitter and receiver units at spacings and angles which provide optimum efficiency for the average user. The handset is made of molded plastic and the transmitter and receiver units are mounted in position at either end by means of plastic retaining cups. Handset-cord connections to the transmitter and receiver units are made through spring contacts at each end of the handset.

4. TRANSMITTER

The transmitter (Figure 5) is of the sealed-capsule type consisting of:

- (a) The main diaphragm which vibrates in response to air waves created by the person speaking, and
- (b) The carbon-granule cell which changes the mechanical vibrations of the diaphragm into electrical pulsations. The plastic cup which holds the transmitter in the handset has perforations which permit air waves to reach the diaphragm. The design of the carbon-granule cell is such as to assure continuity of the circuit through the carbon granules irrespective of the position in which the handset is held; that is, in all positions.

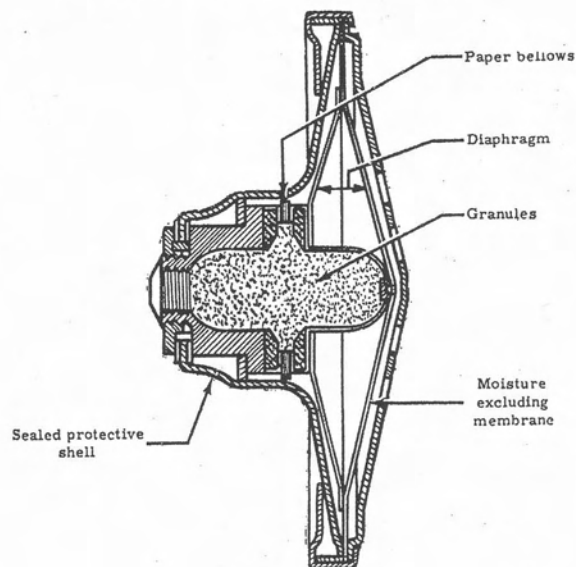


Figure 5. Cross section of transmitter capsule.

5. RECEIVER

The receiver (Figure 6) converts incoming voice currents back into sound waves. It consists of a powerful permanent magnet associated with two pole pieces on which are windings carrying the voice current. The flow of voice current through the windings causes the receiver diaphragm to reproduce the original vibrations of the transmitter diaphragm at the distant telephone.

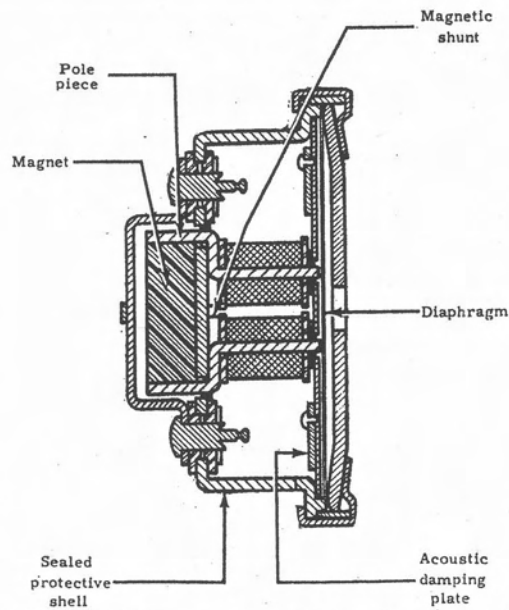


Figure 6. Cross section of receiver capsule.

6. CRADLE SWITCH

The cradle switch is an assembly of contact springs to connect the transmitter, receiver and dial into the circuit when the handset is removed, and to connect the ringer into the circuit when the handset is replaced.

7. CAPACITOR (or "condenser")

Capacitors like that shown in Figure 7 are used in each telephone—one in the transmission circuit and one in the ringing circuit. The capacitor in the transmission circuit improves the telephone output characteristics. The capacitor in the ringing circuit permits ringing current to pass through the ringer, and stops direct current.

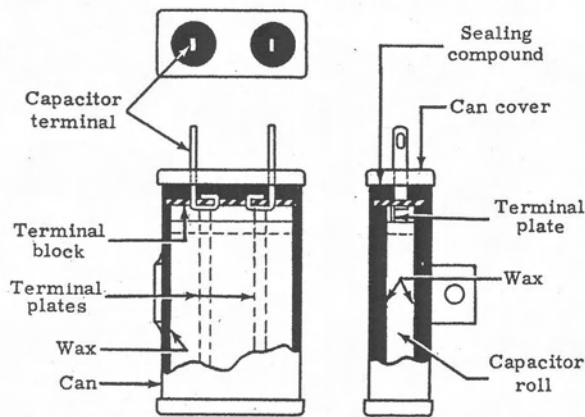


Figure 7. Capacitor construction.

The capacitor consists of a roll of alternate layers of paper and aluminum foil sealed in a metal container. Each layer of foil is separated from the next layer by two layers of paper. The terminals of the assembly are put between the foil and paper during the time the paper and foil are rolled. Then the assembly is impregnated with wax, and inserted into a container where it is further sealed.

8. INDUCTION COIL

The induction coil shown in Figure 8 inductively couples the transmitter and receiver units to the line, increases the telephone output volume, and decreases the effect of speaker hearing his own voice in his receiver while talking into the transmitter.

The induction coil consists of three insulated windings wound on a common laminated-iron core. This type of induction coil has its windings connected to serve as an autotransformer (part of the winding is common to both the input and output circuits). Two small air gaps in the magnetic circuit prevent magnetic saturation by the direct-current supply to the transmitter.

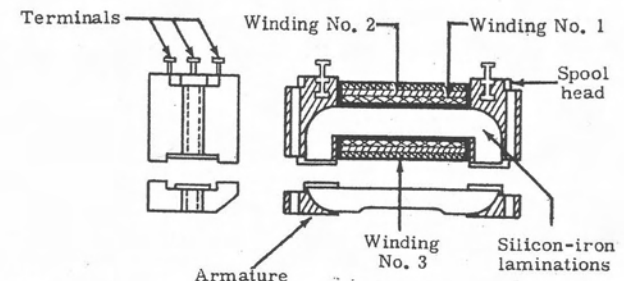
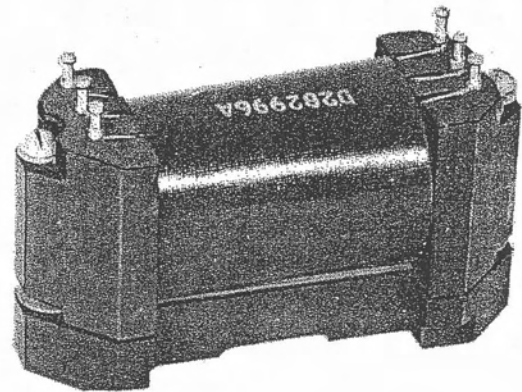


Figure 8. Induction coil (photo and cross section).

9. RINGERS

Call signals may consist of various visual or acoustic signals for calling a subscriber. Ordinarily, however, bell ringers (Figures 9 and 10) are used. Ringers may be of two types:

- (a) Straight-line ringers
- (b) Harmonic (mechanically and electrically tuned) ringers for party-line use.

The principal parts of the two types of ringer are essentially the same: two gongs, an armature carrying a rod and bell-clapper, an electromagnet consisting of two coils, and a permanent magnet to polarize the two electromagnet cores.

When the "straight-line ringer" coils are energized with alternating current, the armature vibrates so that the clapper is moved from side

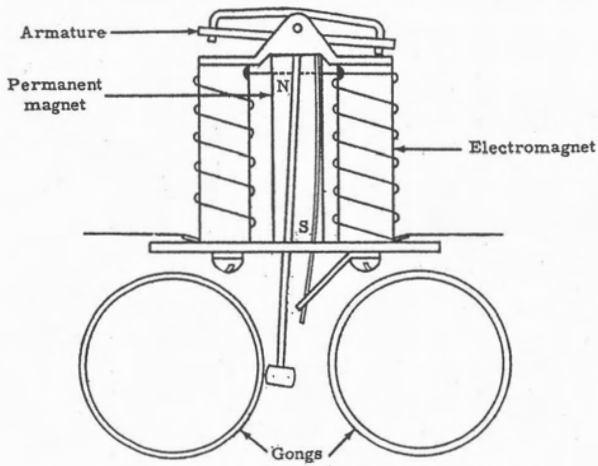


Figure 9. Polarized straight-line ringer.

to side, striking each gong alternately. A spring "biases" the ringer—i.e., holds the armature against one coil core-end. This prevents ringer "tapping" when another party dials on the line, etc. (Also, when pulsating or superimposed ringing is used, the biasing spring restores the armature between pulses.) The biasing spring does not hold the clapper against a gong, however; ringer adjustment keeps the clapper (when at rest) away from the nearer gong, so both gongs are free to vibrate alike.

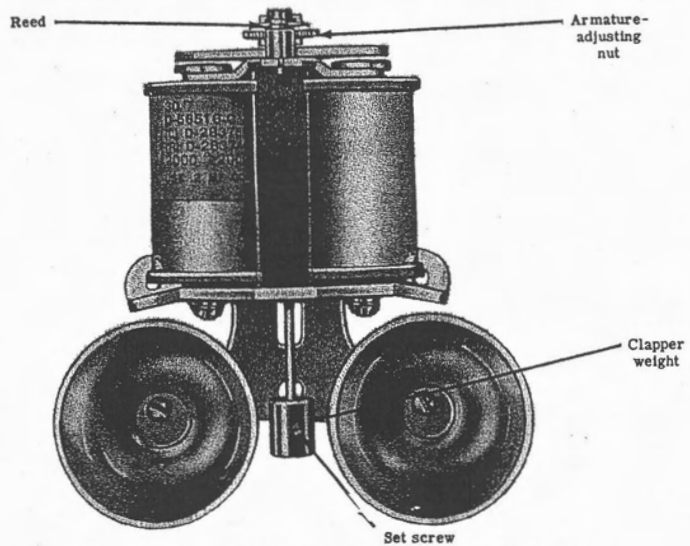


Figure 10. High-impedance harmonic ringer.

The "harmonic ringer" has a "reed" (spring) at the end of a weighted bell clapper. This harmonic ringer is mechanically and electrically tuned. The capacitor used with the ringer is chosen to be resonant with the ringer coils at the frequency of the ringer. In general, a weak spring and a heavy clapper permit vibration at low frequencies; a strong spring and a small clapper at high frequencies.

RELAYS

10. RELAYS

A relay is an electromagnetically operated switch to open and close electric circuits. Figure 11 shows the plan and elevation of a

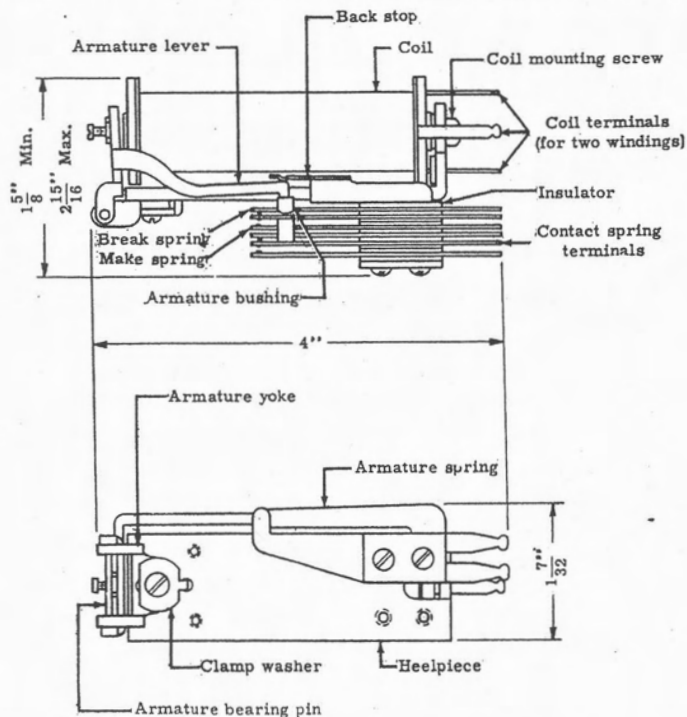


Figure 11. Typical class A single-arm relay.

typical class A relay. The relay performs its switching function by electromagnetically attracting an armature, which, in turn, actuates mechanical contact springs, to which the electric circuits to be switched are connected.

In general, a relay mechanism consists of two or more circuits:

- (a) The electric coil circuit for the relay control.
- (b) The connected electric circuit or circuits which are switched by the opening or closing contacts.

Relays are used for remote control or timing, as:

- (a) when a weak or variable signal must have strong or unvarying control over a local circuit.
- (b) when one circuit-change must cause changes in more than one other circuits.
- (c) to obtain and utilize delays or sequential operation(s) or both.
- (d) when several causations occurring only simultaneously or only in a certain sequence must change another circuit.

11. TYPICAL RELAYS

The principal parts of a typical relay are the operating coil with a soft-iron core, the armature, and the spring assembly mounted on its heelpiece.

The relay in Figure 12 is Automatic Electric Company's class A relay, used in most selectors, connectors, etc. The relay in Figure 13 is Automatic Electric Company's type 57A relay, used in toll switchboards, Directors, SATT equipment, etc.

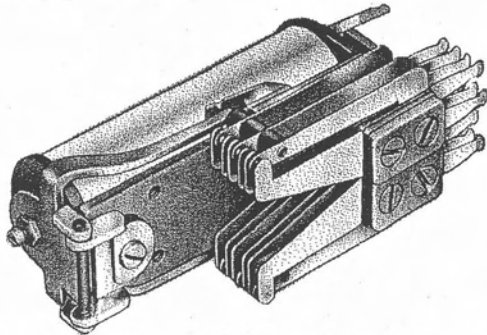


Figure 12. Typical class A double-arm relay.

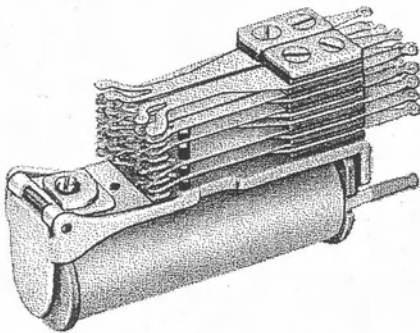


Figure 13. Typical type 57A relay.

The relay is one of the most important single pieces of apparatus used in telephone switching. Nearly every telephone circuit uses one or more relays.

In appearance the relay is a simple mechanism. Its design and manufacture, however, involve many complex considerations. Proper engineering and experienced judgment, however, assure an efficient and durable product. The high sensitivity of Automatic Electric Company relays results from practical design both of the coil windings and of the magnetic structure. The exceptional durability of our relays is due to the unique pin-type armature bearing and to the quality of the specially selected materials used.

In figure 12, the armature has a non-magnetic screw which, when the relay operates, determines the residual air gap remaining between armature and core. After the coil circuit is opened, the space thus left between armature and core prevents residual magnetism keeping the relay operated. It insures release.

12. TIMING

The relay's operating and release time may be changed by adding a copper collar around the coil core. The relay is made slow both to operate and to release when the collar is on the armature end of the core, and slow to release (only) when on the heel end of the core. A copper sleeve around and along the entire core length also makes the relay somewhat slow to operate and quite slow to release. These relays are known as slow-acting relays. Such relays are used when the contacts must remain operated while their coil circuits are repeatedly interrupted for short periods.

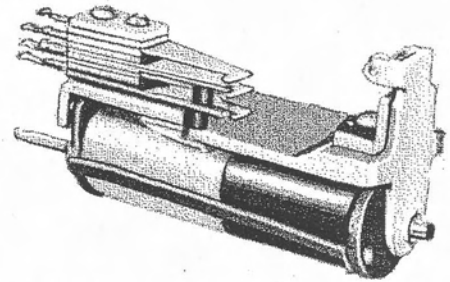


Figure 14. Slow-release relay with short-lever armature.

When greater release delay is required than can be provided by a copper collar or sleeve, different armature construction can be employed. In this design, the distance from coil-core end to pivot is about the same as the distance from spring-actuating bushing to pivot (see Figure 14).

This short-lever (1:1 ratio) armature eliminates the mechanical advantage (about 2.25:1 for class A relays, figure 15; 1.65:1 for type 57A relays) of the contact springs acting on the standard armature and tending to restore it

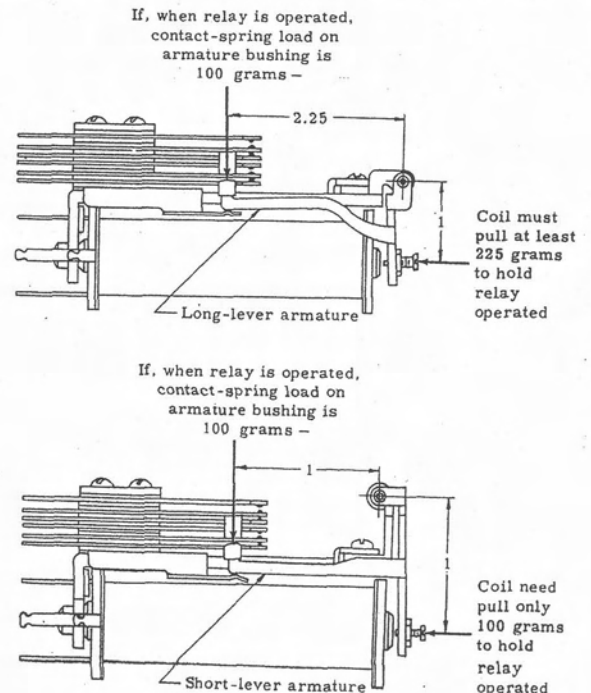


Figure 15. Comparison of leverage ratios of long- and short-lever armatures (class A relays).

to normal. Thus, the springs are unable to restore the armature until the magnetic field has died down to a considerably lower value, which results in a release delay which may be as much as half a second. For a given spring-contact load and release time, the 1:1 ratio also permits a larger residual setting, which is more permanent and avoids armature sticking.

13. SPRING ASSEMBLIES

The relay spring assembly is made up of a number of metallic springs, insulated from each other and from the heel piece. The rear ends of these springs are terminals for the leads from the circuits to be switched. Each spring has one or more precious-metal electric contacts through which circuits (electrical connections with other springs) can be established. The spring assemblies are made in various combinations the circuits require. The armature springs all move together because of mechanical coupling through their bushings. The spring assemblies used with class A relays are illustrated individually in Figure 16. The springs are assembled between laminated paper-base phenolic insulators, which have been heated to exclude all moisture.

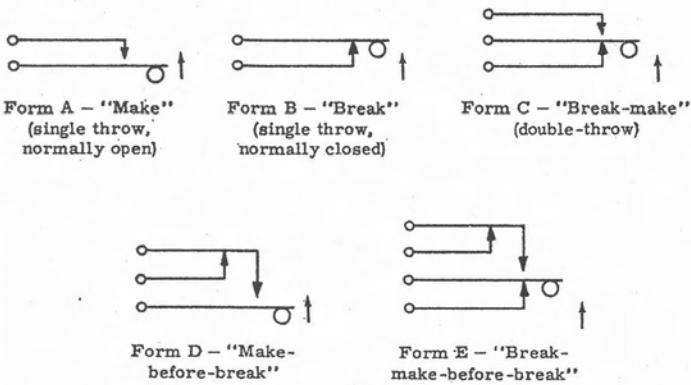


Figure 16. Basic contact assemblies. (shown in normal [unoperated] position).

The complete assemblies are then placed in special compression jigs and held by "high-tensile" steel screws tightened with power-driven screwdrivers.

The number of spring combinations which can be operated depends upon the number of ampere turns developed in the coil. This depends upon the number of turns of wire used to wind the coil, the resistance of the coil, and upon the voltage drop available in the circuit.

Twin contacts are specified sometimes. They have two contacts on each spring. Each contact is mounted on a separate section of spring to permit each to operate independently. Thus even if one contact were held open by dust, the other contact would complete the circuit. All type 57A relays (Figure 13) have twin contacts.

14. MOUNTINGS

Relay mountings are made from sheet steel shaped to provide the most practical arrangement in every case.

The individual relay bracket consists of an electrogalvanized steel right angle (Figure 17) having punched holes for the coil terminals, mounting screws, and insulating bushings. Sometimes a slip-on sheet-steel cover with a guide is used for electromagnetic and electrostatic shielding between relays, mechanical protection, and as a dust cover.

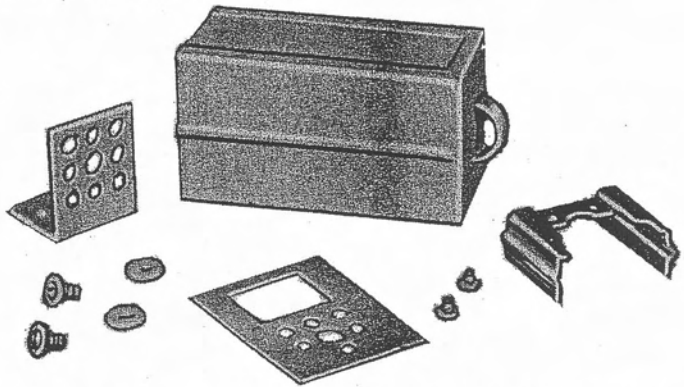


Figure 17. Typical individual relay bracket and cover.

When relays are mounted in a row, electrogalvanized steel channels (Figure 18) provide a light and rigid support. Covers for such mountings are not individual but cover all the relays or spaces in the entire row.

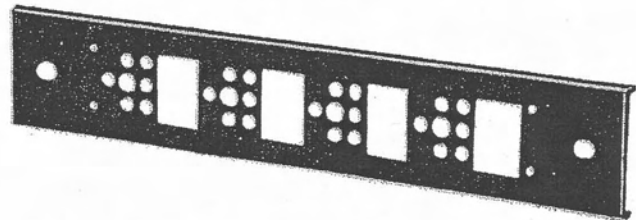


Figure 18. Typical relay mounting strip.

When relays are mounted in groups (Figure 19), a sheet-metal base simplifies their mounting, assembly, and maintenance by providing a standardized mounting on which apparatus easily may be added, rearranged, or removed.

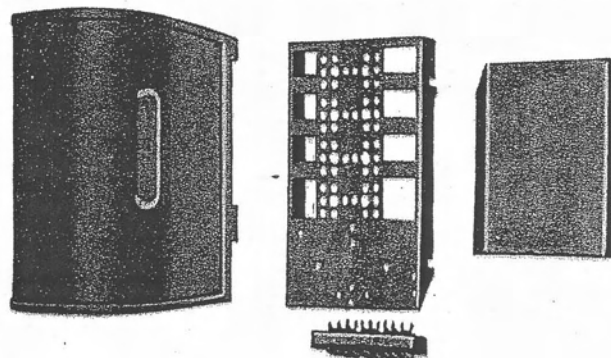


Figure 19. Typical relay-group mounting with jack-in base (showing front and rear covers and the jack).

The pulse repeater (Figure 20) shows relays mounted on a group base.

Figures 39, 41, and 43 show relays mounted similarly on two-motion-switch bases.

Equipment mounted on each base is connected to a switch jack (made up of many contact springs mounted on the back of the base), which engages similar springs of a shelf jack to extend electrical connections.

Sometimes relays are mounted on plates which are not jacked in but are bolted permanently to the central-office iron framework.

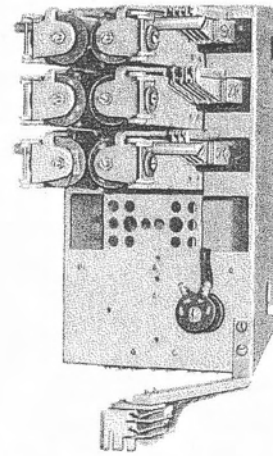


Figure 20. Pulse repeater.

PLUNGER LINESWITCHES

15. LINESWITCHES

All types of telephone system require some kind of electrical device associated with each line for the purpose of giving an individual subscriber access to selecting equipment when (and only when) he originates a call.

During the early Strowger automatic telephone practice, individual connector switches were employed in telephone systems up to one hundred lines. In systems of more than one hundred lines, each line had its individual selector switch. A more advanced arrangement consists of employing a smaller switch permanently associated with each subscriber's line and made up of simpler and more economical design. Such a switch is known as a lineswitch and automatically extends the calling line to either an idle selector or connector prior to dialing. It is this characteristic of being independent of dial pulses for its operation that classifies it as a non-numerical switch. (A numerical switch may be defined as a switching mechanism in which dial pulses control at least some functions.)

When Strowger automatic telephone systems are required to handle traffic originating from a large number of lines, further use of the lineswitch as a secondary lineswitch has still more economical operating advantages. The secondary lineswitches combine the traffic from a primary group of subscribers' lineswitches and direct it to a group of numerical switches arranged to handle the combined traffic. This arrangement makes each trunk leading to a numerical switch easily accessible from any subscriber's line served by the combined group of trunks.

The secondary lineswitch serves a purpose similar to that of the primary lineswitch since it permits greater use of more costly switches by use of the simpler and more economical lineswitches. The local secondary lineswitch is connected between the primary lineswitch and the first selector. Lineswitches may be of the plunger or rotary (see §24) type.

Sometimes multi-office automatic exchanges also employ secondary lineswitches connected to interoffice trunks at the outgoing end. These lineswitches combine the traffic directed to a distant office which originates from the various subscriber lines in the originating office. It gives access to all the inter-office trunks in each office group. Whenever lineswitches are so used they are connected between the local selector banks and the pulse repeaters.

16. PLUNGER LINESWITCH

Two types of plunger lineswitch have been developed, the earlier type called the fan-tail (also called pick-up and non-aligning, Figure 21) and the later type called self-aligning (see Figure 22).

Plunger lineswitches are electromagnetically operated switches and are grouped under control of a masterswitch. The group usually consists of from twenty-five to one hundred lineswitches per master-switch. Each lineswitch has access to a maximum of ten trunks.

When the fan-tail type switch is released by a calling subscriber, the plunger is not aligned with the other lineswitch plungers until the master-switch in its oscillation passes the trunk previously used by the lineswitch, whereupon

PLUNGER LINESWITCHES

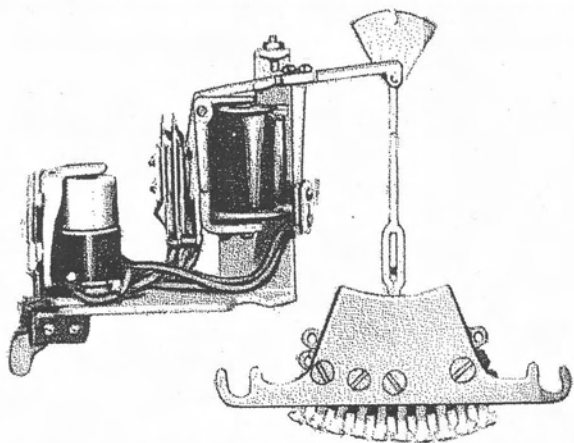


Figure 21. Fan-tail plunger lineswitch and bank

the spline of the master-switch guide shaft engages a slot in the fan-tail on the end of the plunger. The fan-tail plunger is now primarily used in making additions to existing automatic telephone installations of the same type.

When the self-aligning lineswitch is released by a calling subscriber, the plunger is immediately aligned with the other idle lineswitch plungers on the master-switch guide shaft.

The lineswitch bank (Figure 21) is the complete assembly of contact springs with which the plunger connects when a call is made. Each bank is composed of ten sets of contacts, each set terminating one end of a trunk leading to the next succeeding switch.

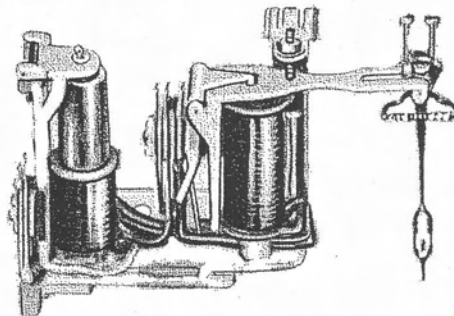


Figure 22. Self-aligning plunger lineswitch.

The master-switch (Figure 23) consists of a locking segment by which the switch shaft is held opposite various trunks. A large solenoid furnishes electromagnetic power for moving the shaft from right to left. A centrifugal governor regulates the speed of the switch movement. Relays and tripping arms are used to control the operation of the master-switch.

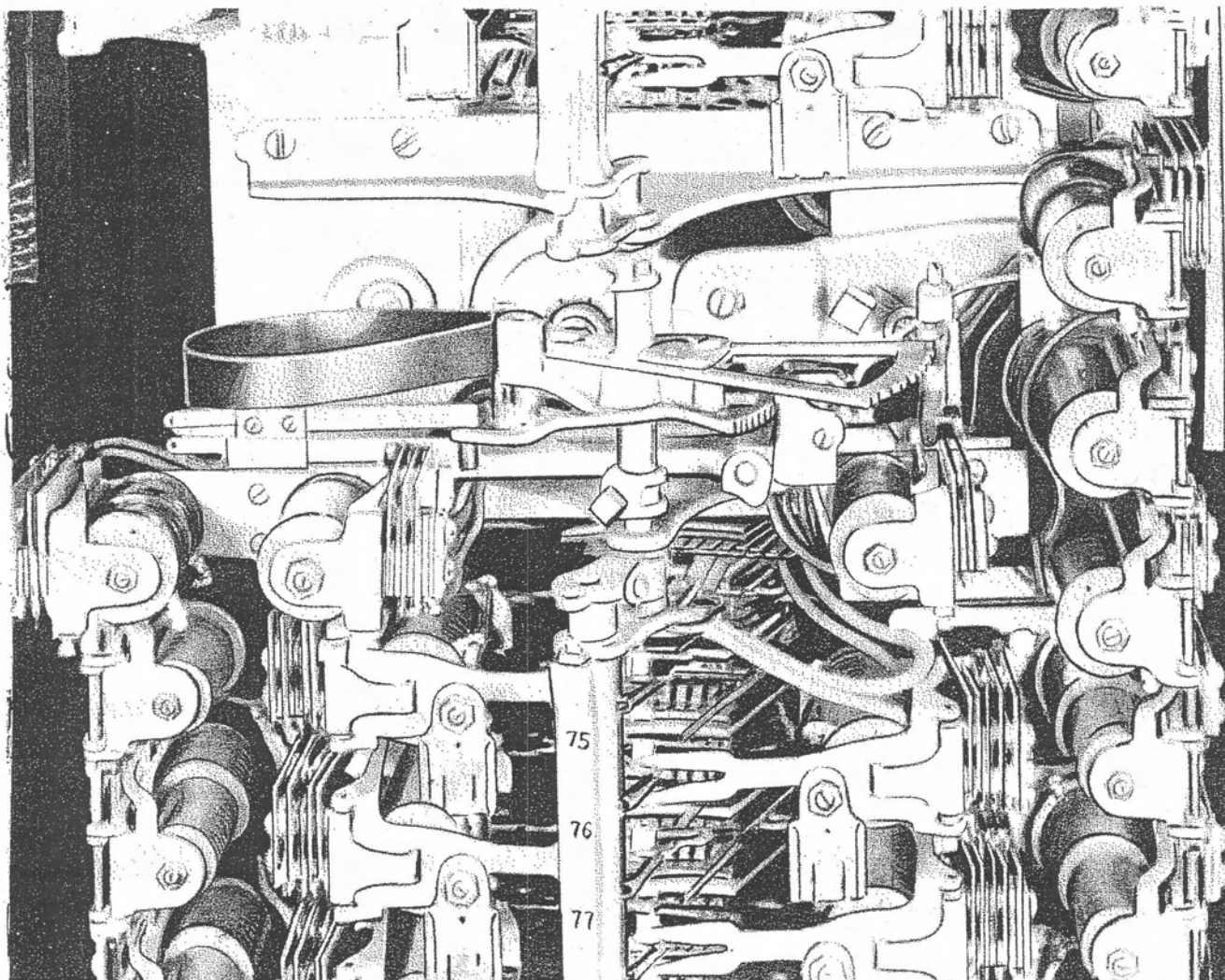


Figure 23. Master-switch and self-aligning plunger lineswitches.

STEPPING SWITCHES

17. BASIC MECHANISMS

High-speed, multi-contact switches are commonly used to perform three kinds of control operations:

- (a) Select one circuit from many circuits.
- (b) Carry out operations successively in separate individual circuits.
- (c) Furnish timed pulses at equal or unequal intervals.

Electromagnetically operated stepping-switch mechanisms can be classified according to the way their wipers move during:

- (a) The selecting function,
 - (1) Direct drive
 - (2) Indirect drive
- (b) Restoration to normal
 - (1) Release by retracing path of operation
 - (2) Restoration by stepping ahead to home position
 - (3) Non-homing

Two schematic diagrams of the direct-drive stepping switches are shown: Figure 24 is for remote-control (or pulse) operation, and Figure 25 (page 12) for automatic (self-interrupted) operation.

Three basic stepping mechanisms are used for switching operations:

- (a) Single-motion selection (rotary, step-by-step) and reverse-motion restoring (rotary travel from last step backward to starting position) (Minor switches)
- (b) Single-motion selection and restoring (Rotary switches)
- (c) Two-motion selection (vertical, then rotary stepping) and restoring (rotary reverse travel, then gravity vertical drop) (Strowger Switches)

Single-motion stepping switches are of ratchet-type construction. These switches are made up basically of one or more wipers fixed on a shaft

rotated by the pawl-and-ratchet mechanism. This mechanism is operated by an electromagnet responding to current pulses. Operation of the switch can be controlled either manually or automatically. The switch can be operated manually (Figure 24) by transmitting current pulses from a dial, a push button, or any other remote or local pulsing device. The switch can be operated automatically (Figure 25) by self-cycling interrupter springs mounted on the switch and connected in series with the switch-operating circuit.

The pawl and ratchet mechanisms used consist of two types of drive:

- (a) Direct
- (b) Spring

18. DIRECT DRIVE (See figures 24 and 25)

The direct-drive stepping switch uses its stepping magnet to drive the pawl into the ratchet to rotate the wiper assembly. A detent holds the wipers in place when the stepping magnet is de-energized and a tensioned spring returns the driving pawl to normal. The switching operation is complete the instant the magnet operates: the circuit of the stepping electromagnet may be held closed for any length of time after the final step. With this method of operation, the pawl is ordinarily disengaged from the ratchet; thus the wiper assembly can be returned to normal by simply having the release electromagnet disengage the holding detent. Direct drive is used in the minor switch (§25) and in Strowger two-motion switches (§26).

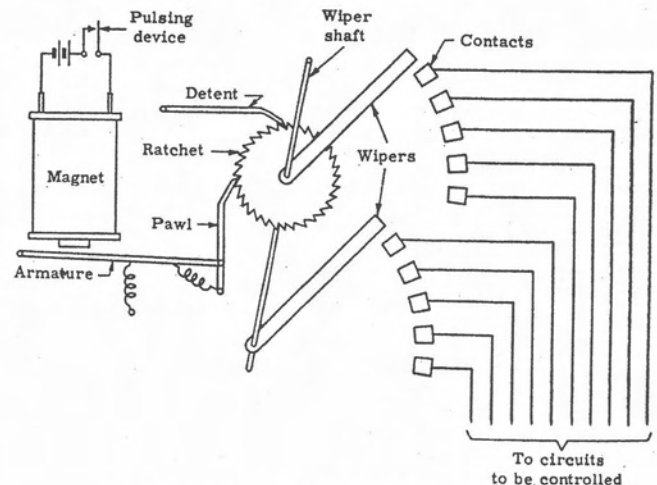


Figure 24. Direct-drive switch. Remote-control (pulse) operation.

21. NON-HOMING TYPE

The wipers remain on the last contact utilized, until the switch is again put into operation.

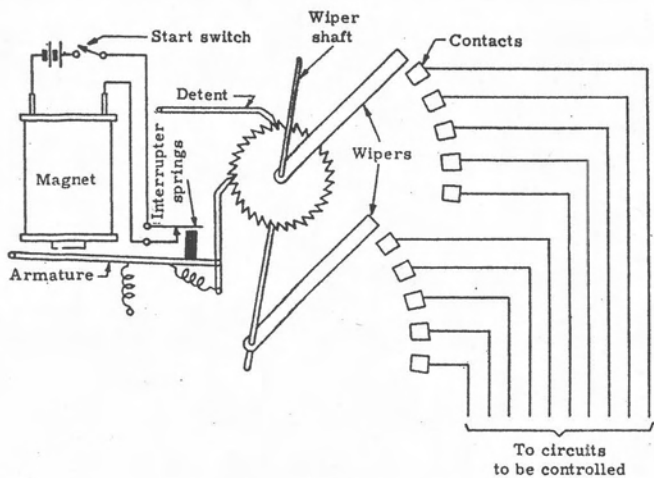


Figure 25. Direct-drive switch. Self-interrupted operation.

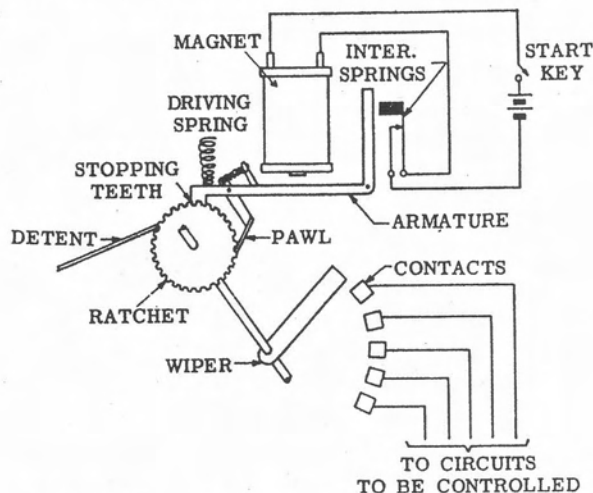


Figure 27. Indirect- or spring-drive switch. Self-interrupted operation.

19. INDIRECT OR SPRING DRIVE (See Figures 26 and 27).

When an indirect- or spring-drive switch is energized, the core attracts the armature, causing the driving spring to compress and the pawl to move out from the ratchet and over to the succeeding tooth. Upon de-energization of the electromagnet, the stored mechanical energy in the compressed driving spring drives the wiper assembly forward one step over a bank of contacts. Figures 26 and 27 show schematic drawings of spring-drive switches.

22. NON-BRIDGING WIPERS

Stepping switches are equipped ordinarily with one wiper or more for switching simultaneously all legs of the circuit being controlled. This control may be of a closed- or open-circuit type. Non-bridging wipers (figure 28) leave one contact before touching the next.

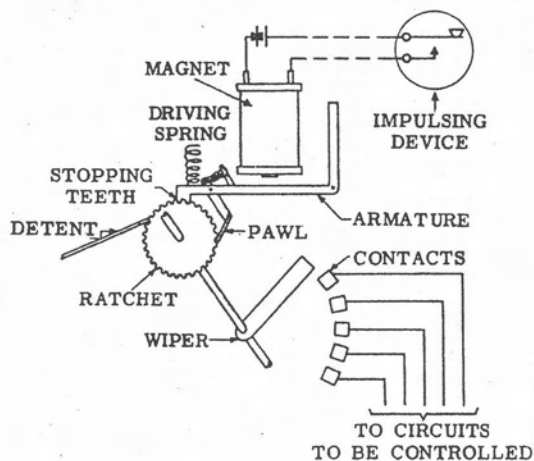


Figure 26. Indirect- or spring-drive switch. Remote-control (pulse) operation.

20. HOMING TYPE

Since the pawl is engaged in the ratchet when the coil is not energized this switch can be adapted to homing or reset operation, that is the wipers are automatically returned to their initial starting point at the completion of a switching operation by electrical means (see bulletin 473, "Rotary Stepping Switches" for further details.)

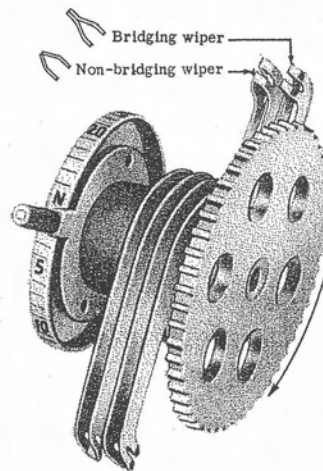


Figure 28. Rotary-switch wiper assembly with bridging (long-tip) wipers and non-bridging wipers.

23. BRIDGING WIPERS

Sometimes the circuit through the switch wipers must be maintained without interruption as the wipers rotate from one contact to the next. Then long-tip wipers are used so that the successive contacts are momentarily bridged as the wipers move from one contact to the next. These long-tip wipers (figure 28) are called bridging wipers.

When at rest, each wiper touches only one contact.

24. ROTARY SWITCH

The rotary switch (Figures 29 and 30) is a single motion electromagnetically operated indirect-drive stepping mechanism.

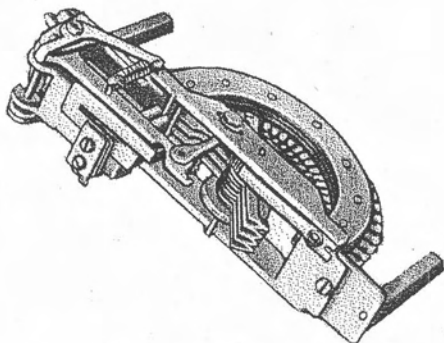


Figure 29. Typical rotary switch.

The switch transmits rotary motion to its double-ended wipers for selecting a circuit from among those terminated on its semi-cylindrical bank of contacts. This single-direction rotary motion may be used also for returning the wipers to the "home" position, when wanted.

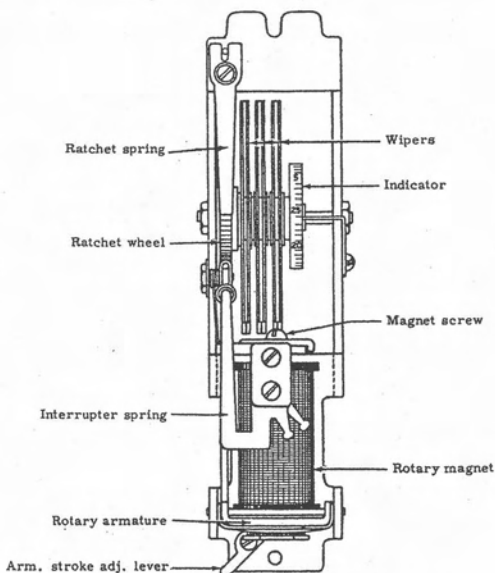


Figure 30. Typical rotary switch.

The switch wipers are rotated by a ratchet and pawl actuated by an electromagnet operating from current pulses. The switch may therefore either be operated by remote control, or stepped automatically over the bank contacts by interrupting its operating circuit through contact springs mounted on the switch base and actuated by the switch operation.

Rotary switches vary in construction, and may have 11, 25, or 50 positions for the wipers on the banks. In most rotary switches the wipers are double-ended and in one half-revolution pass over 25 bank-contact positions. (The "50-point" rotary switch uses two sets of single-ended wipers, staggered 180° apart,

one wiper rotating over one level on the first 25 rotary steps, then the other wiper travels over the adjacent level for the next 25 steps. Thus, in one revolution the switch has access to 50 circuits).

Rotary switches always step the wipers when the operating electromagnet is de-energized.

The manner in which the rotary switch is used determines whether it is a numerical or non-numerical type. The switch may be used in either manner.

The uses of the rotary switch in automatic telephony are usually as lineswitch, linefinder, linefinder distributor, or connector.

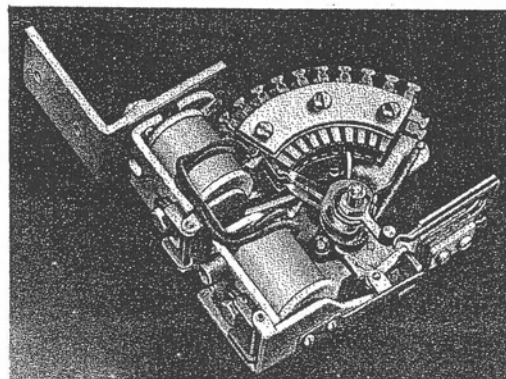


Figure 31. Minor switch.

25. MINOR SWITCH

The minor switch is an electromagnetically operated stepping mechanism of the reset type designed for either self- or remote-controlled operation. Figure 31 shows a minor switch mounted on a bracket. Figure 32 provides switch nomenclature.

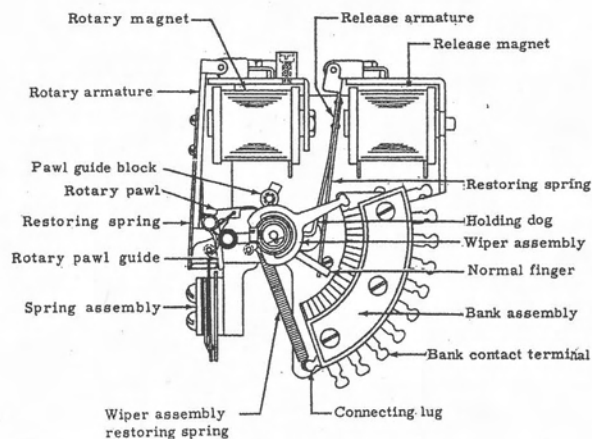


Figure 32. Minor switch.

The switch rotates its wipers clockwise over a ten-point bank assembly during its stepping, and releases the wipers for counterclockwise rotation to return to their normal position thereby resetting the switch for repeated operation.

STEPPING SWITCHES

Movement of the wiper assembly is controlled by two different electromagnets. One is for rotary stepping and one for releasing. The rotary-magnet armature carries a pawl which operates the rotary mechanism. When the dial pulses energize the rotary-magnet its armature is attracted, and the pawl engages one of the teeth of the ratchet wheel, causing the ratchet to turn on its shaft. The number of steps taken corresponds to the number dialed (except that when 0 is dialed, 10 steps are taken).

The holding detent is complete in one piece with the release-magnet armature. It engages the ratchet wheel and retains the wipers on any of the contacts. As the wipers step, a spring attached to the wiper assembly increases its tension. When the release-magnet operates and disengages the holding detent from the ratchet wheel, this tensioned spring restores the wipers to their normal position.

The bank assembly has ten sets of contacts arranged in an arc. The bank assembly on a minor switch may be one, two, or three levels deep depending on the circuit requirements. Each level has associated with it one pair of wiper springs. Usually, the upper surface of each level consists of ten individual contacts, while the bottom surface is one solid segment (common contact). The pair of wiper springs merely closes the circuit from the particular top contact upon which it stops, to the common contact. This common contact is sometimes replaced with individual contacts when the circuits require such an arrangement.

The most common use of the minor switch in automatic telephony is to select the party on a party line. When the switch is so used, it is ordinarily mounted at the top of the Strowger connector switch.

26. STROWGER SWITCH

The Strowger switch (Figure 33) is an electromagnetically operated two-motion stepping mechanism designed to provide selectivity in connecting its wipers with circuits that terminate on its bank contacts. The Strowger switch is the basic switch of the "step-by-step" automatic telephone system.

The Strowger switch gives the following movements to the shaft and wipers:

- (a) Raises the shaft vertically any number of steps from one to ten, then
- (b) Rotates the shaft in on any one of ten contacts of the ten levels, after which
- (c) The shaft is released back to its normal position by first letting the shaft rotate

backward (on any level) under the power provided by an unwinding helical shaft spring, and then letting it drop by gravity.

This up, around, and return motion is the characteristic which distinguishes the American-manufactured Strowger-switch mechanism.

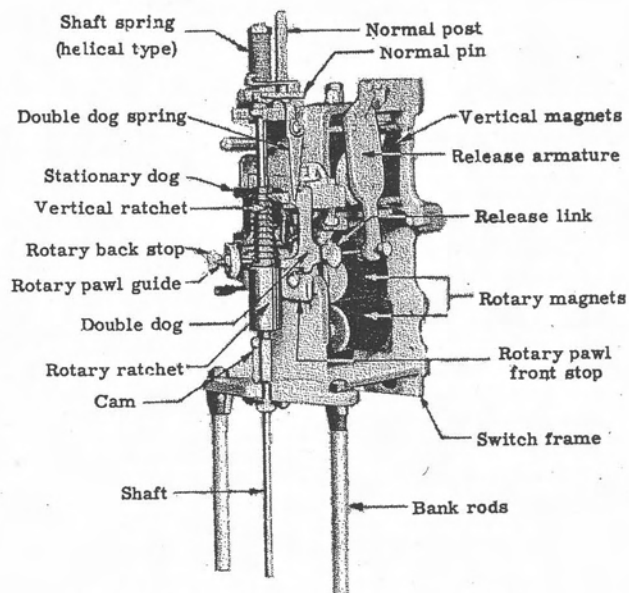


Figure 33. Strowger-switch mechanism.

The Strowger switch consists of banks and wipers, vertical, rotary and release magnets and controlling relays. Figure 34 shows Strowger-switch banks.

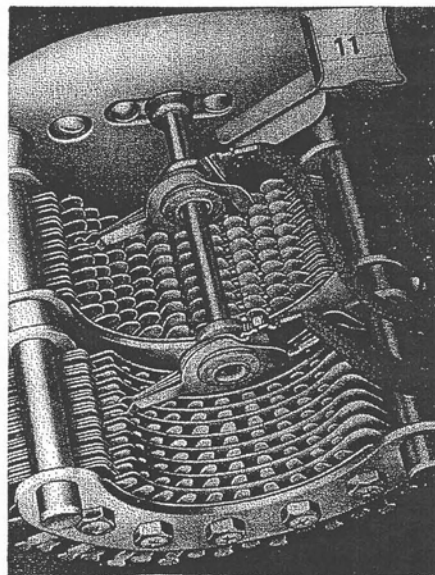


Figure 34. Strowger-switch wipers and banks. The upper wiper and bank are the control wiper and bank. The lower wipers and bank are the - and + line wipers and line bank. The control-bank contacts are wide; as the control wiper passes from one contact to the next it 'bridges'; i.e., before leaving one contact it touches the next (useful in absence-of-ground-searching circuits).

The Strowger-switch mechanism can be made to function equally well as a connector, selector, or linefinder by changes in its electric circuit and mechanical components.

STEPPING SWITCHES

The switch has a spring assembly fastened to the top end. Underneath this assembly is a normal-pin (see Figure 36 right-hand view) which rests against the normal-pin stop when the shaft is at normal. This arrangement prevents the shaft from traveling too far to the left due to the torque applied to the shaft by the shaft spring. When the shaft is in its normal position, the normal pin rests on an arm which causes the off-normal springs to operate.

The weight of the shaft rests on the normal-pin clamp (Figure 36 left-hand view) which strikes on the upper shaft bearing when the shaft is normal. The shaft is guided by two bearings, one at the top and one at the bottom of the switch frame.

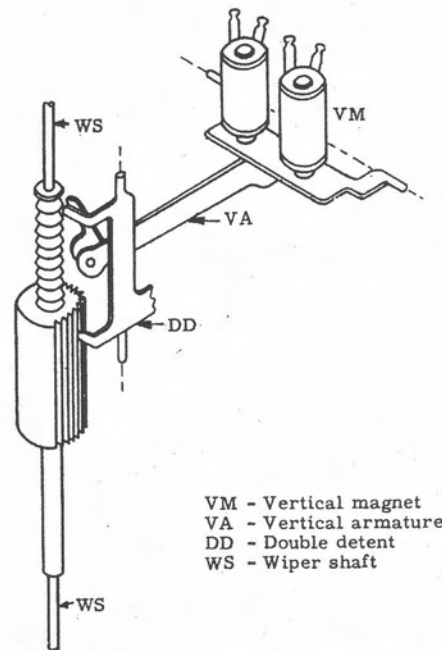
The hub of the shaft consists of two sections, the upper section is the vertical ratchet and the lower section the rotary ratchet. The vertical ratchet consists of ten horizontal teeth cut into the upper part of the hub. The rotary ratchet consists of eighteen vertical teeth cut into the lower part of the hub. The vertical ratchet is for lifting the shaft and the rotary ratchet is for rotating the shaft.

Auxiliary mechanisms such as detents (lock or unlock a mechanical movement) are associated with the ratchets. The detents engage teeth in the ratchets when the ratchets move off normal and hold the ratchets in the position last operated. Two such detents are used; the stationary detent and the double detent (see Figure 36 left and right views respectively). The stationary detent, as the name implies, does not move. It is auxiliary to the double detent and is used to hold the vertical ratchet elevated when the shaft is rotated. The double detent serves two purposes as follows:

- (a) To prevent the shaft from falling while the shaft is being stepped vertically, and
- (b) To prevent the shaft from returning to normal while the shaft is being rotated and when the rotation is completed, hold the rotary shaft in the last operated position.

The shaft is lifted by relaying current pulses from the dial to the vertical magnet (see Figure 35 and Figure 36 top left view). With each current pulse transmitted, the vertical electromagnet is energized and the pawl associated with the vertical armature presses upward against the vertical ratchet teeth which causes the shaft to lift the wipers one bank level; and when the first series of pulses has ceased, the

wipers are in line with the desired bank level. The vertical tooth of the double detent engages a tooth of the vertical ratchet to keep the shaft in its elevated position. With each de-energization of the vertical-magnet circuit, the vertical pawl is withdrawn from the ratchet.



VM - Vertical magnet
VA - Vertical armature
DD - Double detent
WS - Wiper shaft

Figure 35. Mechanism for shaft vertical movement

When the switch is not in use the double detent (see Figure 36 top right view) is held clear of the shaft ratchets by a flat spring called the release link (see Figure 36 top left). This spring extends from beneath the vertical-armature lever of the double detent where it hooks over a lug on the double detent. When the vertical magnet (see Figure 36 top left) is first energized, a finger on the underside of the vertical armature lifts this spring from the lug permitting the double detent to engage the ratchet teeth of the hub.

A groove on the left side of the vertical teeth (see Figure 36 top left) allows the shaft to pass the stationary detent during vertical movement. The stationary detent supports the weight of the shaft during rotary motion. On the underside of each vertical tooth is a metallic rise or bump. These bumps (see Figure 36 top right) are engaged by the vertical tip of the double detent during vertical stepping. The stationary detent is adjusted so that as the bump on the vertical tooth moves off the tip of the double detent (on the first rotary step), the edge of that vertical tooth (at the groove) passes on to the stationary detent without raising the shaft or allowing it to drop discernibly. Therefore, as soon as the bump on the underside of the vertical tooth has left the vertical tip of the double detent, there is clearance between the double detent and the vertical tooth and the stationary detent supports the weight of the shaft.

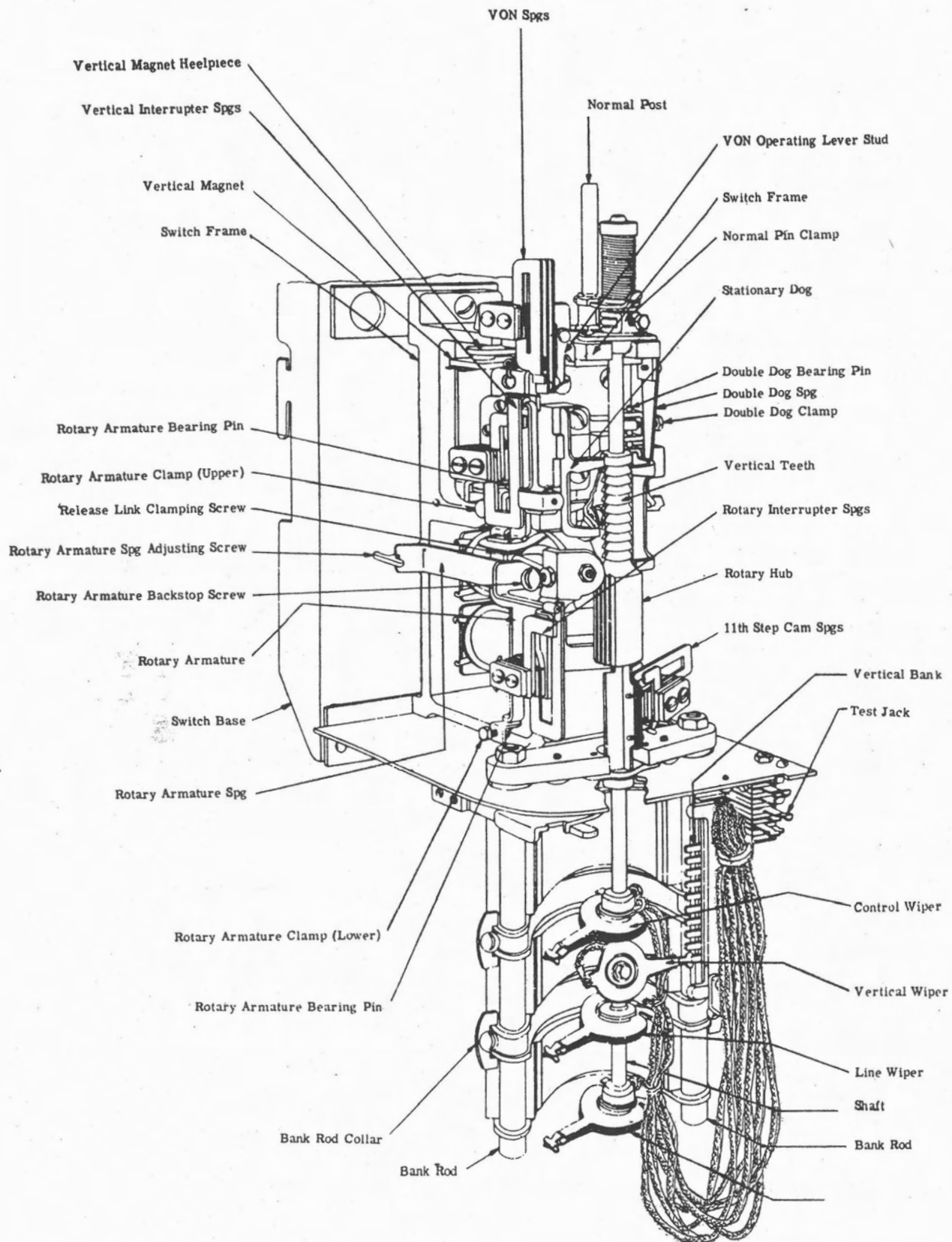


Figure 36. Strowger-switch mechanism with attachments.

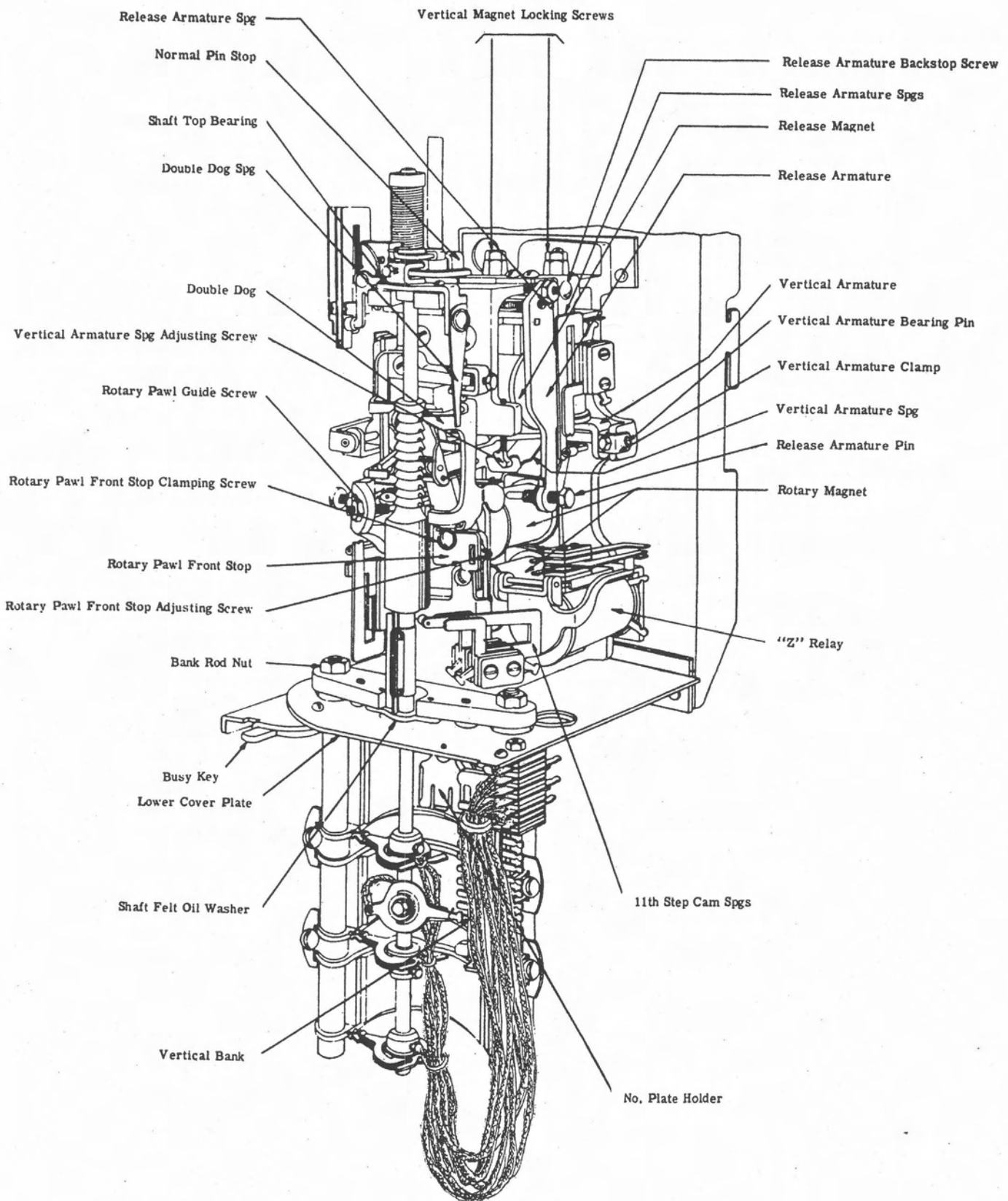
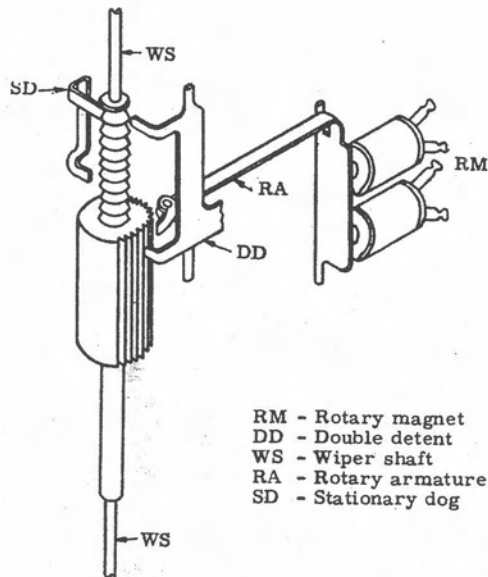


Figure 36 (continued).

STEPPING SWITCHES

The rotary magnet (see Figure 36 middle right and Figure 37) rotates the shaft to the desired contacts on the selected bank level. With each current pulse transmitted, the rotary magnet is energized, and the rotary pawl engages a tooth in the ratchet and causes the shaft to rotate the wipers one step. The rotary tooth of the double detent (the bottom tooth) engages a tooth of the shaft ratchet, to prevent the shaft from returning to normal and when rotation is completed, hold the rotary shaft in the last operated position (see Figure 36 top right view).



- RM - Rotary magnet
- DD - Double detent
- WS - Wiper shaft
- RA - Rotary armature
- SD - Stationary dog

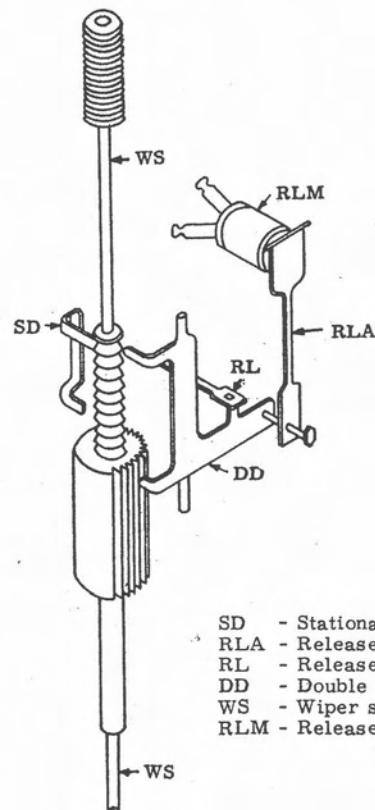
Figure 37. Mechanism for shaft rotary movement.

When the rotary armature is completely operated, the shaft is moved around just far enough to cause the rotary tip of the double detent to drop into a rotary notch in the shaft hub. While the rotary armature is unoperated the armature rests against the rotary-armature backstop screw. This pin is adjusted so that the pawl of the rotary armature just clears the hub of the shaft as the shaft is being stepped vertically or released. A flat piece of stainless steel spring fastened to the armature and bearing against an adjusting screw in the frame (Figure 36 middle left) gives the necessary tension to restore the rotary armature to its normal position.

The vertical, rotary, and release electromagnet coils each have a brass cap over the coil core end to cause the armature to release quickly after the coil circuit is opened and thus allow quick, reliable response of the armature.

A Strowger switch is released through the energization of the release magnet (see Figure 36

top right view and Figure 38) located in front of the vertical electromagnet. When the release magnet is energized, the stud of the release armature presses against the double detent, and causes it to withdraw the vertical and rotary teeth from the ratchets of the shaft. A flat spring ("release link") hooks over the projecting lug of the double detent and keeps the double detent in the normal position out of engagement with the ratchets of the shaft.



- SD - Stationary detent
- RLA - Release armature
- RL - Release link
- DD - Double detent
- WS - Wiper shaft
- RLM - Release magnet

Figure 38. Mechanism for shaft release.

When the double detent is out of engagement with the shaft ratchets, a helical spring, located at the upper end of the shaft, causes the shaft wipers to rotate back and clear the bank. While the shaft is being returned to its rotary starting position, the shaft is prevented from dropping by the stationary detent, but when the wipers are clear of the bank the detent finds the slot in the ratchet, and gravity causes the shaft to drop to the normal position.

Strowger switches are equipped with spring assemblies as the circuit designs require. These spring assemblies vary depending whether the switch is used as a connector, selector, linefinder, etc.

STROWGER-SWITCH FUNCTIONS

27. CONNECTOR (see also bulletin 807 "The Connector")

The connector (Figure 39) is a numerical two-motion electromagnetically operated stepping switch.

This Strowger switch steps up and around to connect its wipers with the dialed line.

This switch is stepped up and around by electric current pulses produced by the calling telephone's dial. The connector switch automatically performs the switching function previously handled by an operator in a manual telephone exchange.

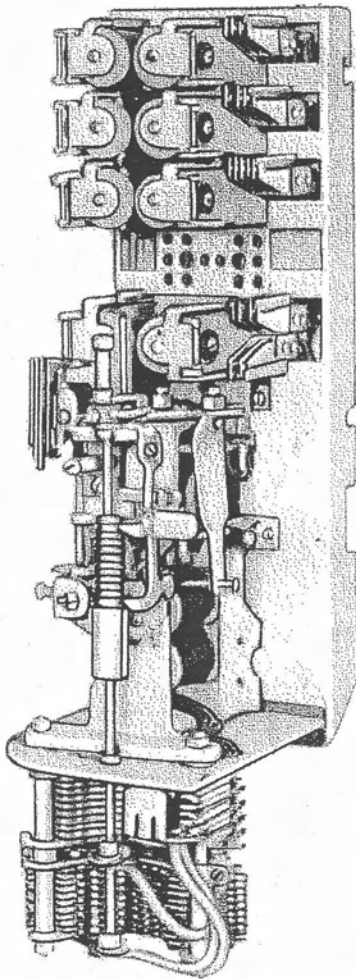


Figure 39. Typical connector.

Figure 40 is a line drawing of a connector switch with the nomenclature of its parts. The last two digits of a telephone number are always handled by a connector switch.

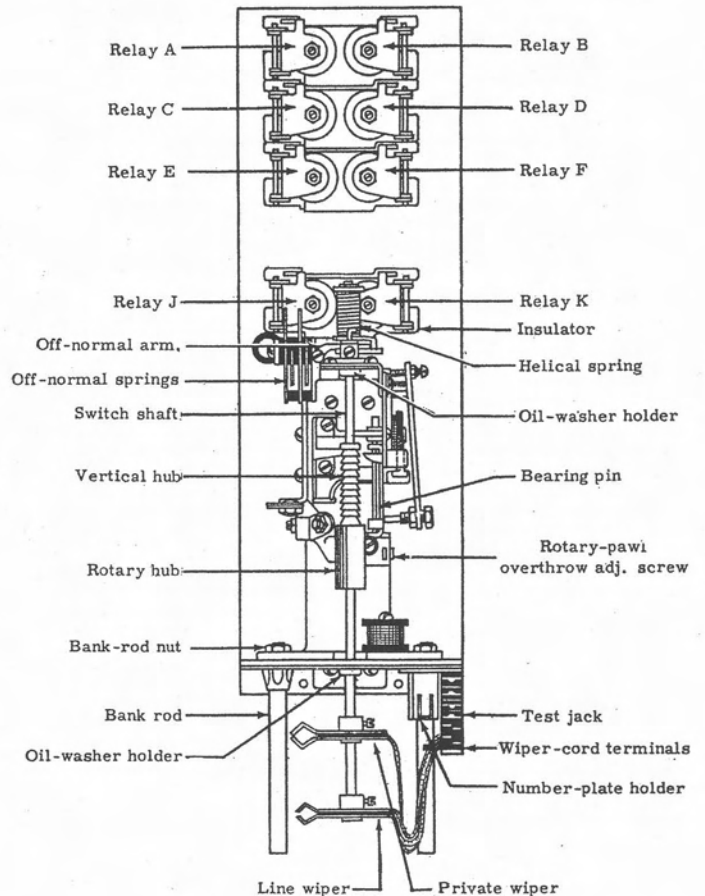


Figure 40. Typical connector.
(Factory stamps A, B, C, etc., on the relays to indicate their mounting-position sequence).

28. SELECTOR (see also bulletin 808 "The Selector")

The selector (Figure 41) is a numerical two-motion electromagnetically operated stepping switch.

The Strowger switch steps up and around to connect its wipers with the first idle trunk leading to the next succeeding switch.

The vertical stepping is controlled by electric current pulses produced by the telephone dial, and rotary stepping is automatic and caused by current pulses produced by the rotary-interrupter springs.

This switch has cam springs which operate on the eleventh rotary step in case all trunks on the dialed level are busy. Selectors may be identified by their relatively few relays.

Figure 42 is a line drawing of a selector switch with the nomenclature of its parts.

29. LINEFINDER (see also bulletin 821 "Line-Finder Switches")

The Strowger linefinder (or finder) has a non-numerical two-motion electromagnetically operated stepping mechanism (see Figure 43).

This Strowger switch automatically steps up and around to connect its wipers with the calling line.

Pulses derived from the vertical and rotary interrupter springs step the switch up and around automatically.

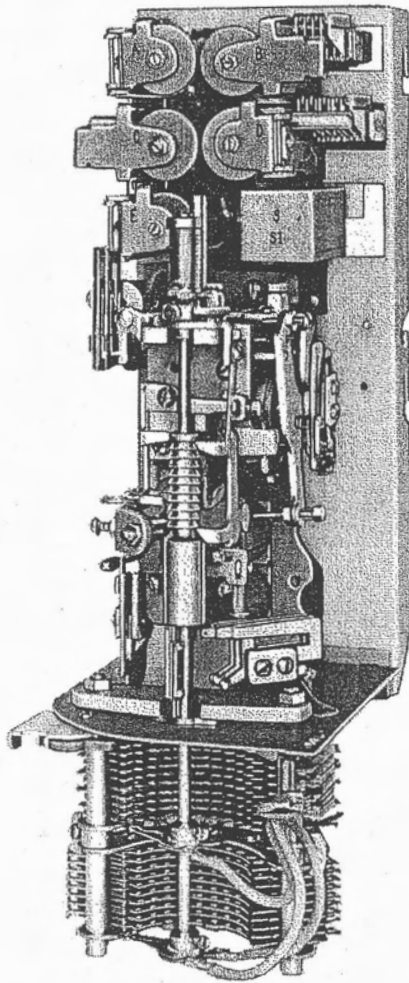


Figure 41. Typical selector.

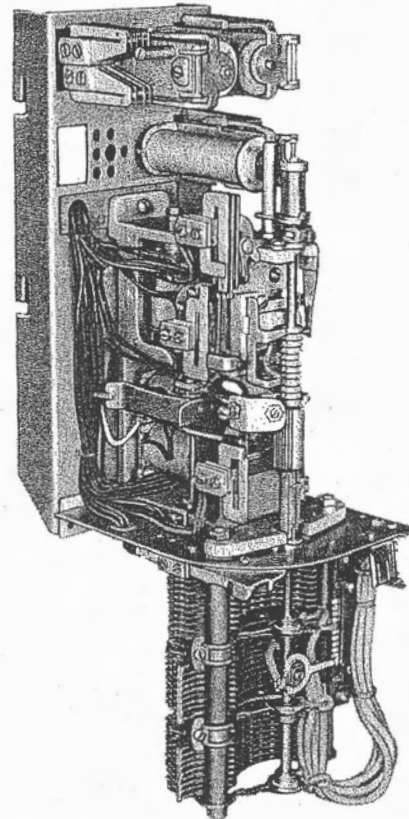


Figure 43. Typical 200-line linefinder.

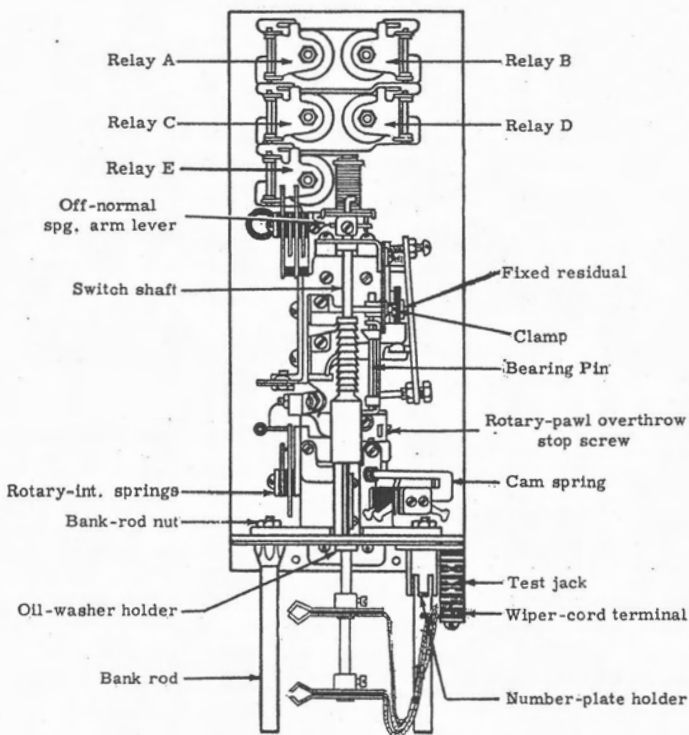


Figure 42. Typical selector.

The linefinder switch also has cam springs (see Figure 36 middle left view) which operate to stop the finder on the eleventh rotary step when a call is abandoned before the finder has found the calling line.

The Strowger linefinder telephone system has economic advantages over the previously used lineswitch systems. Modern Strowger installations, therefore, usually have linefinder systems.

On 200-line connectors or linefinders, the Strowger switch will have three banks of 200 contacts each (Figure 46). The bottom bank of 200 contacts will serve 100 lines; the middle bank, the second group of 100 lines; the top 200 contacts will be the control leads for both lower banks. Thus when the switch shaft has stepped up one step, the lower wipers will be

STROWGER-SWITCH FUNCTIONS

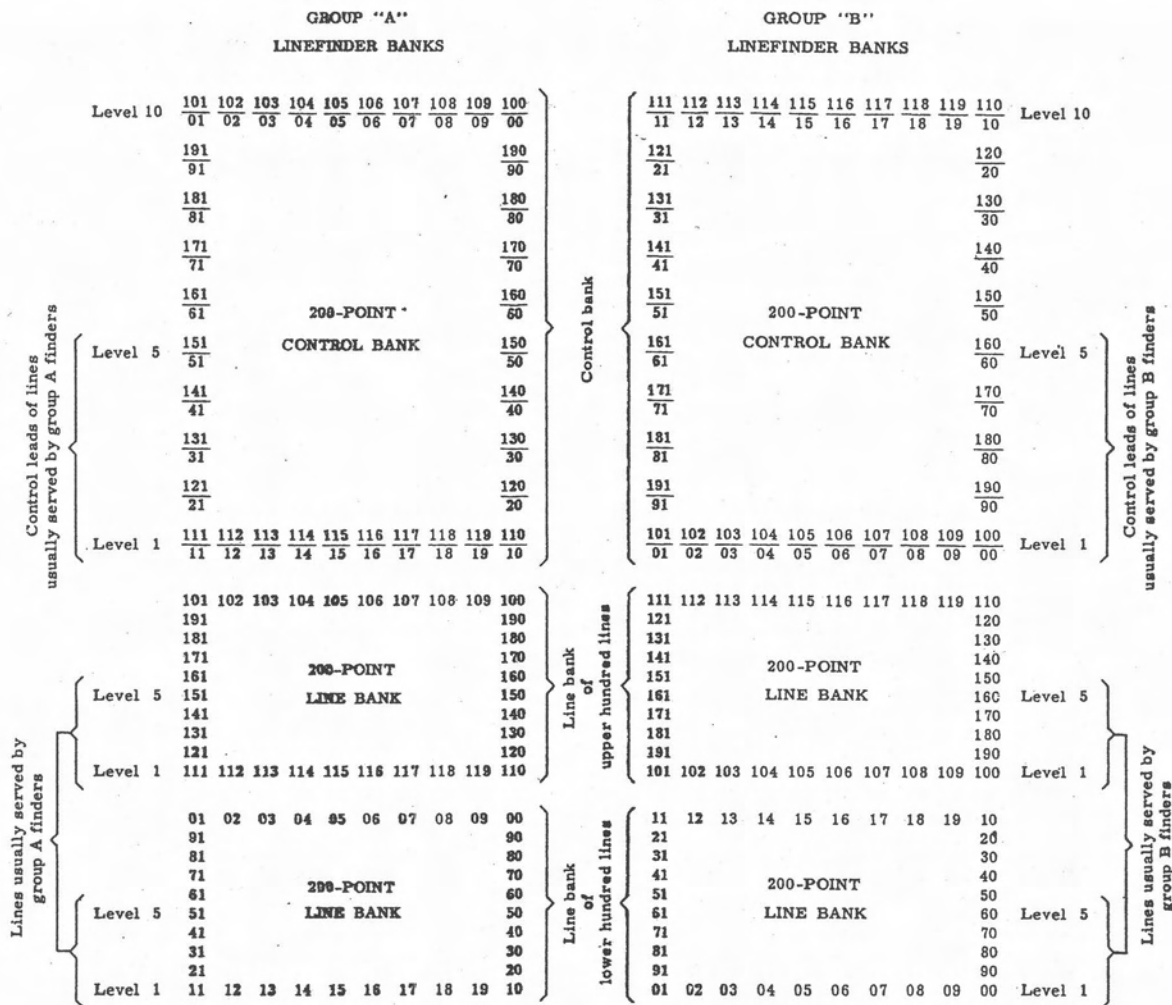


Figure 44. Bank numbering for 200-line linefinders.

opposite lines 11 to 10; the middle wipers opposite 111 to 110; the top wipers will be opposite the control contacts for both these groups. The bottom spring of the wiper will contact the control leads 11 to 10; the top, 111 to 110. Thus when rotary action starts, two sets of contacts are available at each step. Relays, however, select and utilize only one set of wipers for the telephone connection.

The banks of all linefinder switches are not multiplied alike for if they were, subscribers with line equipments numbers 100 and 00 would always have to wait the maximum hunting time. To avoid this and to minimize hunting time, the linefinders are divided into two groups, A and B. Between these groups, a vertical level-reversal is made in the multiple as indicated in Figure 44. Thus in group A, lines 111 to 150 and 11 to 50 occupy the first five levels as before. But in group B, lines 101 to 160 and 01 to 60 are on the first five levels. Group A finders answer calls in group A, only, unless all finders in group B are busy. Group B finders answer calls in group B, only, unless all finders in group A

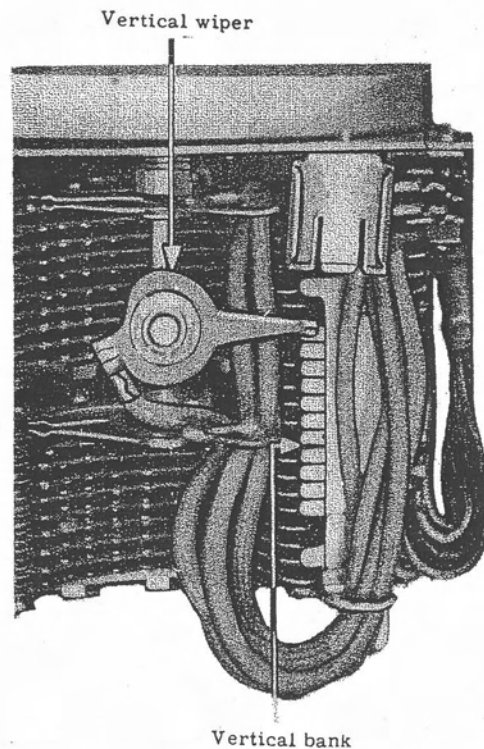


Figure 45. Linefinder vertical wiper and vertical bank.

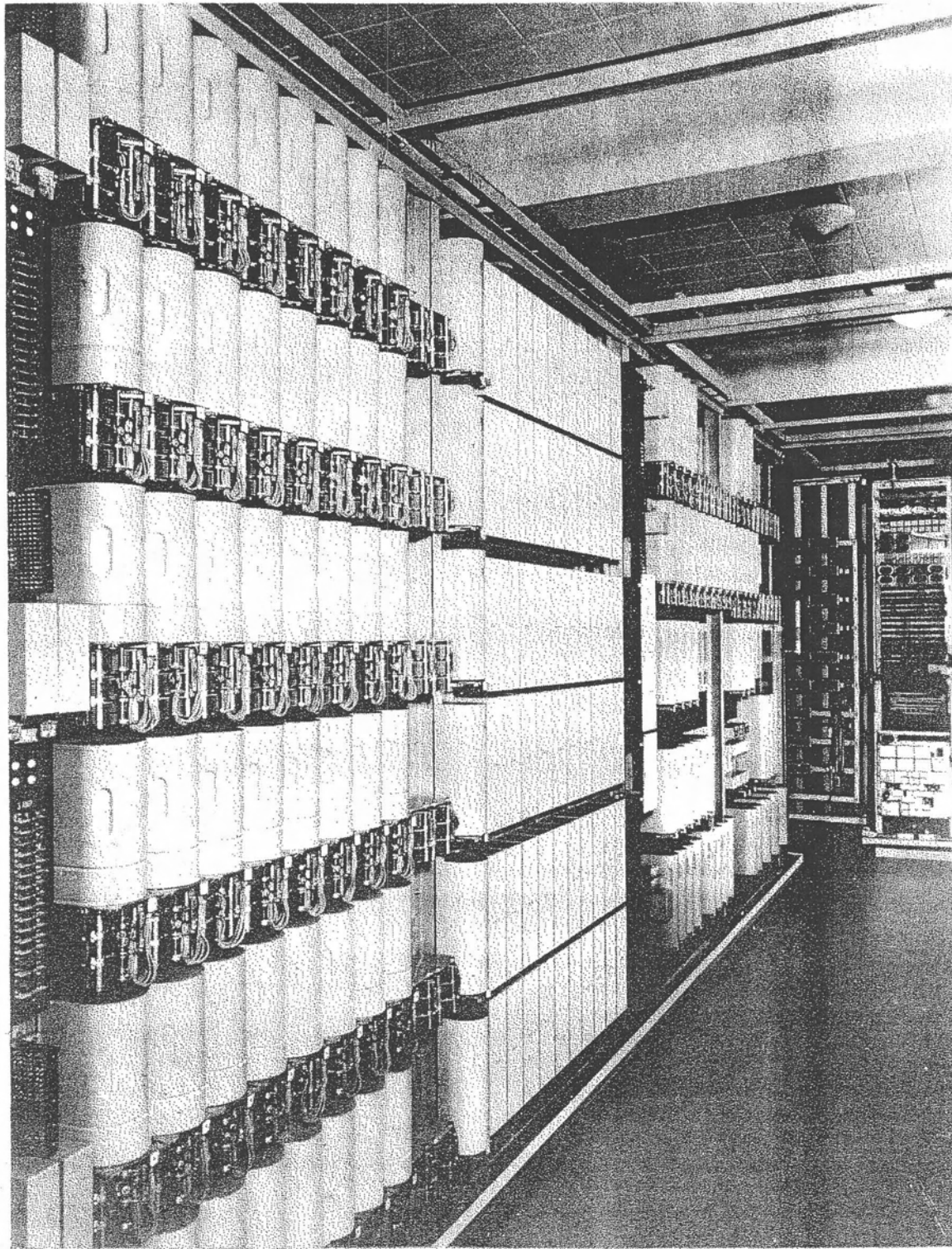


Figure 46. In the foreground, a bay of linefinder shelves in a central office.

are busy. Thus under ordinary traffic, a linefinder need not step more than five levels, yet each can reach all 200 lines.

Each linefinder switch has a flat vertical row of bank contacts (Figure 45) to control the vertical hunting. This vertical bank is located just to the right of the semicylindrical banks. While the shaft is being stepped vertically, the

vertical wiper engages this flat bank of contacts. At the first rotary step the vertical wiper disengages from this bank.

The physical arrangement and mountings of Strowger linefinder switches are shown in Figure 46. Notice all banks are wired, but not all are equipped with switches. Thus switches may be added easily through the standard jack-in bases and bayonet slots.

AUXILIARY SWITCHES

30. AUXILIARY SWITCHES

Strowger switches are equipped with such spring assemblies as their circuits require. These assemblies vary according to how the Strowger switch is used, e.g. as a connector, selector, linefinder, etc.

The limit switches usually encountered on the Strowger-type switches are listed below:

- (a) Vertical off-normal springs are operated as the shaft takes the first vertical step. A set of vertical off-normal springs is mounted on all Strowger switches. These springs are mounted near the top left-hand side of the switch-mechanism frame.
- (b) Vertical interrupter springs are operated at each vertical step.
- (c) Rotary interrupter springs are operated at each rotary step.
- (d) Cam springs are operated on the eleventh rotary step.
- (e) Rotary off-normal springs are operated when the shaft takes the first rotary step. Rotary off-normal springs and cam springs may be mounted on a Strowger switch as one pile-up. Under this condition a two-step cam is used. The rotary off-normal springs' portion of the pile-up operates during first rotary step. The cam springs' portion operates during the eleventh rotary step.
- (f) Normal-post springs (Figure 47) are operated when the shaft has been stepped vertically to a selected level. These springs are mounted on top of the Strowger switch.
- (g) Release-magnet springs are operated while the release magnet is energized.

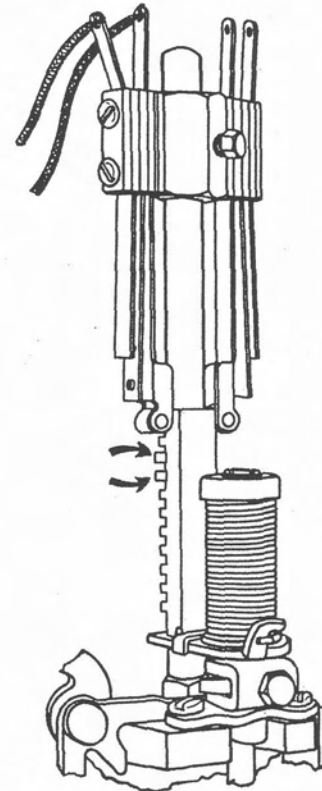


Figure 47. Normal-post springs. Arrows show cam lugs bent 90° to operate left normal-post springs when wiper-shaft is opposite or cut in on level 2 or 3.

The vertical and rotary interrupter spring assemblies each consist of only two contact springs. The moving spring of the assembly is actuated by an arm which is part of the armature of the electromagnet with which the spring assembly is associated.

Interrupter springs are used to interrupt electric current into pulses for automatically stepping Strowger switches. A selector switch has rotary interrupter springs for trunk-hunting on the dialed level. A linefinder has both vertical and rotary interrupter springs. Release-magnet springs are actuated by a lever which is attached to the release armature.

ADJUSTMENTS AND MAINTENANCE

31. ADJUSTMENT STANDARDS

The purpose of all standard adjustments is to put the knowledge gained from extensive tests and operating experience into a procedure which will insure positive operation of apparatus and long service life.

Relay spring forms and typical spring assemblies are shown in Figure 51. Relay spring adjustments comprise two main operations:

- (a) Spring gauging
- (b) Margining

“Spring gauging” is adjusting (bending) stationary springs so they open enough to break circuits when they should, and so “stationary” springs “follow” moving springs to exert pressure in break contacts when the relay is unoperated, and in make contacts when operated.

“Margining” is measurement of moving-spring tension by checking response of the armature at specific electrical limits, viz. “operate” (O) current and “nonoperate” (NO) current. The current may be determined by one of two methods, as follows:

- (1) Measurement with a milliammeter, or
- (2) Application of a constant known voltage to the relay coil with a specified resistance connected in series with it.

“Margining” measures the total mechanical resistance to the operation of the armature due to the tension of the springs. Adjust the springs so they load the armature enough that it cannot operate when the “non-operate” current flows in the relay coil. This spring tension exerts contact pressure between the armature springs and the back-contact or “break” springs. The springs must not be too stiff, because the “operate” current must operate the relay completely.

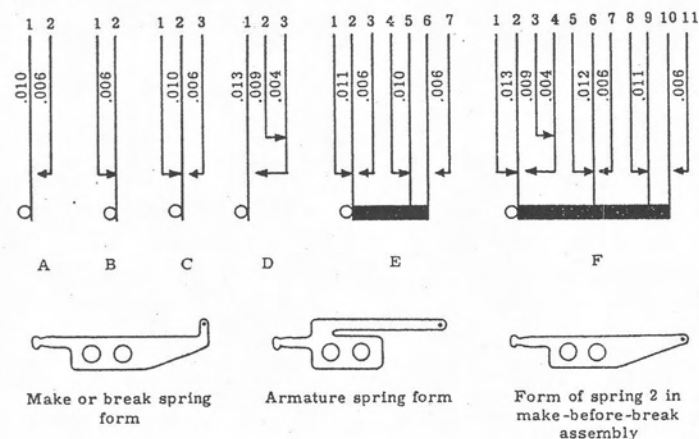


Figure 48. Typical relay spring gauging and spring shapes.

In Figure 48 the decimal values alongside the lines representing springs of the various assemblies show the proper gap in inches between the residual screw of the armature (see Figure 11) and the coil core when the springs just make or break contact. To measure the gap, insert one or more thickness gauges between the residual screw and the end of the coil core. For example, the springs shown in assembly B (Figure 48) must just break contact (judged visually) when the armature still has 0.006” to travel.

“Stroke” is the normal armature air gap, viz. the air gap with the armature unoperated, and is adjusted by bending the armature backstop

(see Figure 11). Stroke values usually are necessary only for relays which do not have a break contact as the first spring in the assembly. The contacts in assembly A must just make contact when the armature still has 0.006” to travel. The values listed along the springs in the other spring assemblies similarly determine spring “follow” in terms of armature travel.

The adjustment specifies also the amount the non-magnetic residual screw protrudes through the armature— i.e., the gap between armature and coil core with the relay operated.

32. ROUTINES

A “routine” in automatic telephone maintenance is a periodic check of the functioning of telephone apparatus to detect faults so they can be repaired before subscribers are inconvenienced by and complain of them.

Service routines are designed to detect actual faults that may result in service interruptions. Service routines are made at quite frequent intervals just after equipment is placed in service. Thereafter the frequency is determined by the nature of the faults detected and by the amount of subscribers’ complaints.

33. LUBRICATION

Extensive lubrication of the Strowger automatic telephone switching equipment is not necessary. The lubrication recommended by the manufacturer is, however, important for the most economical maintenance, the most efficient operation, and the longest service life of the equipment.

Automatic Electric Company recommended practices specify surfaces requiring lubrication, the lubricant to use, and the amount and method of application for each bearing.

The purpose of lubrication is to provide a film of oil between a bearing and a moving part, which will result in a minimum of friction. Lubrication in excess of this film is wasteful.

The lubricant best suited for a particular type of bearing depends upon type, size, metals used, humidity, temperature, speed, etc.

Any lubricant recommended for a particular bearing is the result of both exhaustive tests and universal observation over a half-century under various actual operating conditions.

Typical Strowger switching lubricants include watch oil, spindle oil, dash-pot oil, machine oils, and switch lubricant. The lubricants for any piece of equipment will be found specified on the applicable Standard Adjustment sheets.

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