THE

STEP-BY-STEP DIAL TELEPHONE SYSTEM

Telephone Systems Training

COURSE: CENTRAL OFFICE EQUIPMENT

LESSON NO. 3

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Western Electric Company, Inc.
Hawthorne Works
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Course: Central Office Equipment

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This lesson is issued to describe the general features of the Step-by-Step Dial Telephone System. Information contained herein is to be used for training purposes only.

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NOTE: Section 7 has been added by the Installation Organization.

Bibliography

Bell System Publications

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SECTION 1. HISTORY AND DEVELOPMENT

Shortly after the invention of the telephone by Alexander Graham Bell in 1876, many inventors labored to design a system in which mechanical equipment would replace the operators in the central office, whose function it was to switch calls manually from one line to another. The first successful system which was to replace the operators was the invention of a mechanical switching device in 1889 by A. B. Strowger, a Kansas City undertaker.

As early as 1879, Connolly and McTighe conceived the idea of having mechanical equipment perform the entire work of switching calls in a central office. In their system each subscriber station equipment was provided with a switch by means of which the line could be connected either to a "make and break" impulse sending device or to the telephone set itself. The subscriber, with the switch turned so that the "make and break" device was connected to the line, would cause current impulses to be sent out on the line into the central office equipment, where magnets associated with his line would be operated, and thereby control the operation of step-by-step switches, which in turn would connect his line to other lines terminating in this office.

While the basic plan of automatically switching calls was practical for small areas, many years of development were required until a system was designed which would meet the service and traffic requirements of a large exchange area.

One of the most important features of Strowger's work was that of simplifying the contact arrangement in the central office, upon which the different subscriber line wires terminated. These contacts were arranged on curved surfaces in a number of levels or rows, one row above the other. This arrangement makes it necessary for the associated brushes or wipers to move first in a vertical direction, selecting a particular level of terminals, and then rotate over the terminals in that level until contact was made with a particular subscriber line terminal. This feature, involving first a vertical and then a rotary movement of the wipers, contributed a very important idea to the art of mechanical telephony. The wipers which made connection with the contacts were directly under the control of the subscriber calling device and therefore could be made to move a certain number of steps in either a vertical or horizontal direction depending upon the number of impulses generated by the calling device. The defects in this first system were many. Five wires from each subscriber station to the central office were required. The commercial development of the Strowger Automatic System began with a central office installation in LaPorte, Indiana in 1892 and has continued more or less steadily since that time.

In 1894, a system was produced by Keith, Lundquist, and Erickson which involved several new features. A common battery was installed in the central office which operated switch magnets similar to those of Strowger's. The number of line wires required for each subscriber station was reduced from five to two. This system included a calling device located at each subscriber station which consisted generally of three push button type keys labeled "hundreds," "tens," and "units." If the subscriber wished to call No. 125, for example, he would push the "hundreds" button once, then the "tens" button twice and "units" button five times. By means of this arrangement a subscriber was assured fairly good service, the greater percentage of errors being traceable to the subscriber himself, due to improper operation of the push buttons or not holding the key long enough for the switches in the central office to function. As a result of these subscriber errors, Keith and Erickson in 1896 invented the first dial.

As a result of these inventions, the mechanical system of switching calls from one line to another then became a real competitor of the manual system.

Several semi-mechanical systems were also developed which were part manual and part mechanical in operation, and the switching operations required in order to complete the call were performed by mechanical equipment under the direct control of the operator who handled the originating call.

During the first World War, labor conditions over the entire country reached such a stage that telephone companies found it almost impossible to obtain a sufficient number of girls to operate the manual system. These conditions led telephone companies to adopt the mechanical system on quite a large scale.

In 1920 the Bell System began the installation of the Panel Dial System, developed primarily for large cities. However, the demand for a mechanical system to serve small and medium sized cities led to the adoption of the Step-by-Step Dial System for these areas. In 1925, Hawthorne Works began the manufacture of Step-by-Step dial equipment with a schedule of 25,000 lines. By 1929 this had risen to approximately 200,000 lines for the year. During the years of the depression the manufacture of this equipment was discontinued at Hawthorne, reverting back to the Automatic Electric Company which supplied the small demand during that time. In 1936 the demand for this equipment began to increase and manufacture was again resumed at the Hawthorne Works. By 1941 production rose to 740,000 lines.

During the war years the output of all telephone equipment was at a standstill with manufacture being resumed in 1945. The present schedule for the manufacture of Step-by-Step Equipment is about 900,000 lines - (1954)

Figure 1 is a view of typical equipment installed in a Step-by-Step Dial Central Office today.

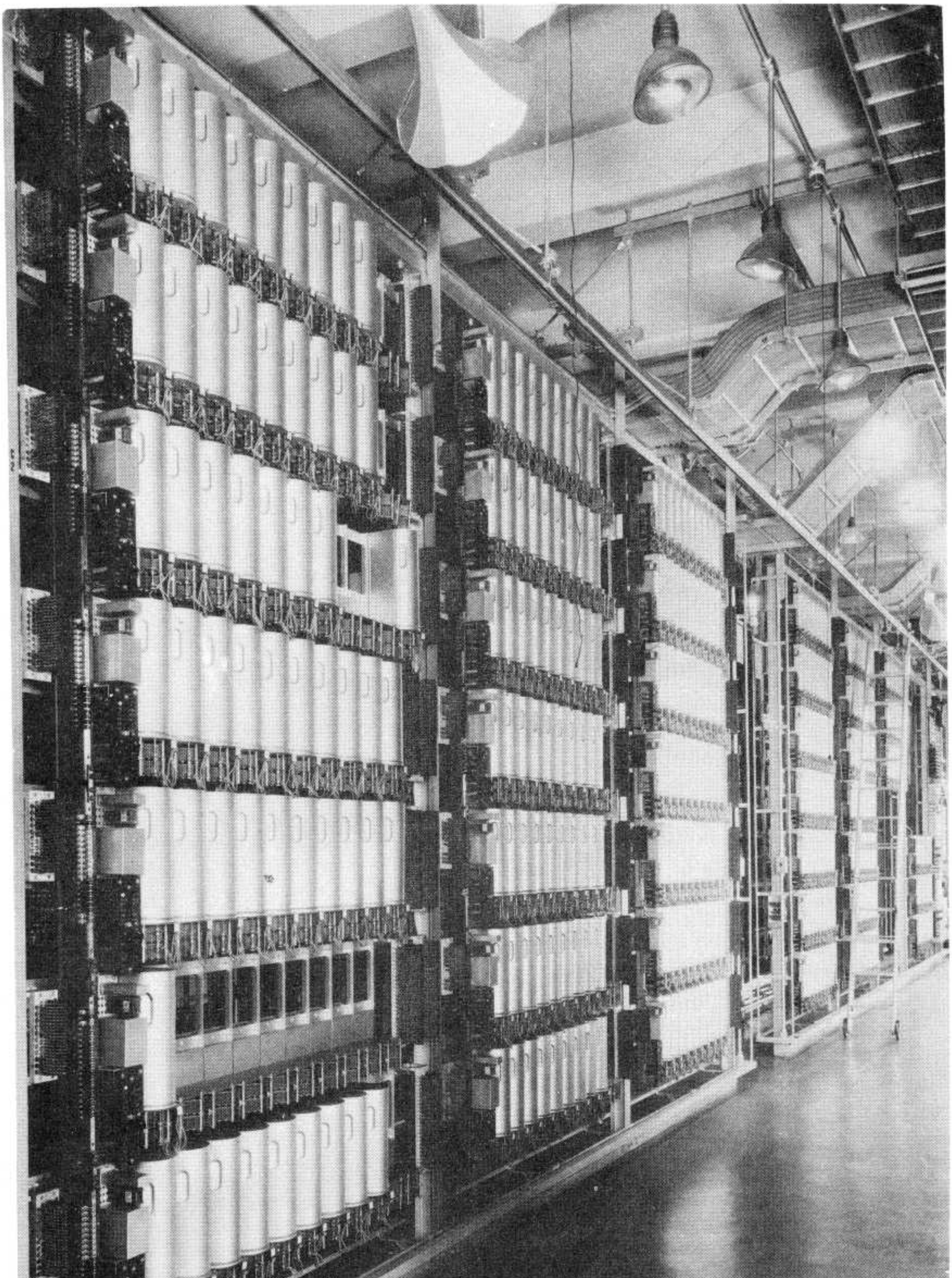
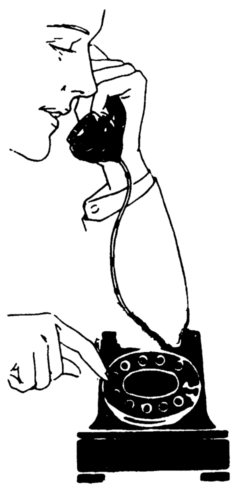


Figure 1
Step-by-Step Dial System Central Office Equipment

SECTION 2. PRINCIPLES OF DIAL SWITCHING

The function of any telephone system is to connect the lines of any two of its subscribers so that they can talk over the electric circuit thus established.



In a manual telephone system the subscriber orally transmits the number he desires to an operator who selects the number for him and connects his line to the line of that number; or who, in larger systems, connects the line with a trunk to a distant office and repeats the number desired to another operator who completes the connection to the called line. In a dial system the operator is entirely eliminated in so far as regular calls are concerned, but the sequence of operations is somewhat similar, with the operations being performed by electro-mechanical switches.

Since an electro-mechanical switch cannot respond to the voice of the subscriber as an operator can, each subscriber equipment includes a "dial" (Fig. 2), by means of which he transmits electrically the number he is calling. Actually, when the dial is operated by a calling subscriber, the electric circuit between the subscriber and the central office is opened and closed a certain number of times, depending on the digit or letter dialed. For example, if number 4 is dialed, the circuit is opened and closed 4 times, thus generating 4 pulses, which transmit definite information to the mechanical equipment in the telephone office.

The simplest form of a dial telephone system (Fig. 3) would be some form of an electro-mechanical switch electrically connected to the subscriber line, the

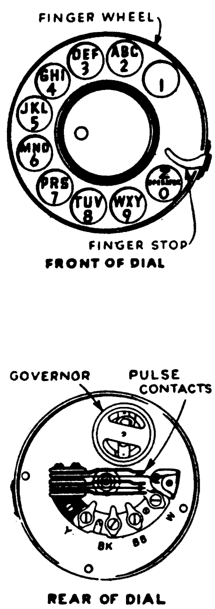


Figure 2 Dial

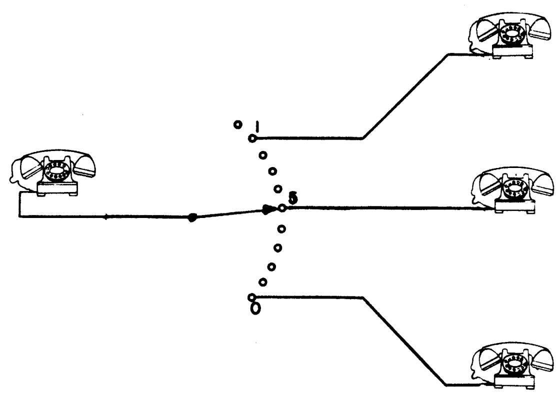


Figure 3

selector arm of which, would, by means of an electro-magnet, be moved one step each time the circuit of the subscriber line was broken and made by the operation of the dial. This would enable the suscriber to connect his telephone to any one of a group of telephones by a single rotation of the dial. By dialing one (1), the telephone connected to the first contact of the switch would be selected; by dialing two (2), the telephone connected to the second contact would be selected. As many telephones could be selected at the one switch as there were digits on the dial. Zero is the tenth and last digit on the dial, and when the dial is rotated from the zero finger hole, ten dial pulses are sent out and the telphone connected to the tenth contact of the switch would be selected.

More telephones could be reached by the subscriber with the use of additional switches arranged as in Fig. 4. Here the first rotation of the subscriber dial sends out pulses which cause the selector arm of the first switch to move and connect to a path, called a trunk, to a second switch.

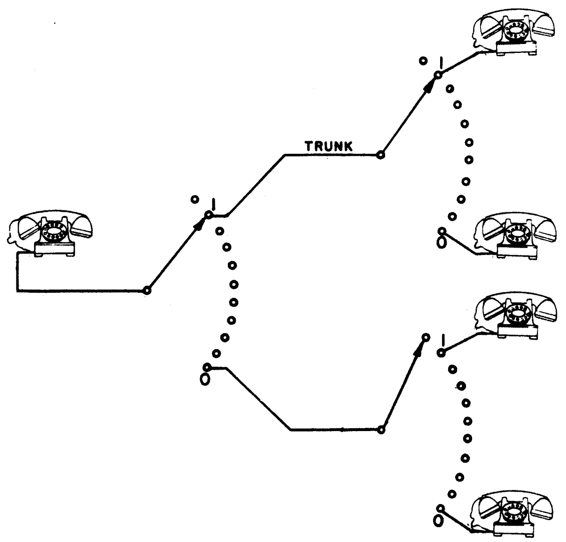


Figure 4

A slow release relay is employed to insure that all the digits dialed are received. This relay is so slow that it will not release between the rapid pulses produced by the dial, but does release in the pause which ensues when the subscriber reaches for the second pull of the dial. This slow release relay involves a fundamental principle of all dial telephone systems. The second rotation of the dial operates the selector arm of the second switch to reach the called subscriber station.

The two arrangements thus far described allow for only one telephone to originate calls to any of the others. In order that the other telephones may originate calls also, it is necessary to equip each telephone with a selector switch of its own. During the time that the subscriber is not using his telephone this switch of course would be idle.

This condition can be eliminated by introducing a switch known as a "line finder." One or more of these switches are provided for a group of subscriber lines, the lines being connected to the terminals of the switch banks. The switches are so designed that when a subscriber lifts his receiver, a selector arm automatically rotates and finds the calling subscriber line terminal in the bank and makes contact with it. This connects the subscriber line to an associated first selector switch, via the line finder, and the operation of the dial causes the called line to be selected the same as in the system described above. Fig. 5 represents a complete telephone system, which operates on this principle. The system includes a line finder switch which connects the calling subscriber line in circuit with one of the first selector switches.

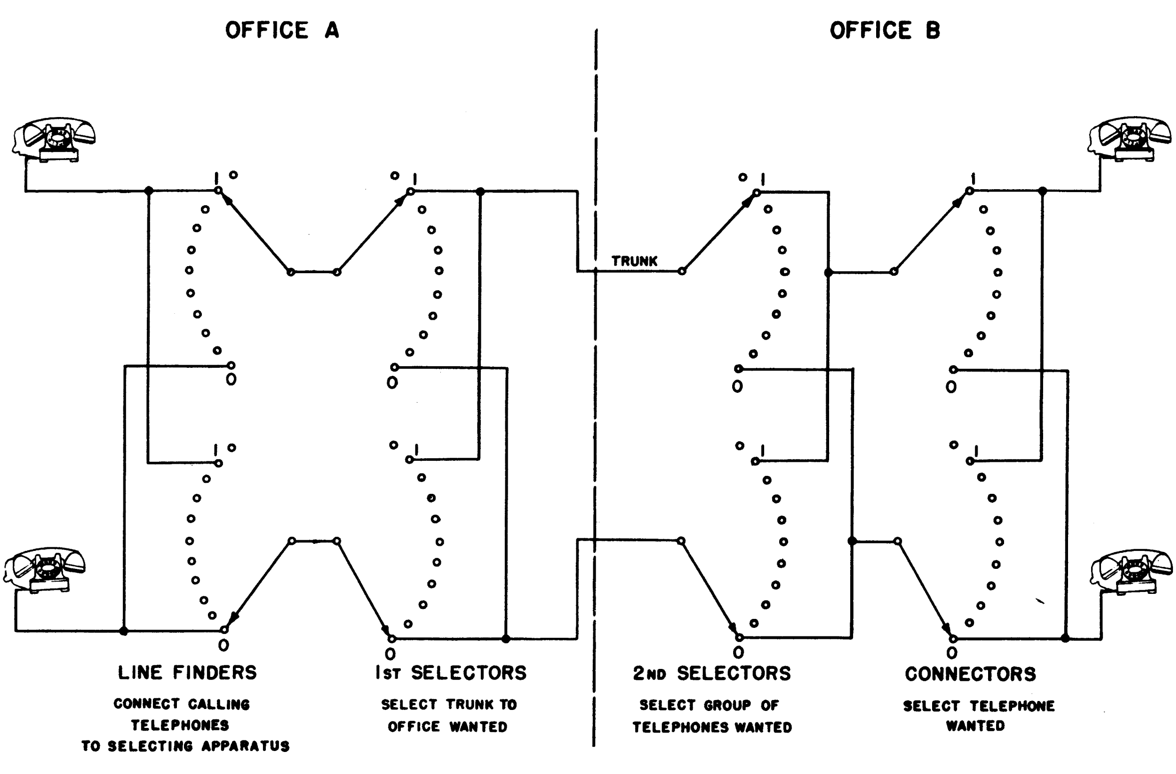


Figure 5

The first selector switches are shown connected by means of trunks, to second selector switches. After the line finder switch has connected the calling subscriber telephone to the selecting equipment, the first selector, under control of the first dialing, selects a trunk to the office wanted (it may be the same office in which the calling subscriber line is connected). The trunk connects to a second switch, in the called office, which is controlled by the second dialing to select a trunk to the group of telephones wanted. This group of telephones is connected to a third switch known as a connector switch. The third dialing causes one of these lines to be connected to the selected trunk, completing the connection between the calling and the called telephones.

An additional feature is illustrated in Fig. 5. It will be noted that there are two trunks between office "A" and office "B" and that these trunks are multipled to both the selector switches shown. Thus, two subscribers may at the same moment talk from office "A" to office "B", but this requires an additional feature in the selector switch. It must be so arranged that if it is moved by a subscriber dialing to a trunk which is already in use, it will automatically move to the next trunk. This feature is known as "trunk hunting" and is characteristic of dial telephone systems of this type. In such systems, the number of trunks in any group over which a selector can hunt is generally limited to ten by the mechanical limitations of the switch and the numerical system employed in dialing. Where more than ten trunks are required, they must be divided into two or more groups, each of which does not exceed ten.

The present Step-by-Step Dial System operates much like that described and is based on a system of trunking using first, second or more selectors and connectors, as shown in Fig. 6, to build up the connection between any two lines, a section at a time. The number of selectors to be used (namely first, second, third, etc.) depends on the number of digits that must be dialed to reach all subscribers.

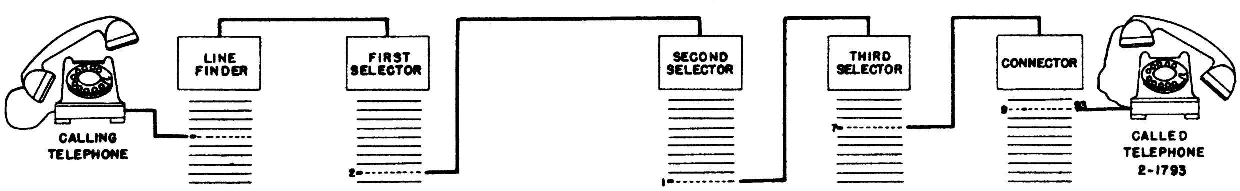


Figure 6

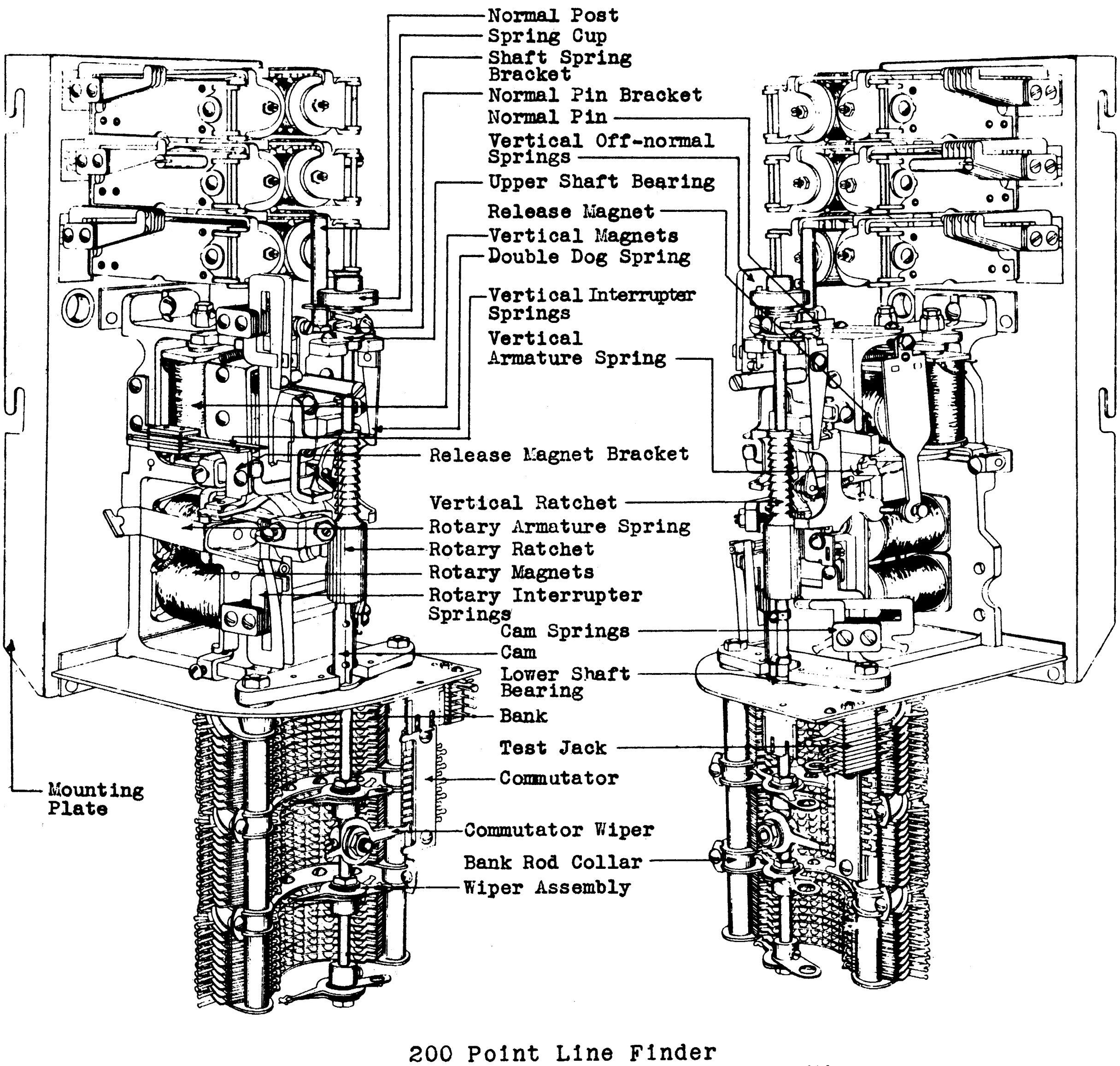
The Path of a Call Thru the Step-by-Step Dial System

SECTION 3. EQUIPMENT AND FRAMES

1. Line Finder Switch, Unit and Frame

The purpose of the line finder switch is to automatically find the calling line when a subscriber removes his receiver, and to connect the line through to the next piece of equipment to be used in completing the call. The switch is therefore arranged for automatic vertical and horizontal stepping to the desired level and bank contact terminal associated with the subscriber line. Each subscriber line is represented by three contact terminals on the line finder switch banks designated as tip "T," ring "R," and sleeve "S." The tip and ring contact terminals are connected to the two subscriber line wires coming into the central office from his station, while the sleeve contact terminal is connected to a control lead used within the office in setting up and supervising the call.

The line finder switch together with the associated banks is shown in Fig.7. The essential parts of a line finder switch include a mounting plate, lower cover plate, frame, relays, condenser, magnets, shaft and shaft spring, ratchets, wipers, pawls, dogs, commutator, test jack, plug, fanning strip, spring assemblies, and a cover.



200 Point Line Finder

Left View　　　　Right View

Figure 7

Line Finder Switch with Banks Attached

The line finder banks are not considered as part of the line finder switch since they are contained in the bank multiple which is manufactured as a separate component. However, the close association between the line finder switches and the banks makes an explanation of banks advisable at this time.

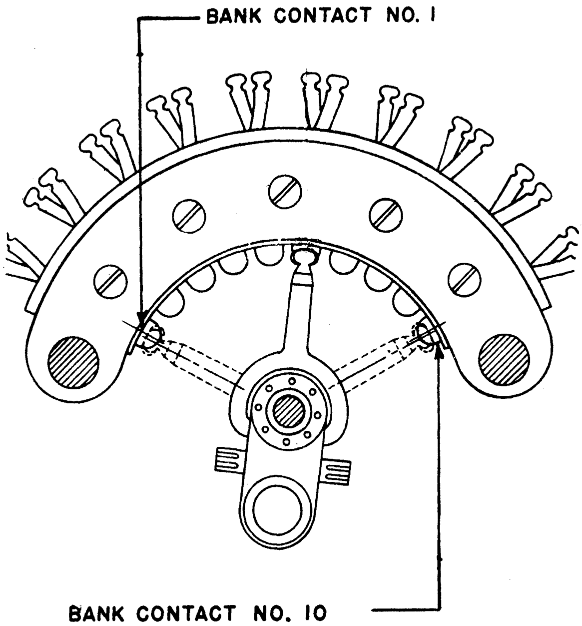


Fig. 8 - Top View of a 100 Point Switch Bank

Banks are of two types; namely, "100" point and "200" point. In the 100 point bank one hundred terminals are assembled in ten horizontal rows one above the other. Each row is insulated from the next and the individual terminals are insulated from each other. Each horizontal row consists of ten brass terminals, approximately 1" long, one end of each terminal projecting out on the front of the bank as a contact and the other projecting out on the rear of the bank as a wiring lug. A metal spacer is also placed between each row, or level of the bank, to give it rigidity. The entire bank assembly is held together with five bolts as shown in Fig. 8. The 200 point bank is assembled in the same manner as the 100 point except that 200 terminals are now provided with ten "pairs" of terminals mounted in each horizontal row. In this type bank the metal spacers between the rows are shorted together to eliminate cross talk as well as to give it rigidity.

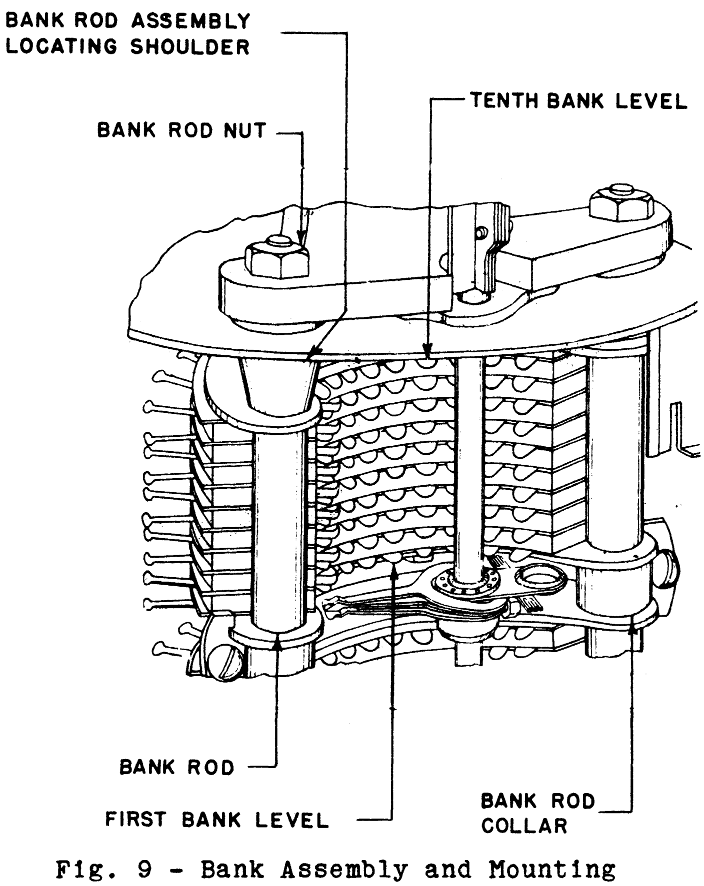


Fig. 9 - Bank Assembly and Mounting

Banks are mounted on two bank rods by means of bank collars. The bank rods are attached to the switch frame through holes in the lower cover plate. Banks are mounted on the bank rods in such a way as to allow wipers, which are attached to a shaft, to make contact with the bank terminals when they are raised and rotated (Fig. 9). Wipers are associated with the front part of the bank terminals, while the bank multiple wiring is connected to the rear of the terminals.

Fig. 10 represents the bank numbering of a 200 point bank with terminals numbered from 00 to 99 instead of 1 to 100. The first row or "level" as it is normally referred to, has ten pairs of terminals; the first pair at the left being numbered 11, the second 12, etc. up to 19 and the tenth pair, 10. The first pair of terminals of the second "level" is numbered 21 and

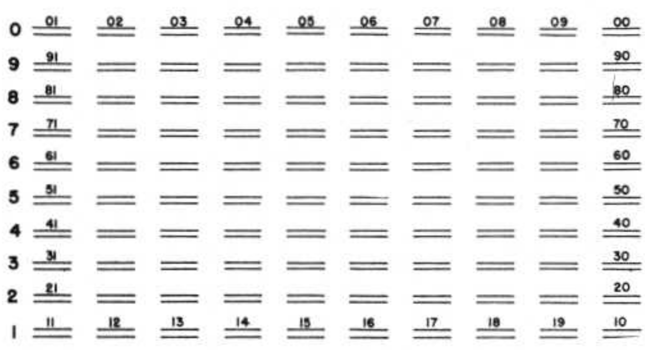


Fig. 10 - Line Bank Numbering

the others respectively 22 to 29 and 20. The numbering of the other levels follows the same sequence; the first pair of terminals of each level being successively 31, 41, etc. up to the tenth level which is numbered from 01 to 09 and 00. This is a general numbering scheme for all banks and except for uniformity would not be required on the line finder since the switch shaft and wipers are raised and rotated automatically to find the calling subscribers line. However, this numbering plan is necessary in the case of selectors and connectors which are dial controlled, and must conform to the numbering plan followed on the dial.

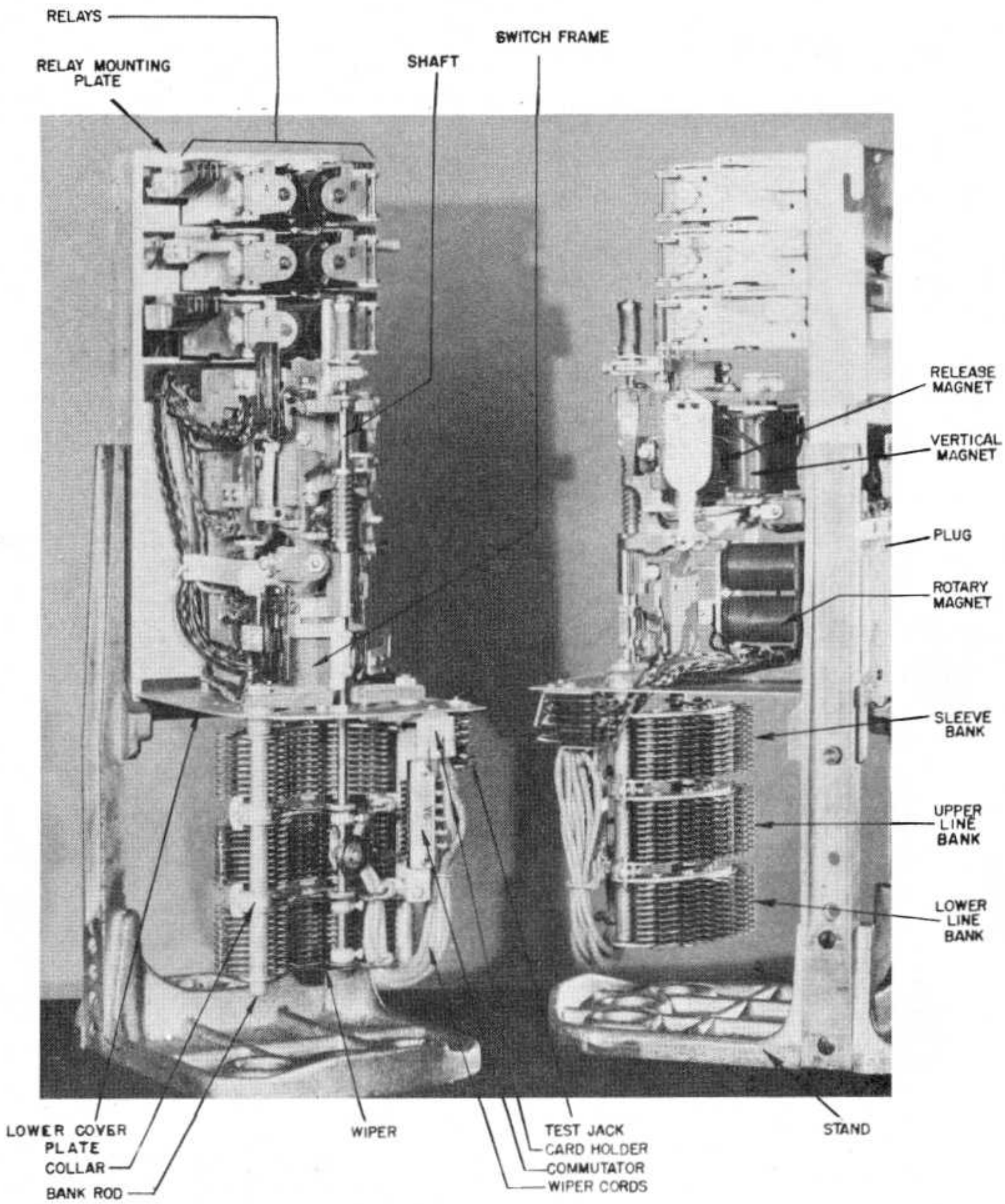


Figure 11 - 200 Point Line Finder Switch and Banks

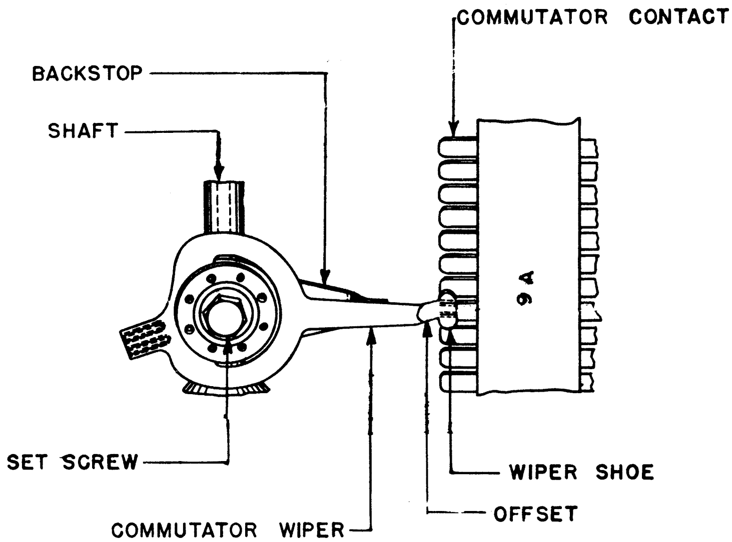


Figure 12 - Commutator and Commutator Wiper

The two lower banks on a 200 point line finder (Fig. 11) are designated as "lower" and "upper" line banks and are 200 point banks. The subscriber line wires tip "T" and ring "R" are connected to these line bank terminals. The lower line bank serves the first group of 100 lines numbered 00 to 99 and the upper line bank serves the second group of 100 lines numbered 100 to 199. The top bank of the 200 point line finder is also of the 200 point type with each level providing a termination for 20 sleeve "S" wires of 20 subscriber lines. In this case, the lower bank terminals of the "pairs" on level 1 are connected to sleeve wires for lines 11 to 10. The upper bank terminals of the "pairs" on level 1 are connected to the sleeve wires for the second hundred group or numbers 111 to 110. Levels 2 to 0 are wired in like manner. The 100 point line finder, which is not being discussed in this lesson, contains two banks, the lower a 200 point line bank and the upper a 100 point sleeve bank.

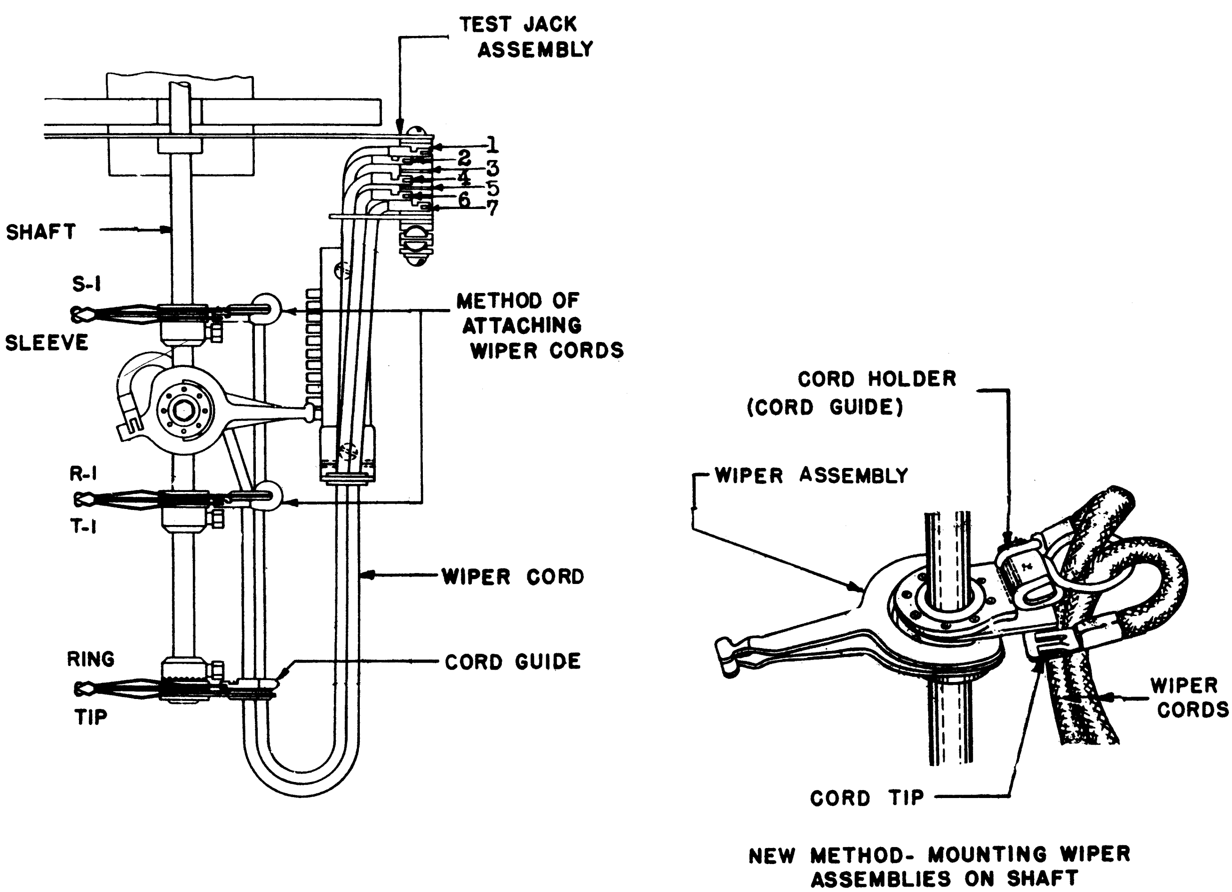


Figure 13 - Wiper Assemblies and Method of Locating them on the Shaft

A commutator, mounted at the right of the banks, consists essentially of eleven vertically mounted contact terminals insulated from each other. It, together with a commutator wiper which is mounted on the shaft, provides a means for stopping the vertical stepping of the line finder shaft when the level of the calling subscriber has been reached. The shaft then rotates horizontally to find the "T," "R," and "S" contact terminals of the line. The first contact terminal of the commutator serves as a rest for the commutator wiper when the shaft is normal and the remaining ten represent the respective levels 1 to 0 of the switch banks (Figs. 12 and 13).

Four wiper assemblies, so mounted on a shaft that they are suspended before the three banks, are used to make contact with the commutator and bank contact terminals (Fig. 13). The commutator wiper, which is made up of a single phosphor bronze spring, wipes over the commutator contact terminals as the shaft carrying it moves upward. The three bank wipers, each made up of two tinned brass springs which are insulated from each other, serve no purpose during the vertical movement of the shaft, but wipe over the bank contact terminals as the shaft carrying them moves in a rotary direction. No. 1 contact metal is welded to the contact surfaces of the bank wipers to provide better transmission and longer equipment life. Flexible cords are soldered to the lug end of each spring on the wiper assembly. These cords are also attached to a test jack assembly thereby providing connections from the wipers to the switch circuits. The lower wiper is associated with the lower line bank, the middle wiper with the upper line bank and the upper wiper with the sleeve bank (Fig. 11).

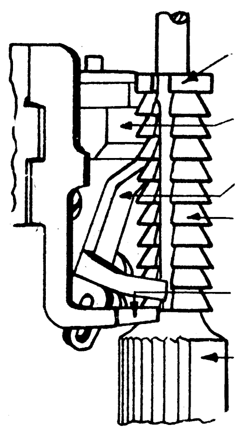


Figure 14 - Vertical and Rotary Ratchets

A steel rod about 10-1/2 inches long and 3/16 inches in diameter is used as the shaft for controlling wiper movement. It is supported in proper position by means of two shaft bearings attached to the switch frame. Ten slots or teeth are machined in a bronze sleeve forming vertical ratchets; while 18 teeth are machined in a second sleeve forming rotary ratchets. Both sleeves are then forced and pinned onto the shaft to provide for its vertical and rotary movement. (Figs. 14 and 15.)

Associated with the ratchets are two "dogs," designated as "double" and "stationary" (Fig. 15). These consist of blanked out pieces of metal bent to proper shape to engate the ratchet teeth. The double dog in turn has two projections called the vertical and rotary dogs which engage the ratchet teeth. The vertical dog keeps the shaft from dropping to normal during the vertical stepping while the rotary dog keeps it from returning to the rotary normal position during the rotary stepping of the switch. A tensioned double dog spring is used to force the double dog into the ratchet teeth.

The stationary dog has two projections. One of these rides in a vertical slot in the vertical ratchet during the vertical movement of the shaft, and in one of the teeth on the vertical ratchet when the shaft is rotating. It performs no function during the vertical shaft movement, but on the rotary movement it carries the weight of the shaft. The other projection or vertical pawl guide acts as a guide and rest for the vertical armature pawl (Figs. 14 and 15).

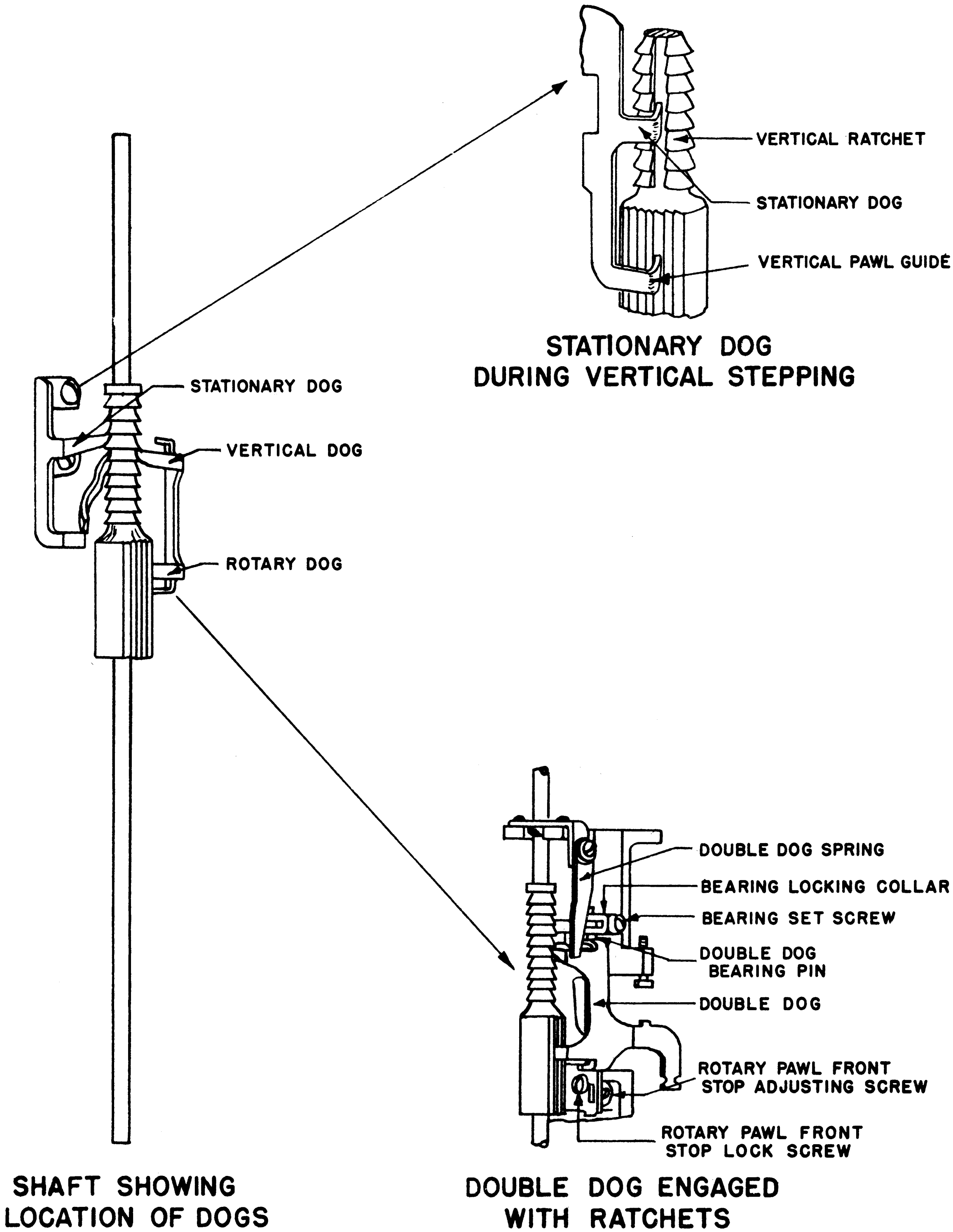


Figure 15 - Dogs

The shaft bearings and dogs are mounted on a cast or molded switch frame. This frame is of such a shape that numerous switch parts may be mounted on it in various positions for proper operation.

The operation of the switch requires three magnets known as vertical, rotary, and release. The vertical and rotary magnets are made up of two coils, while the release magnet has only one. These magnets when operated cause the shaft and associated wipers to be elevated, rotated or released.

The vertical magnet armature has a pawl attached to its outer end (Fig.16). When normal, the pawl arm rests against a vertical pawl guide which holds the pawl away from the vertical ratchet teeth against the tension of a coil spring. When the vertical magnet is energized, the armature is pulled upward, allowing the coil spring to pull the pawl into the vertical ratchet teeth with an upward thrust thus raising the shaft.

The vertical dog, of the double dog, holds the shaft up when the vertical armature falls back.

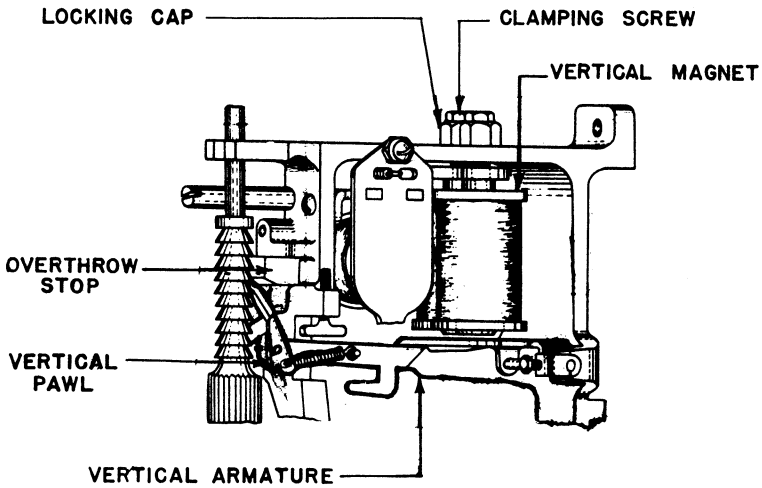


Figure 16 - Vertical Magnet and Associated Parts

The rotary magnet armature also has a pawl attached to its outer end (Fig. 17). When normal, the pawl rests against a rotary pawl guide which holds it away from the rotary ratchet teeth against the tension of a coil spring. When the rotary magnet is energized, the armature moves to the right. This allows the coil spring to pull the rotary pawl into the rotary ratchet and move the shaft around. The rotary dog, which is part of the double dog, keeps the shaft from rotating back to normal when the rotary armature falls back. Both the vertical and rotary armatures are returned to normal by means of reed (flat) springs.

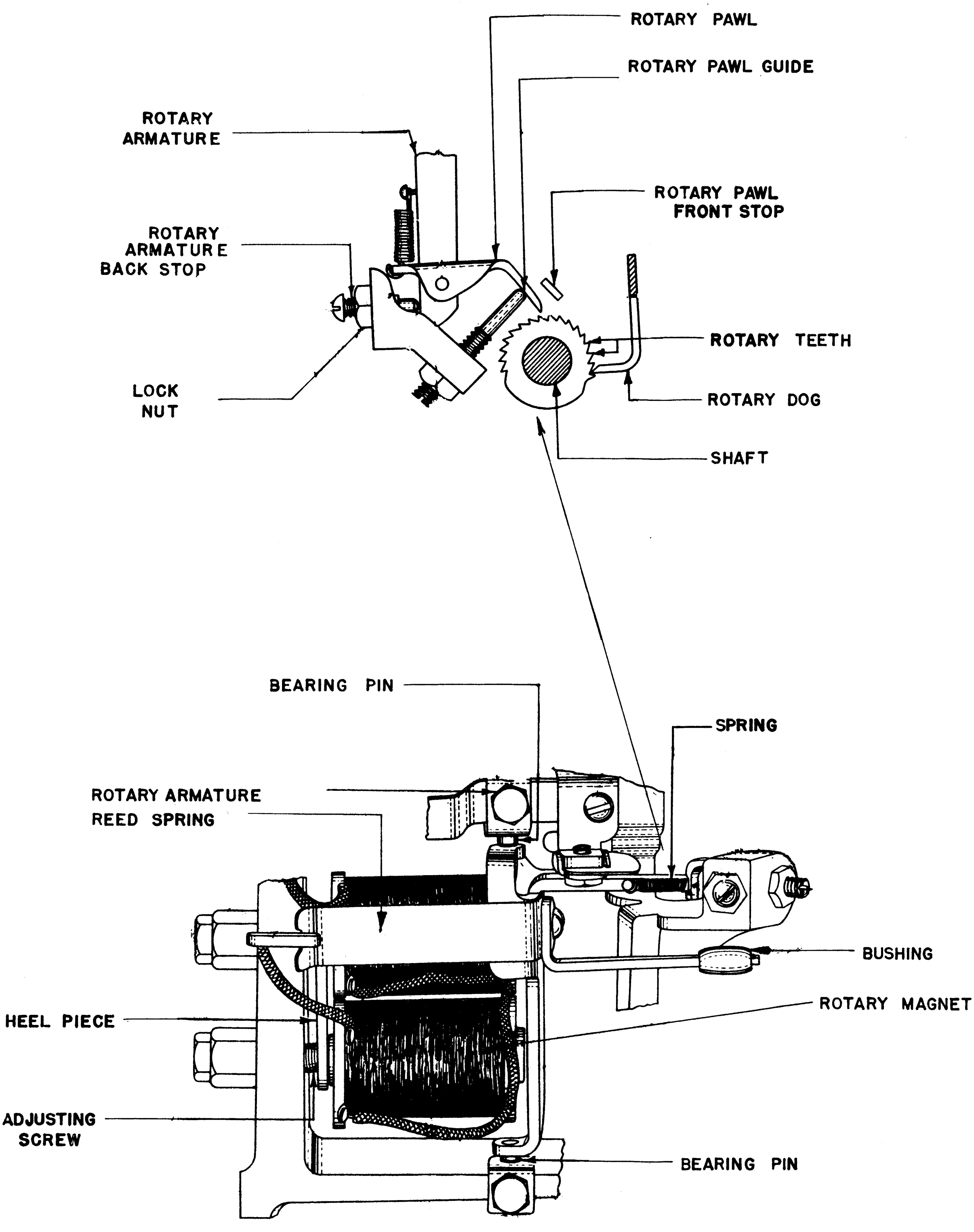


Figure 17 - Rotary Magnet and Associated Parts

The release magnet armature (Fig. 18) has a release armature pin attached to its lower end. When normal, the armature is held at its upper end by a release armature coil spring. When the magnet is energized, the release armature pin pushes the double dog thereby disengaging it from the vertical and rotary ratchets. This will allow the shaft to restore to its normal position.

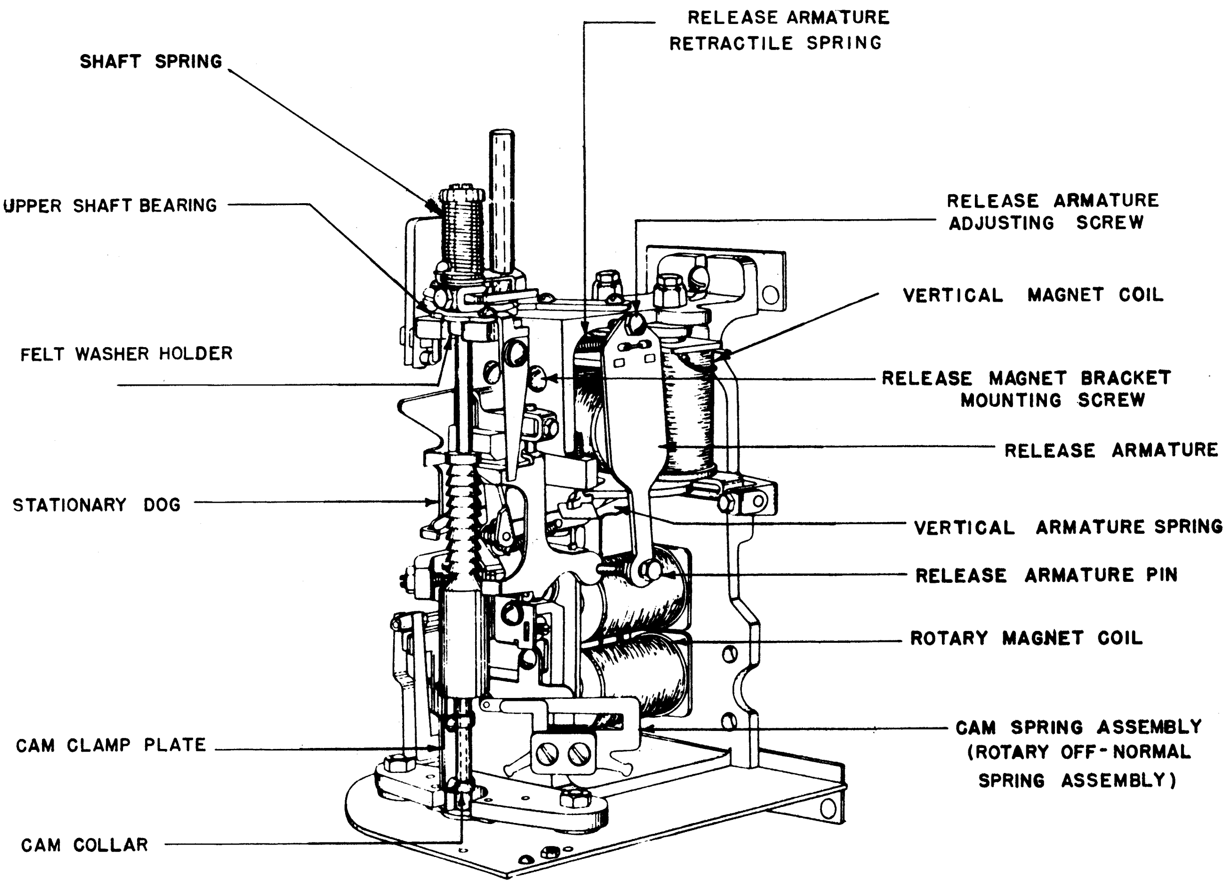
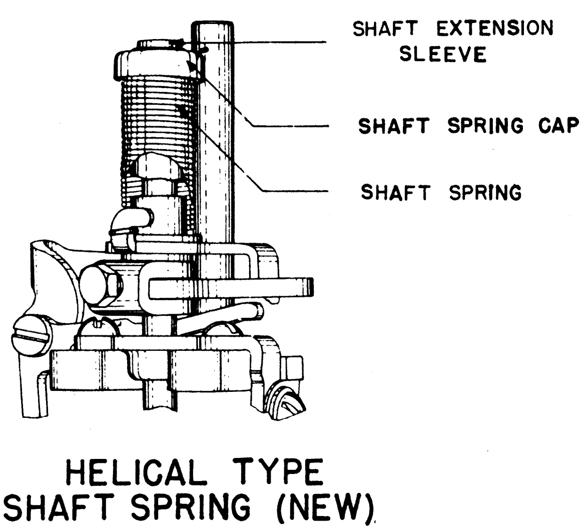


Figure 18 - Release Magnet and Associated Parts

The shaft spring is of the helical type (Fig. 19) and is attached to the top of the shaft by a clamp. The spring winds up as the shaft moves in a rotary direction moving the wipers over the bank contact terminals. This spring returns the shaft to its rotary normal position as soon as the shaft is released by the double dog. The shaft is prevented from swinging past its rotary normal position when a normal pin attached to shaft by means of a clamp hits the normal post attached to the switch frame.



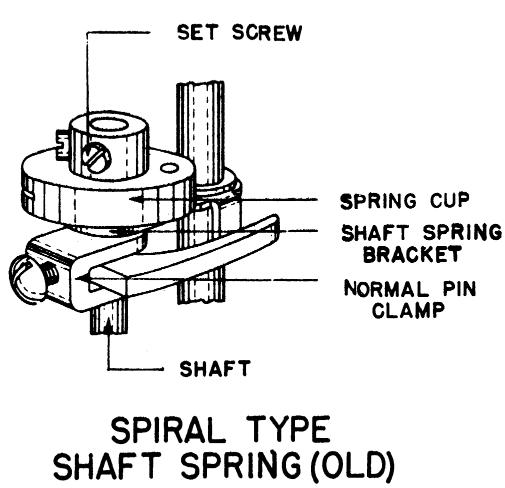


Figure 19 - Shaft Springs

Four spring assemblies are provided on the line finder switch. They are actuated by vertical or rotary action of the switch mechanism and serve as control elements in the switch or associated circuits. Two of these, the vertical and rotary interrupter springs, operate respectively when the vertical or rotary magnets are energized. Vertical off-normal springs operate when the shaft moves vertically from its normal position. The eleventh rotary step springs are operated by a cam, located on the shaft just below the ratchets. Cam and springs are so arranged that when the wipers step from the tenth set of contact terminals in a bank level, the springs will be operated.

The switch mechanism and other components of the line finder are mounted on a rectangular mounting plate (Fig. 11). A lower cover plate attached to the bottom of the mounting plate and switch frame serves as a dust cover and support for the switch test jack and card holder.

Six relays for controlling the operation of the switch mechanism and for supervision are mounted on the upper part of the mounting plate.

A small metal cover is attached to the rear of the mounting plate, and act as a protection for the wiring and as a support for a condenser.

A wood fanning strip containing ten slots is used to facilitate wiring and is attached to the rear of the mounting plate (Fig. 20).

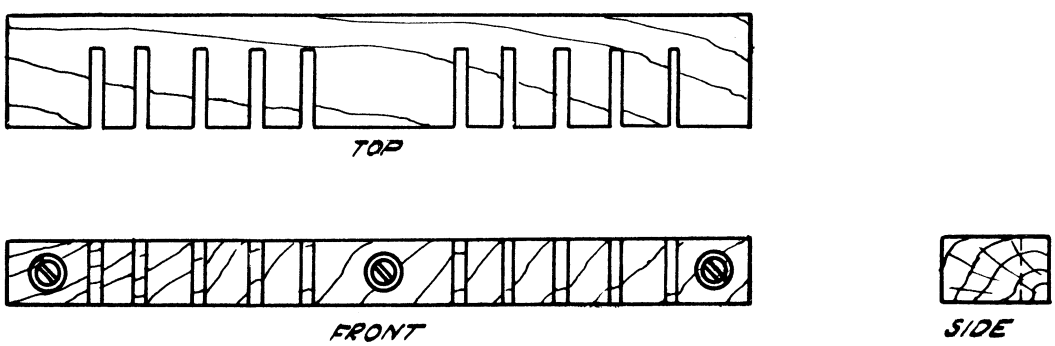


Figure 20 - Fanning Strip

Directly below the fanning strip, there is a plug consisting of a wood block containing a number of springs insulated from each other (Fig. 21). Local switch wiring is connected to the terminal end of the plug springs. When the switch is mounted on a shelf framework, the plug springs make contact with the springs of a jack, which is part of the shelf equipment, and to which the shelf wiring is connected. This plug and jack arrangement pro-

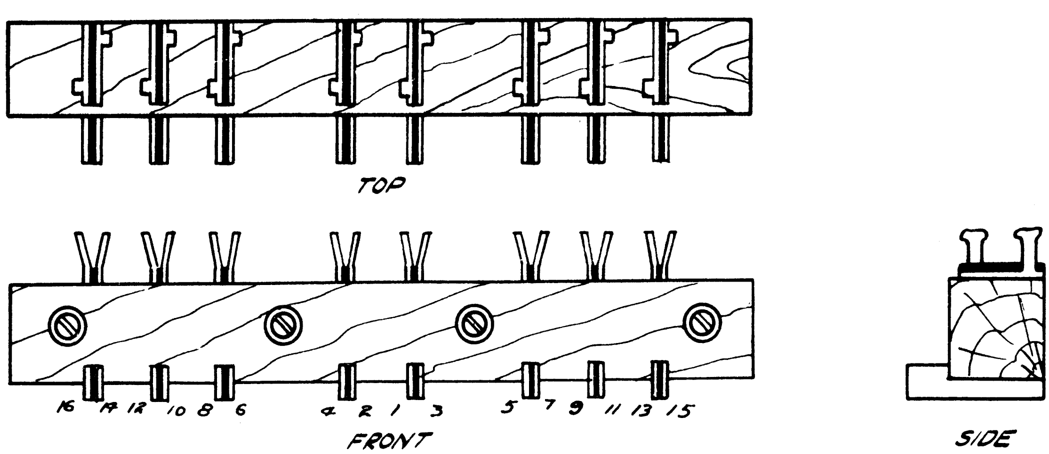


Figure 21 - Plug

vides a means of removing an individual switch from a shelf without disconnecting the associated wiring, either local or shelf. Plug springs are numbered from the center, odd numbers to the right, and even numbers to the left.

A test jack consisting of two springs and several soldering terminals is mounted on the underside and at the right of the lower cover plate. It provides a means of monitoring on the switch.

The following is a brief description of line finder switch operation. As previously described, each subscriber line is represented by three contact terminals tip "T," ring "R," and sleeve "S" on the line finder switch banks. When the subscriber removes or lifts his handset to originate a call, he starts the line finder shaft carrying the wipers stepping upward hunting the level in the banks in which his set of contact terminals is located. As the shaft moves upward, the commutator wiper wipes over the contact terminals of the commutator. For each level of subscriber contact terminals there is one commutator contact terminal, and should any of the subscribers remove their handset a ground potential is placed on this contact terminal. When the commutator wiper touches the grounded terminal, a relay operates preventing further vertical stepping and starts the rotary stepping. The shaft now automatically moves in a rotary direction carrying the wipers from left to right over the subscribers contact terminals in that level. The calling subscriber line is marked by a battery potential on the sleeve contact terminal. When the sleeve wiper makes contact with the battery potential on the sleeve contact terminal, another relay operates and stops the rotary stepping. Relays now operate to extend the calling line to the next switch which is usually a selector.

200 Point line finder units (Fig. 22) are furnished in capacities of 16, 20, or 30 line finder switches, each unit serving a maximum of 200 subscriber lines. The number of calls originated at the same time by a particular group of 200 subscriber lines will determine what capacity line finder unit shall be specified for the particular 200 line group. Line finder units consist of a rectangular steel framework, approximately 3-1/2 feet high and from 7 to 12 feet long, depending upon the switch capacity of the unit. The unit framework of any capacity unit is divided into two bays by using a middle upright. The right bay (front view) provides mounting space for relays, resistances, and terminal strips. Line finder switches, a fuse and jack panel, and a terminal strip are mounted in the left bay. Line finder switches are mounted on two steel shelf frameworks, the number of switches on each shelf being one half the capacity of the unit. The shelf framework contains a jack in each switch position, to which all local shelf wiring is connected. When a switch is placed in its shelf position, the plug springs mounted on the rear of the switch engage with the shelf jack springs, providing a connection from the local shelf wiring to the local switch wiring. All line finder switches in any unit are common to and may be used by any of the 200 subscriber lines connected to the unit.

The line finder frame (Fig. 23) consists of vertical channel uprights fastened to a floor angle and held in place by auxiliary framing and cable racks placed across the top. The standard frame is 11-1/2 feet high, and provides mounting space for three line finder units, located one above the other. The width of the frame depends on the switch capacity of the type unit involved.

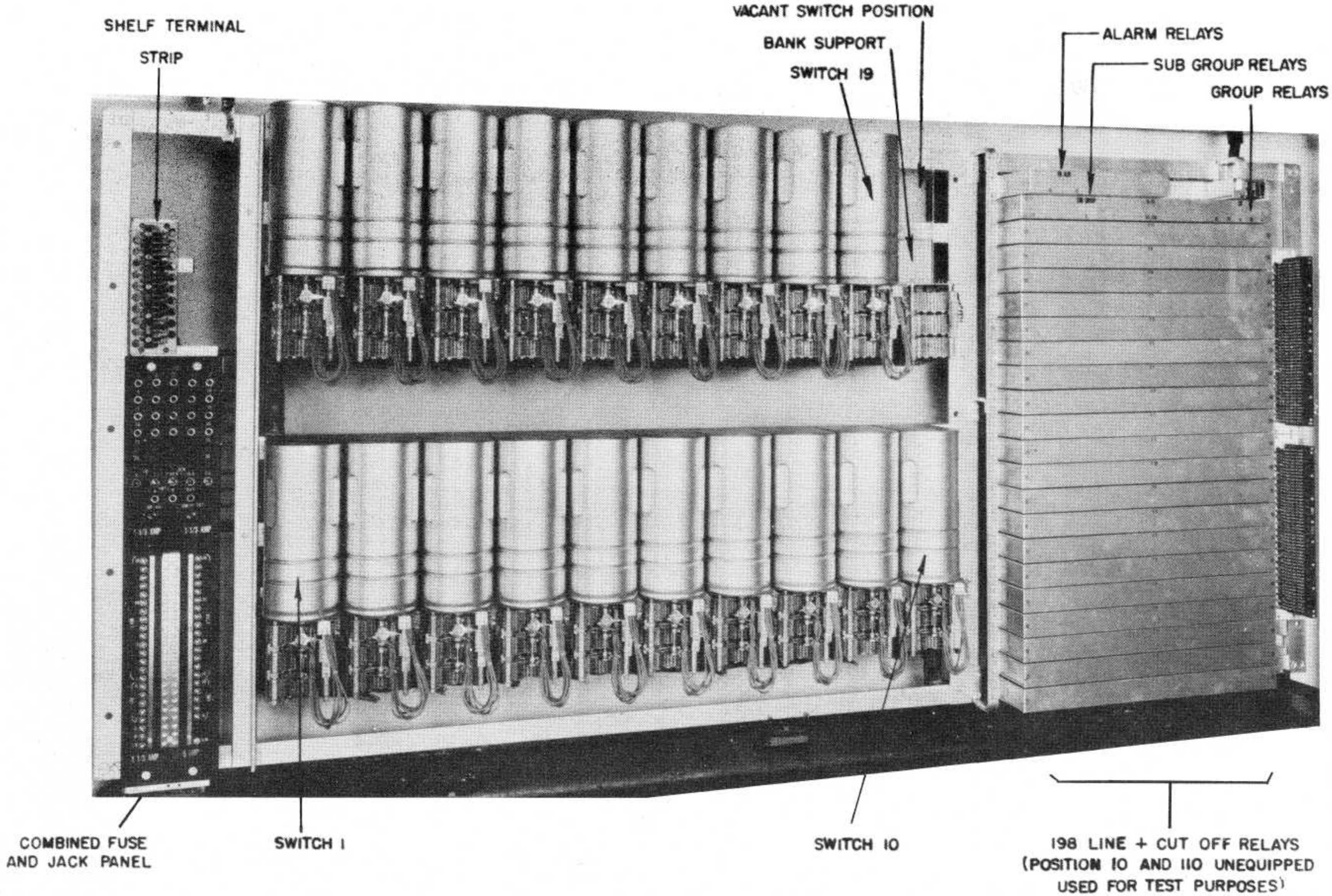


Figure 22 - 200 Point Line Finder Unit - 20 Switch Capacity

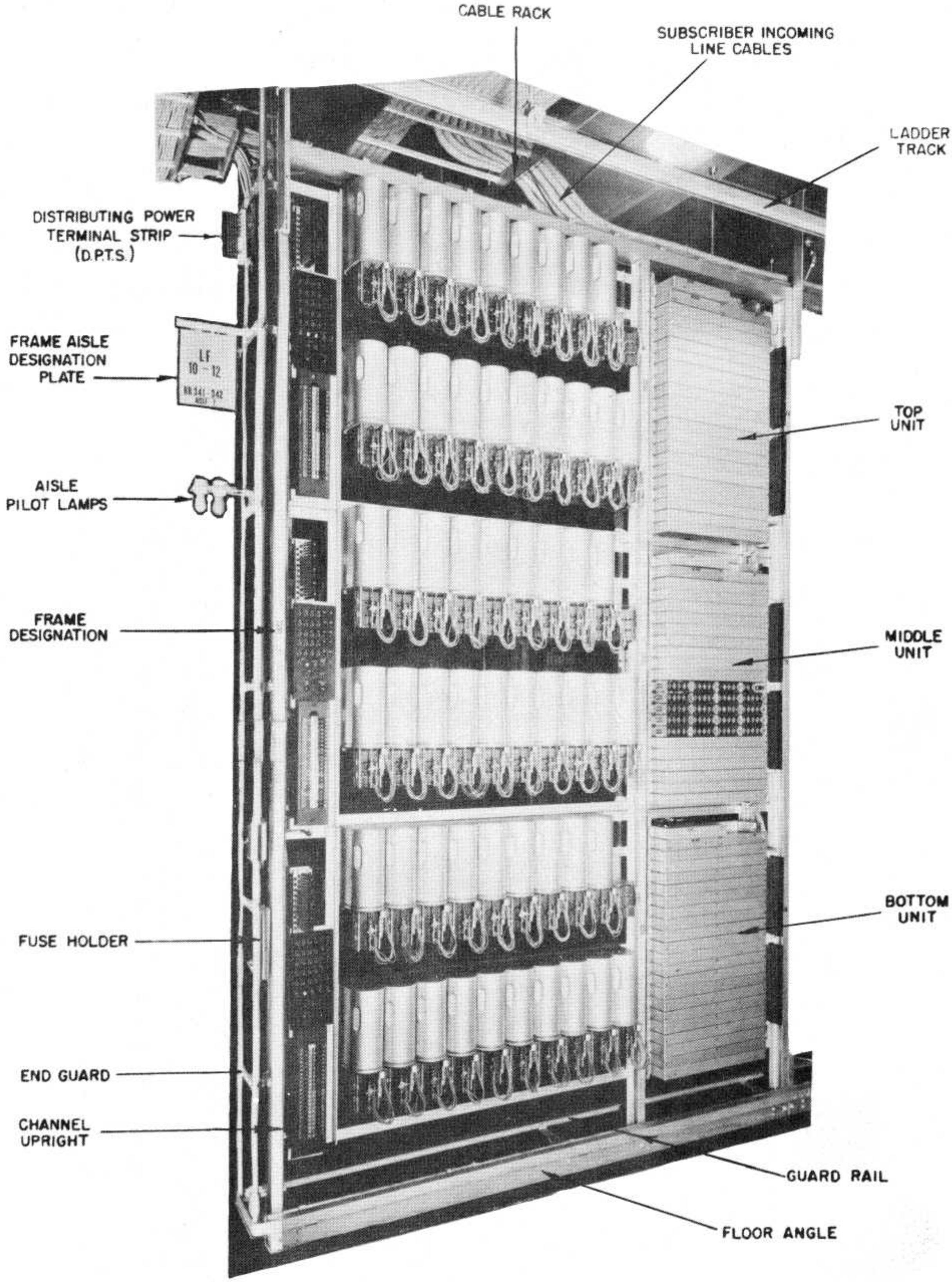


Figure 23 - Line Finder Frame

2. Selector Switch, Shelf and Frame

The next type of switch used in a call after the line finder has found the calling line, is usually a selector (Fig. 24). As its name implies, a selector switch "selects" or picks one of a number of available paths each terminating in a succeeding switch which may be used to further the progress of the call.

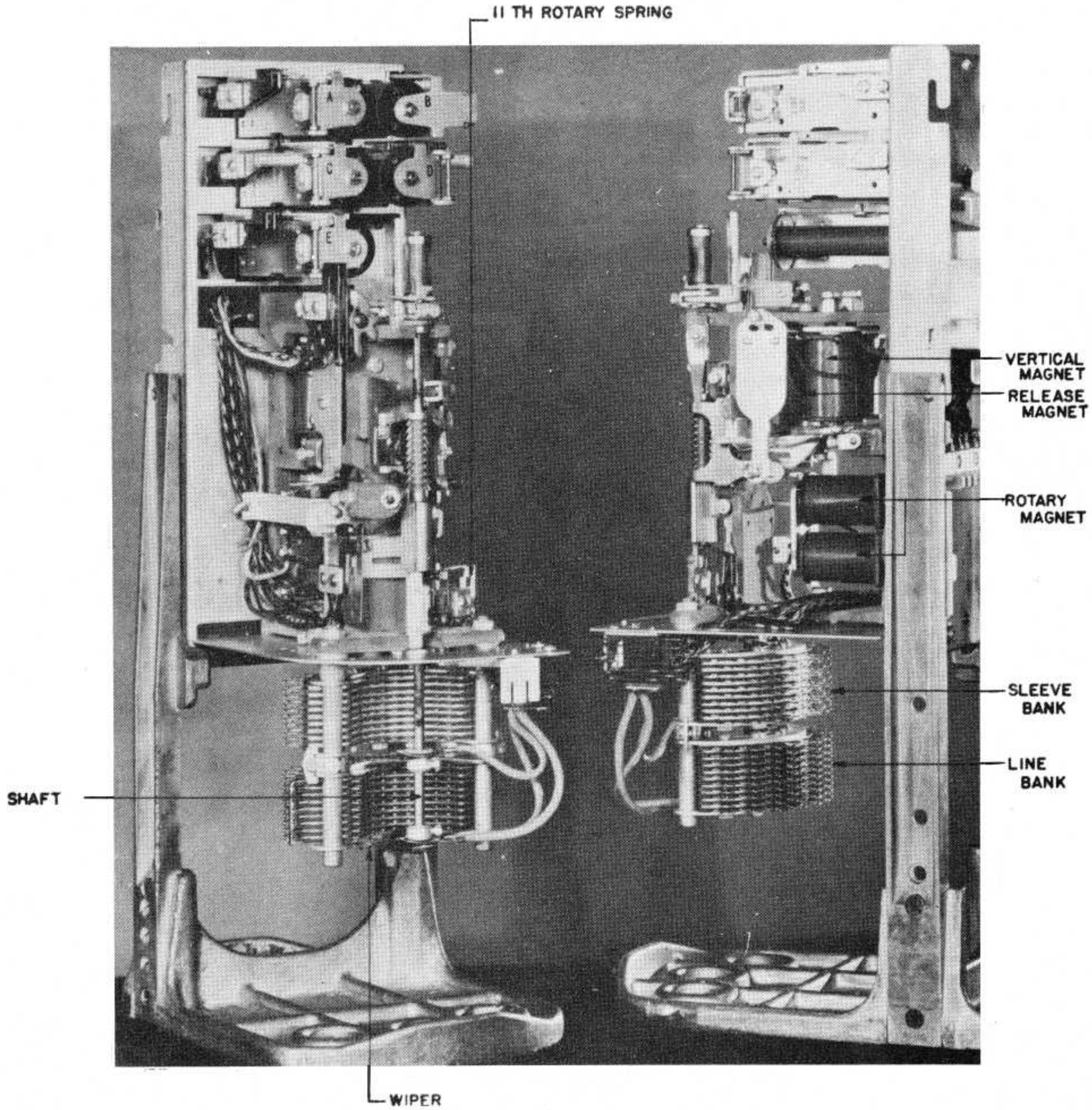


Figure 24 - Selector Switch and Banks

In general, its appearance and parts are similar to the line finder switch but its operation differs in that the upward stepping of the shaft and associated wipers is under control of the dial at the subscriber station. The rotary stepping is automatic, however, and a function of the switch itself.

Two sets of banks are associated with the selector switch. The lower or "line bank" is of the 200 point type, providing connection to the tip and ring leads for 100 trunks to succeeding switches, while the upper 100 point bank "sleeve bank" provides connection to 100 sleeve leads for these trunks.

Since these contact terminals are arranged in ten levels, it is possible to connect to trunks in any given level by dialing the number of that level, thereby elevating the shaft and wipers to that level. When the dialed level is reached, the shaft starts rotating moving the attached wipers over the contact terminals in that level. The rotary stepping of the switch follows the testing of the ten sets of contact terminals, each of which is connected to a succeeding switch, until a set connected to an idle succeeding switch is found. During this testing, the wipers rest momentarily on each set of contact terminals to determine whether the associated succeeding switch is busy (ground potential on the sleeve contact terminal) or idle (no potential on the sleeve contact terminal). If it is idle, the rotary stepping ceases; if it is busy, the stepping continues until an idle set of contact terminals is found. In the event all ten sets of contact terminals on the level test are busy the shaft steps to the eleventh rotary position.

A cam on the shaft then engages and operates a set of eleventh rotary step springs closing an all trunk busy tone circuit to the calling subscriber.

There are several types of selector switches used in the Step-by-Step Dial System all constructed along the same lines and functioning in much the same way. Some of these switches are named to indicate their function such as; local service, toll service, digit absorbing, etc. Other are designated to indicate their position in the path of a call such as first selectors, second selectors, third selectors, etc. First selector switches are usually connected directly to line finder switches, the function of the line finder switch being to connect the first selector switch to the calling subscriber line. The first selector switch will select one of a number of second selector switches and the second selector switch one of a number of thirds, etc.

Selector shelf assemblies may hold either ten or twenty selector switches. The <u>ten switch selector shelf</u> is, for the most part, used in private branch exchanges and community dial offices while the <u>twenty selector switch shelf</u> has been developed for the central offices. The main exception to this is ten switch toll selector shelves used in central offices. The 20 selector switch shelf will be described. Shelf assemblies are made to mount 20 selector switches, associated banks and the miscellaneous shelf equipment for alarms and fusing. The banks associated with each half shelf of ten selector switches are multipled together and connected to a 180 type terminal strip (Fig. 25). Shelves are arranged for mounting on either the right or left bay of a selector frame (Figs. 26 and 27).

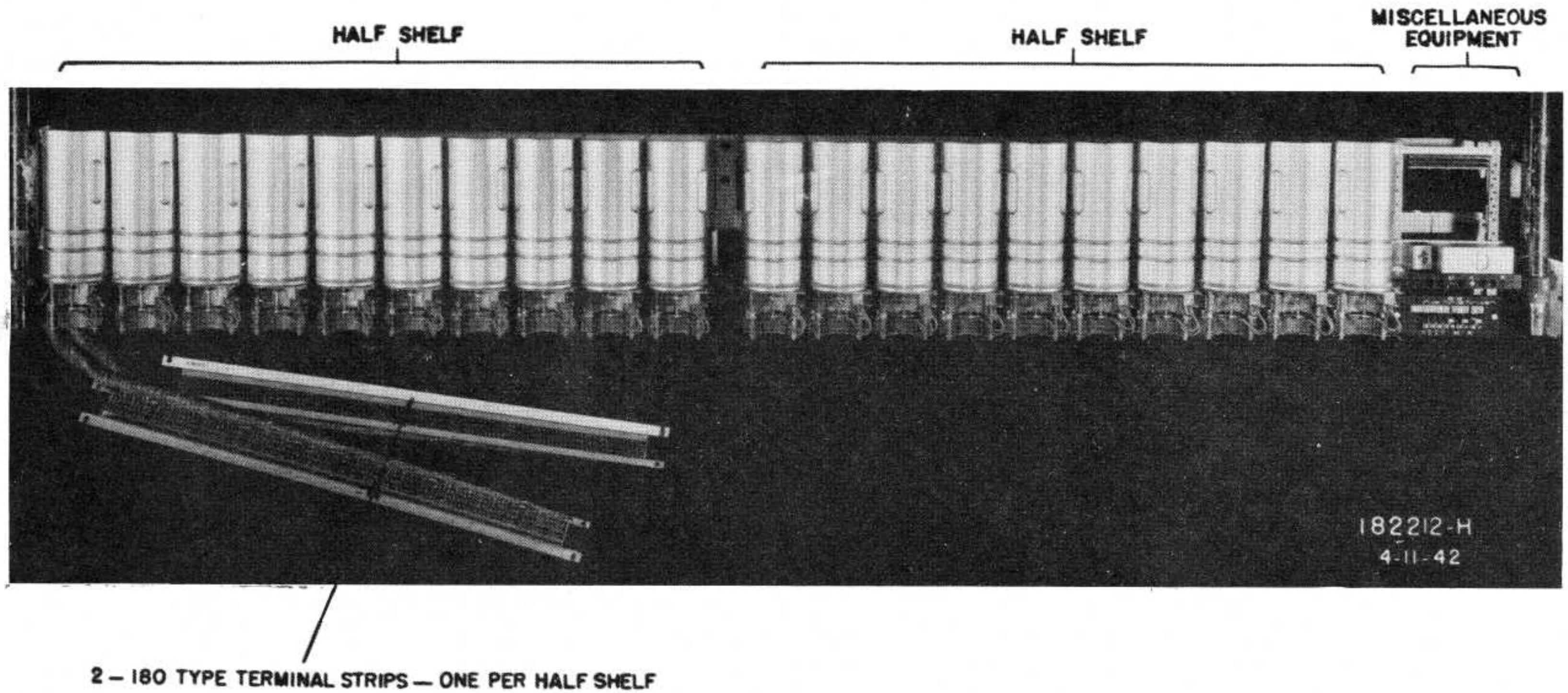


Figure 25 - Selector Shelf

A typical 11' 6" high selector frame as shown in Figures 26 and 27 is made up of three bays - a left selector bay and a right selector bay with a distributing terminal assembly bay in the center of the two. These frame bays are made up of eight channel uprights on which the selector shelves and terminal strips are mounted.

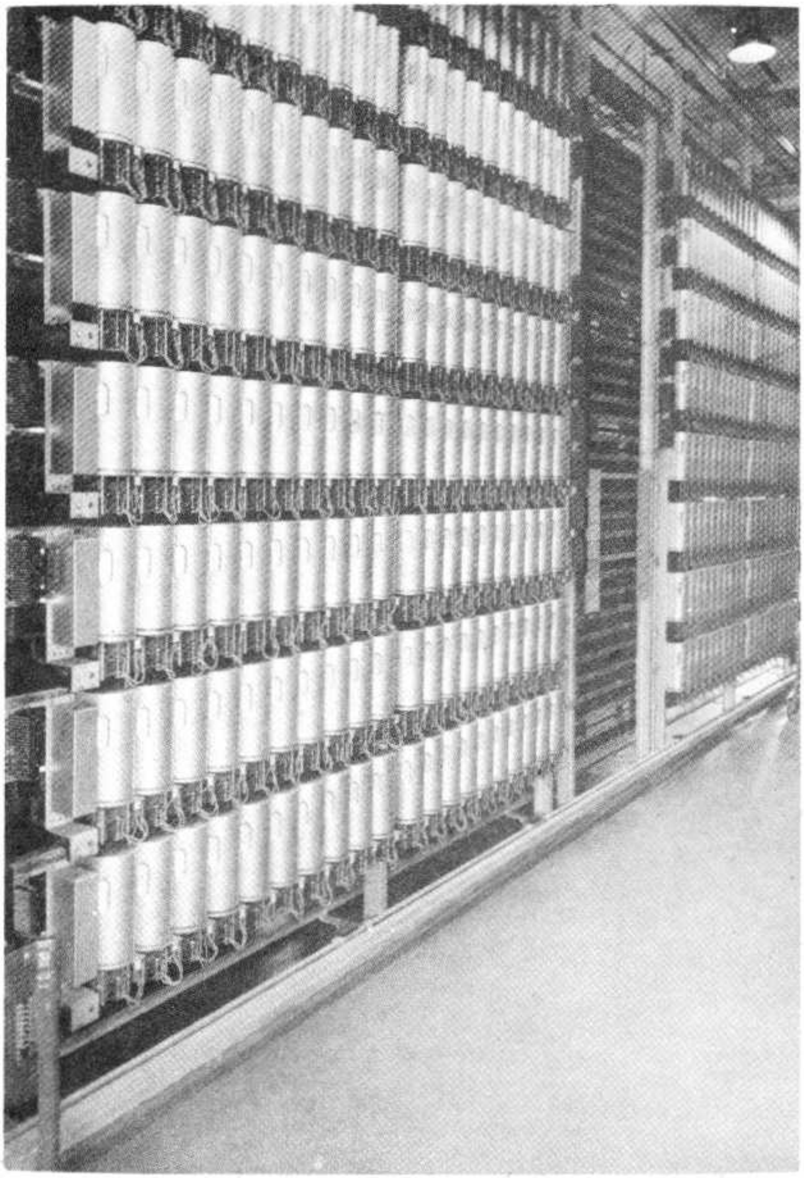


Figure 26 - Selector Frame

The left bay contains eight shelves of selector switches or sixteen half shelves. Each of these half shelves have their banks multipled together and wired to 180 type terminal strips at the right side of the shelf. The right selector bay also contains eight shelves of selector switches or sixteen half shelves. Each of these half shelves have their bank multipled together and wired to a 180 type terminal strip at the left side of the shelf. In this manner, the thirty-two 180 type terminal strips associated with the thirty-two selector switch half shelves are mounted on the frame, one above the other, in the center bay. This arrangement allows for connecting the bank levels of the banks on the various selector half shelves together as necessary.

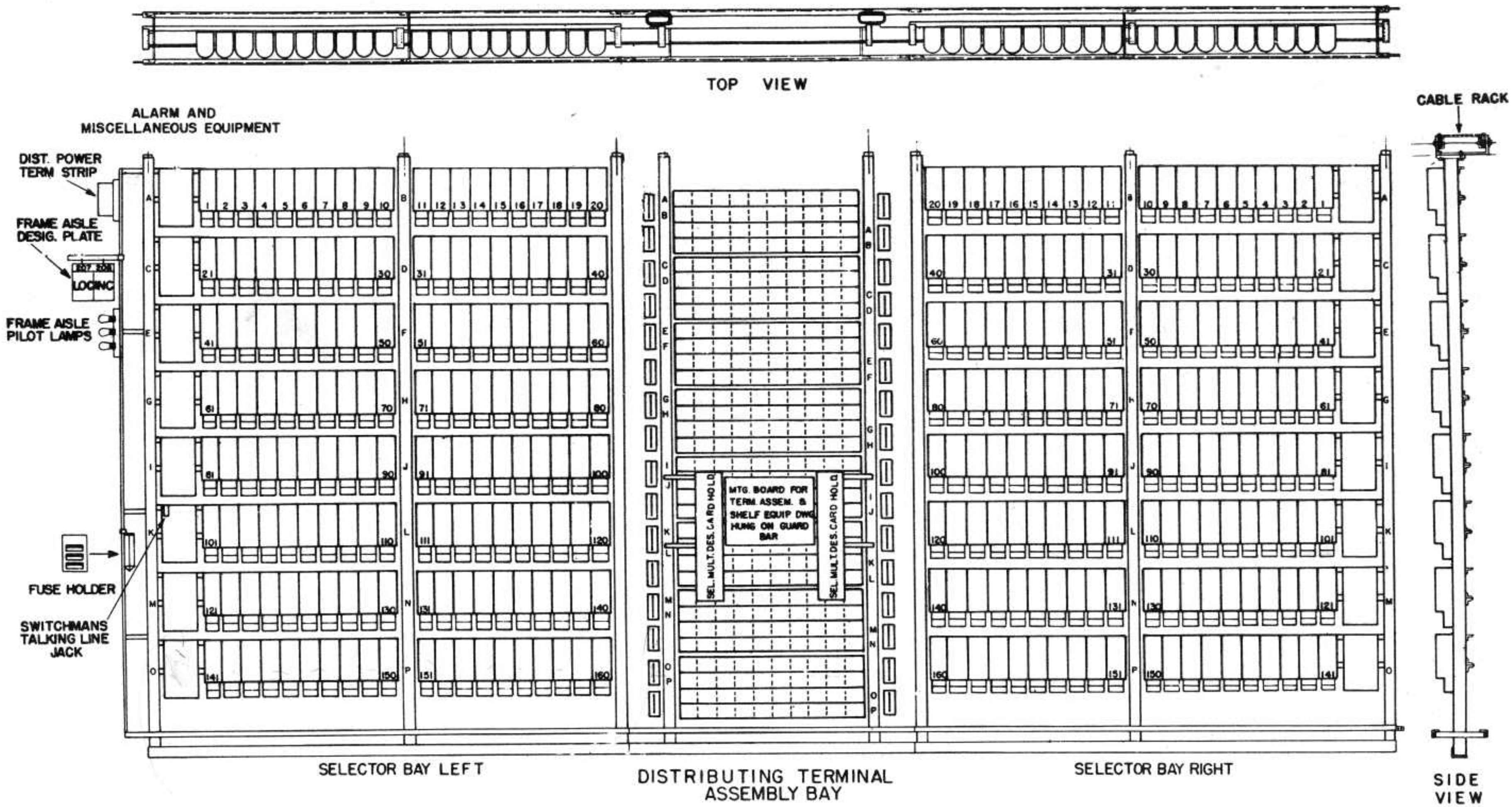


Figure 27 - Selector Frame Sketch

3. Connector Switch, Shelf and Frame

The connector switch is the last switch used in a call between two subscribers (Fig. 28). The vertical and rotary stepping of the switch shaft are both controlled by the dial pulses, thereby causing the associated wipers to be elevated and rotated to the desired called line terminals. This called line, together with 99 other subscriber lines, are each connected to a set of tip, ring and sleeve contact terminals on the two banks associated with each connector switch. These two banks, a line bank (200 point) and a sleeve bank (100 point) have the 100 sets of subscriber contact terminals arranged in 10 levels of 10 sets of contact terminals each.

Connector switches not only connect to the called line but test it to determine if it is busy or idle. Should it be idle, the connector switch places a ground potential on the sleeve contact terminal of the line to prevent it being seized by other connector switches, places a ringing current on the line to ring the called subscriber bell, and after he has answered, supplies talking battery to both subscribers so they may talk. Should the called line be busy, the connector switch will send a busy signal to the calling line. The connector switch requires more relays than the selector switch in order to perform the additional functions listed above and is therefore larger. The parts that make up the connector switch are similar to those of the line finder and selector switches.

Many different types of connector switches have been developed to furnish required service features. These include local, toll, combination local and toll, 1-ring, 2-ring, 8-party, rotary hunting and level hunting connectors.

Connector switches form the main part of connector shelf equipment. The shelf assembly (Fig. 29) is made of two angles about 6 feet long, with two 8 inch vertical bars welded across their ends. Eleven or twelve vertical bars for holding the switches are riveted to the two angles. A shelf may mount either ten or eleven switches. The switch in the first position to the left (front view) on an eleven switch position shelf is known as a test connector and is used by a test man or operator when they wish to connect to any line on the shelf. One terminal strip is provided on the right end of the shelf to terminate the connector bank multiple wiring. The left end of the shelf mounts a fuse panel, which provides protection for the shelf equipment, and also the common alarm equipment for the shelf. Each of the ten or eleven switch positions is equipped with a jack, the springs of which engage with the plug of the connector switch when the switch is mounted in its position.

Connector frames are 11' 6" high. They are made up of seven shelves of connector switches supported on two channel uprights. The channel uprights are attached at the upper end to a cable rack or auxiliary framing bars and are attached at the lower end to a base angle. A typical connector frame with new universal type shelves is shown in Figure 30.

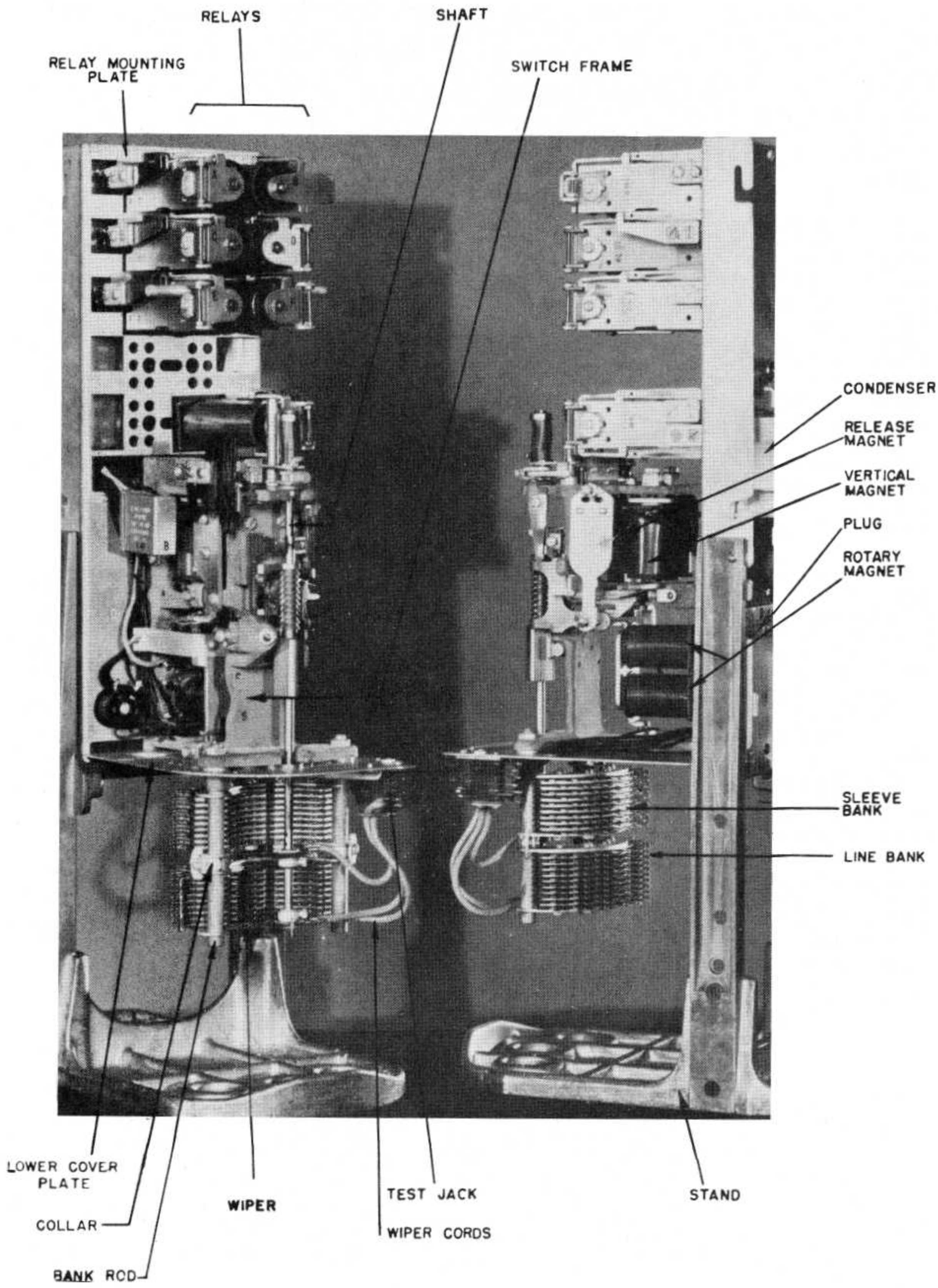


Figure 28 - Connector Switch & Banks

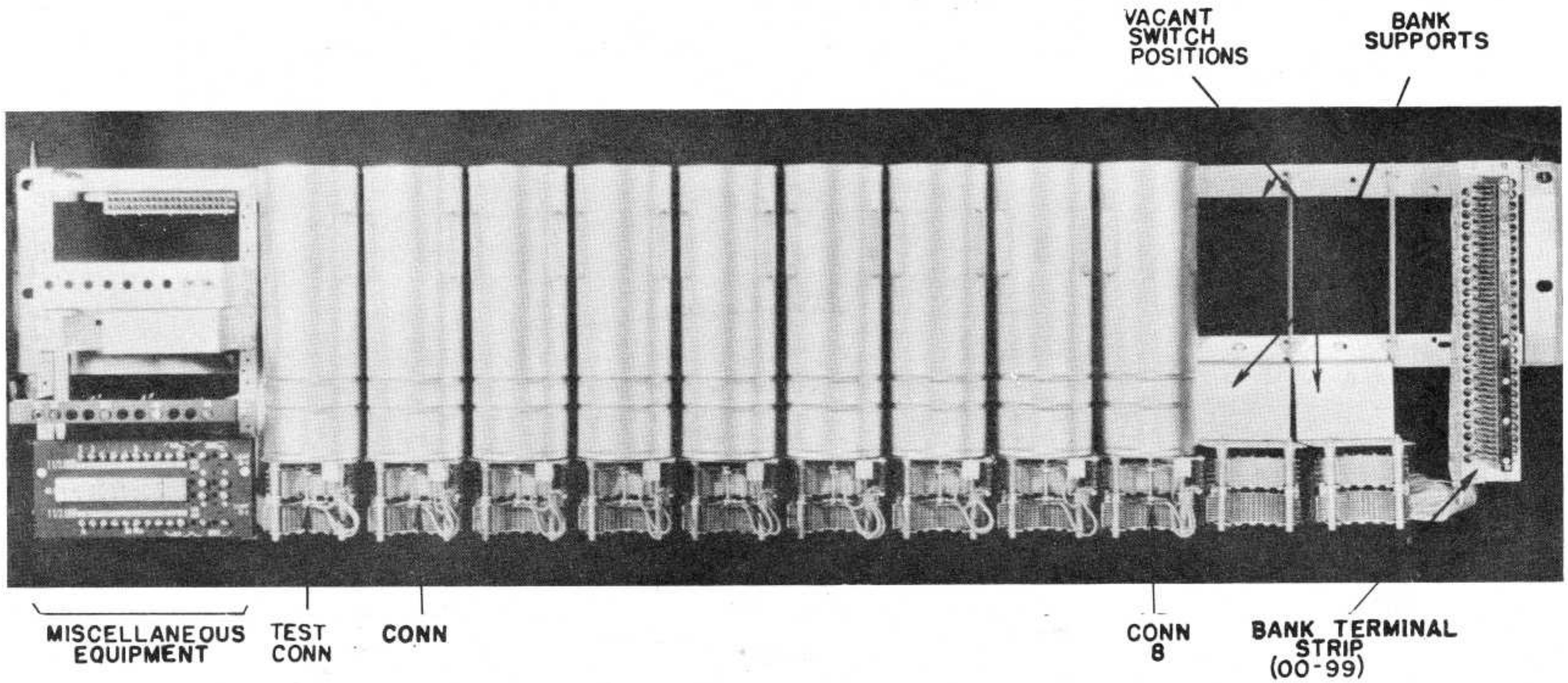


Figure 29 - Connector Shelf - 11 Switch

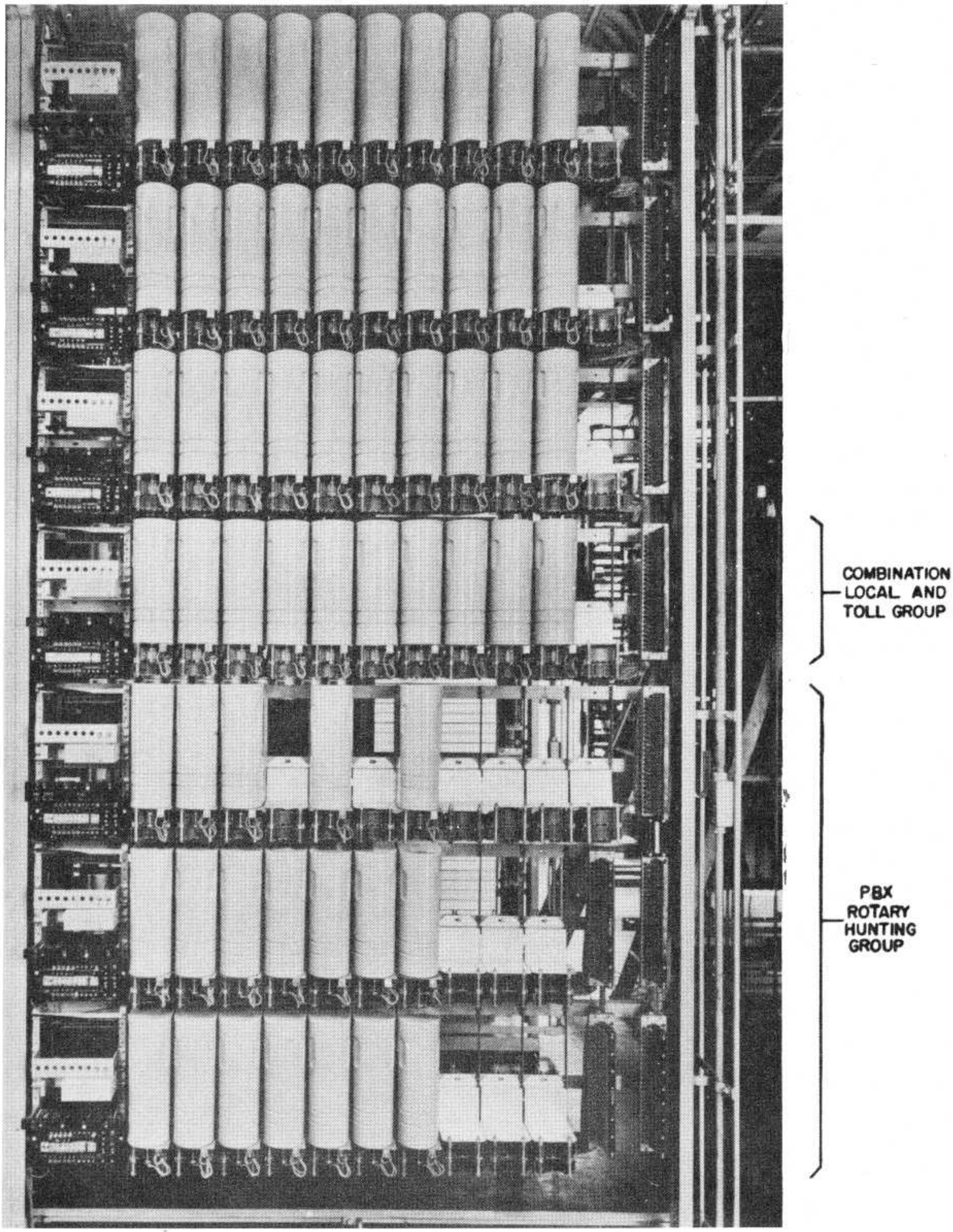


Figure 30 - Connector Frame

SECTION 4. DISTRIBUTING FRAMES AND RELAY RACKS

Auxiliary framing or superstructure consists of rectangular iron bars which are arranged over the tops and connected to the various step-by-step frames in the central office in such a way as to provide a means of holding these frames in a fixed position.

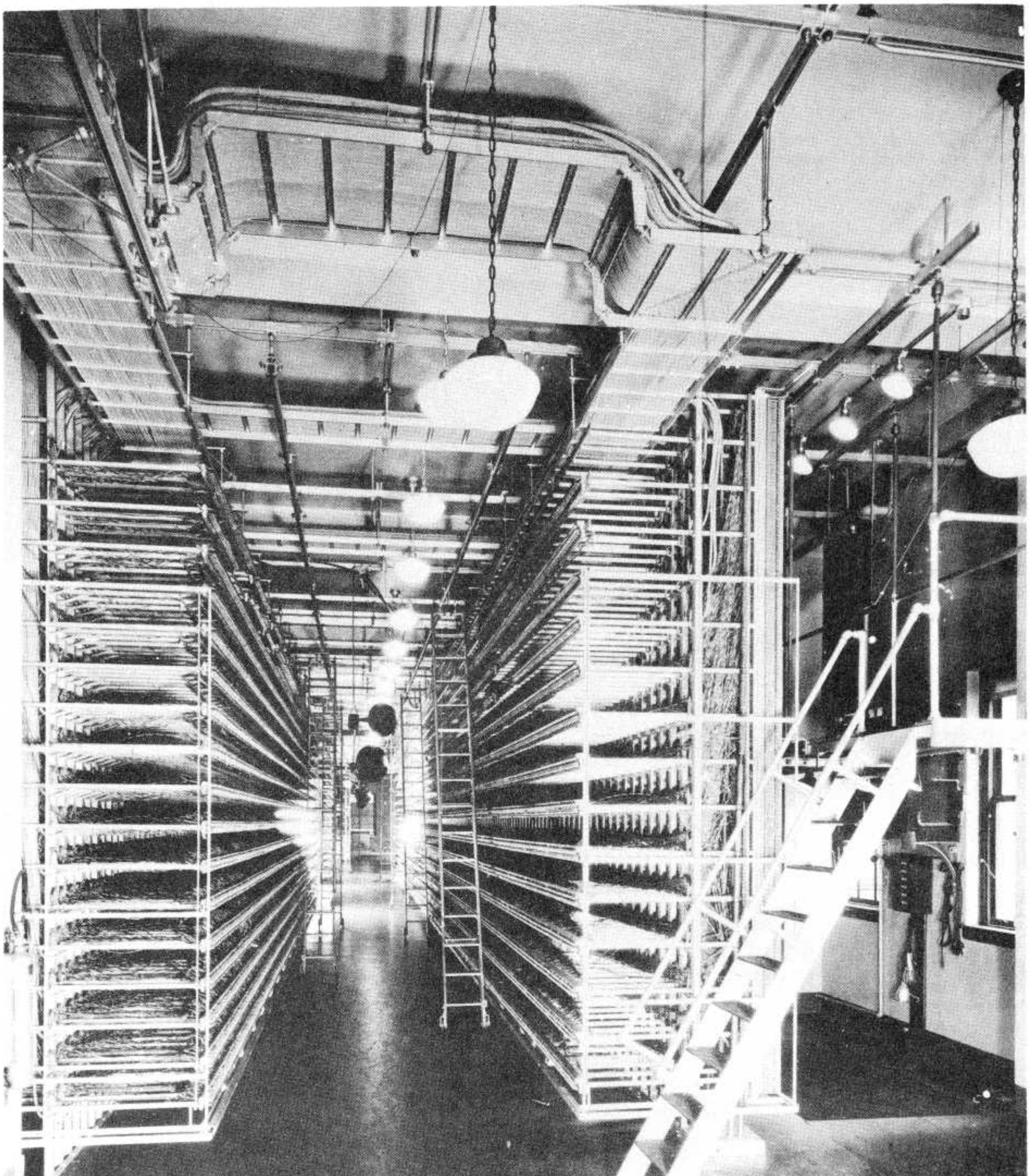


Figure 31 - Main and Intermediate Distributing Frames

The Main Distributing Frame MDF (Fig. 31 at right), is a two-sided steel frame made of vertical angles, channel transverse arms, and base and top angles. The vertical angles are spaced 8 inches apart horizontally and the channel transverse arms are spaced 10 inches apart vertically. The channel transverse arms extend to the rear of the frame forming shelves, either 12 or 15 shelves depending upon the height of the frame. Frames are supported by attaching the base angle to the floor, and the top angle to the auxiliary framing. A distributing ring is provided at every shelf to keep an orderly arrangement of jumper wires (flame-proof wires, running from the horizontal to the vertical side), and to prevent grounding of the jumper wires to the framework if insulation should be defective. The MDF mounts protectors vertically on one side and terminal strips horizontally on the opposite side. All subscriber lines and trunks coming into the office cable vault in lead covered cable are run up through the floor and are terminated on vertical protectors, from which point they are connected to terminal strips on the horizontal side of the frame by means of jumper wires. Lightning arrestors and heat coils mounted in the protectors prevent excessive voltages or currents from getting into the central office equipment over the incoming lines. The MDF also provides a flexible means of cross-connecting the subscriber equipment or trunk equipment in the office to any cable pair entering or leaving the office. This feature is especially convenient if a subscriber changes his place of residence within the area served by the central office and desires to keep his same telephone number. All that is required is to disconnect the two jumper wires from one cable pair and connect them to another cable pair coming in from the new location on the protector side of the MDF.

The Intermediate Distributing Frame IDF (Fig. 31 at left), is much like the MDF in appearance, the main difference being that terminal strips are mounted on both sides, horizontally on one and vertically on the other. The IDF provides a flexible means of cross-connection to route traffic thru the central office equipment.

There are several ways of cabling to the IDF one of which is described here. The terminal strips on the ~~horizontal side~~ vertical of the IDF are cabled to terminal strips on the horizontal side of the MDF and also to connector shelf bank terminal strips. Terminal strips on the vertical side of the IDF are cabled to bank terminal strips on the line finder units. Jumper wires are used to connect from the horizontal to the vertical side.

Many circuits such as trunks between line finders and selectors, line finder and coin box trunks, selectors and repeaters, etc. are also called to the IDF.

The telephone traffic department uses the vertical side of the IDF for a means of connecting to the subscriber lines when making studies of subscriber dialing time, holding time of a call and service. This is called service observing. A clamp called a shoe wired to a long cord having a plug at the other end is used to connect to the line. The shoe is clamped on the terminals of the line to be observed and the plug at the other end of the cord is inserted into a jack in a jackbox, located horizontally at the top of the frame. The lines from the jackbox are extended to a service observing operator.

Relay racks are used to mount relays and other miscellaneous equipment which is not mounted on the regular dial frames (Fig. 32). The rack is single-sided and the equipment so arranged as to be readily accessible for adjustment from the front. I-beam type relay racks consist of I-beam uprights fastened to a base angle and a top angle. The base angle is bolted to the floor and the top angle is attached to the auxiliary framing.

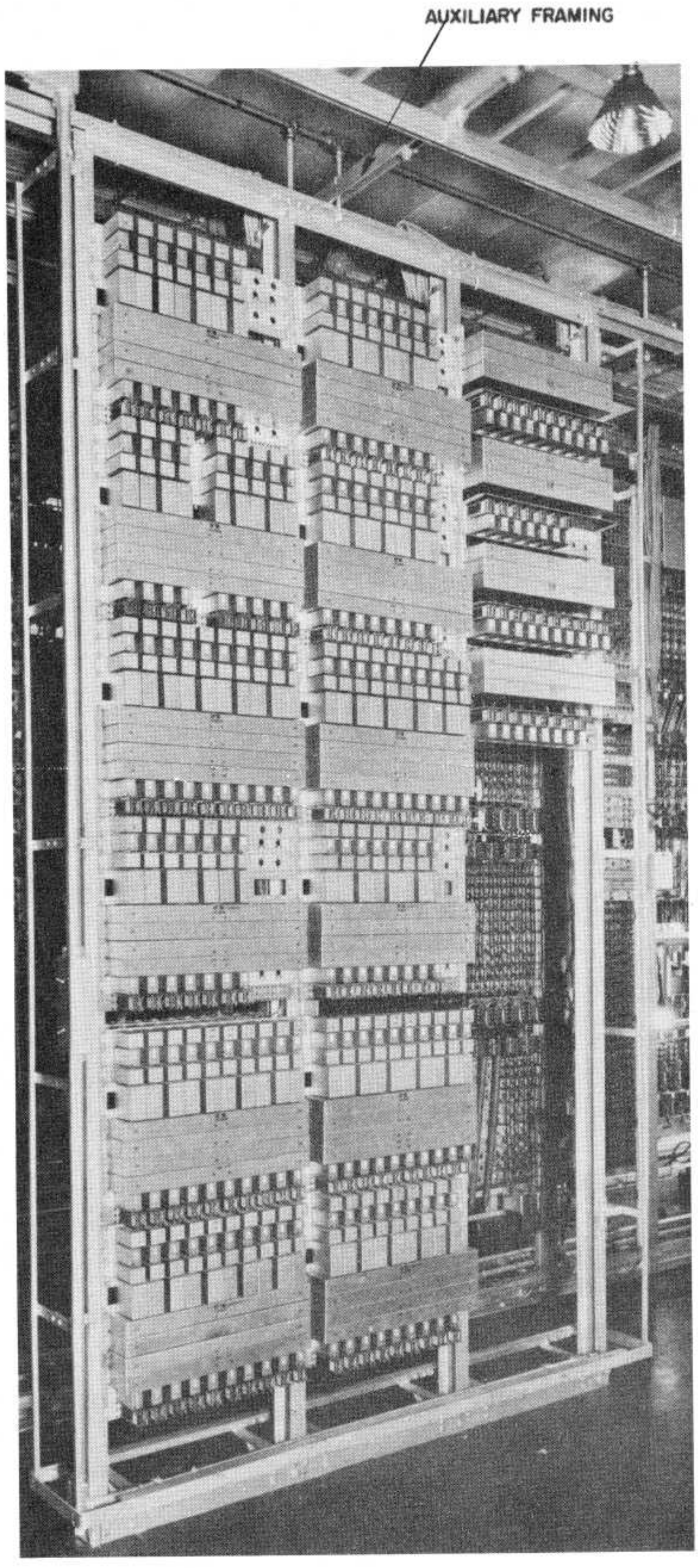


Figure 32 - Relay Racks

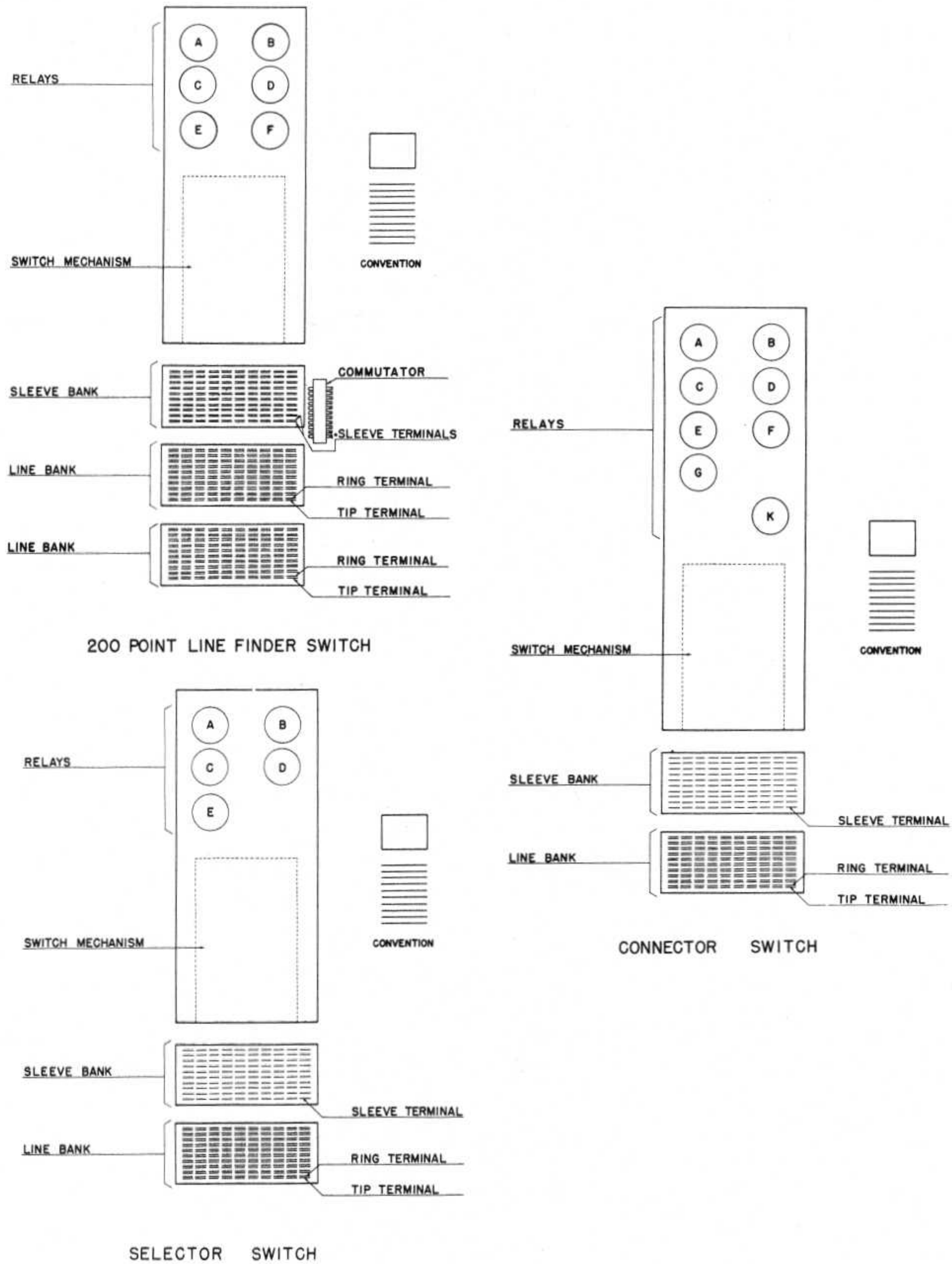


Figure 33 - Sketch of Switches

SECTION 5. METHOD OF OPERATION

1. General

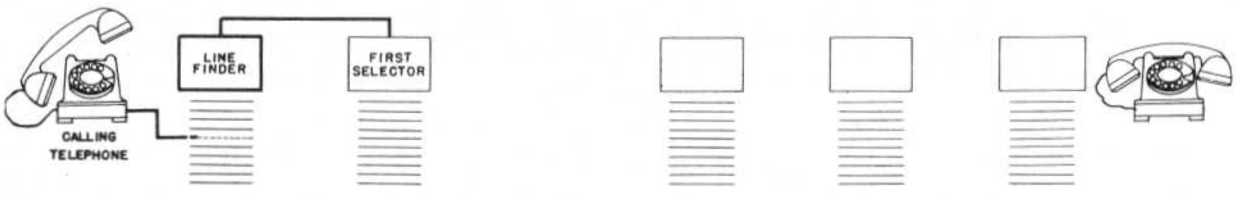
Figure 33 shows sketches of typical line finder, selector and connector switches with their associated banks. Opposite each is a square block with ten horizontal lines under it to indicate the conventional way the switches and banks are indicated on drawings showing the path of a call through the equipment in an office.

The square represents the switch itself, the ten horizontal lines the ten levels on the associated line and sleeve banks. Each horizontal line also represents ten sets of tip, ring and sleeve terminals on the level. This also holds true for the line finder switch but as it has two line banks, the ten horizontal lines may represent either the 100 sets of terminals in the lower or upper line banks.

Sketches one to thirteen depict the various stages of calls made through the step-by-step dial telephone system while the fourteenth sketch shows all of the switches in sequence which are required in completing these calls. In order that the reader may continually have before him the names of all switches used, it is suggested that the page containing sketch fourteen, be left open in following the various steps.

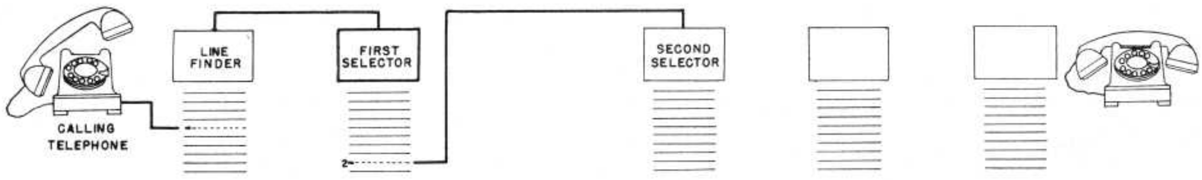
2. Call Between Two Subscribers

When one subscriber wishes to call another in a step-by-step dial system, it is necessary that he remove the handset, wait for a dial tone which tells him the equipment is ready to receive the dial pulses, and then dial the office and number of the subscriber wanted. Each pulse created by the dial as it restores to normal, acts directly on either a selector or connector switch, stepping it vertically in the case of a selector switch or in both a vertical and rotary direction in the case of a connector switch until the called line is located. In the call hereinafter described, it is assumed that the called number is 2-1793.



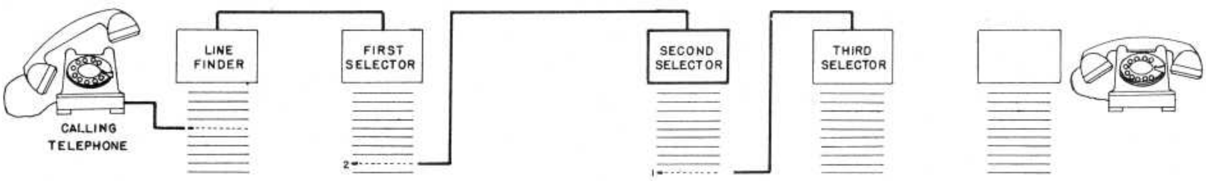
Sketch 1
Calling Subscriber Removes Handset

When the calling subscriber picks up the handset, a line finder switch immediately steps vertically until it reaches the level on which the terminals of the calling subscriber's line appears and then hunts across the level until these terminals are found. The first selector, which is permanently connected to the line finder, then sends back a dial tone to the subscriber as a signal for him to dial.



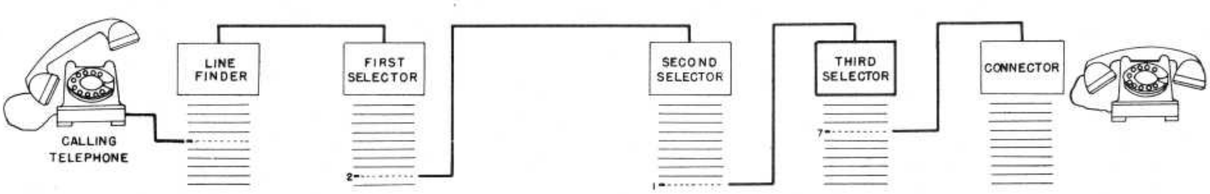
Sketch 2
Calling Subscriber Dials the Office Code - 2

Hearing the dial tone, the calling subscriber proceeds to dial the subscriber wanted 2-1793 (office code 2, numerical code 1793, or in other words central office 2, subscriber number 1793). In returning to normal on the first digit the dial opens and closes the line loop twice (2) causing the first selector switch to take two vertical steps to level two. The switch then hunts across the second level for an idle path called a trunk to a second selector switch.



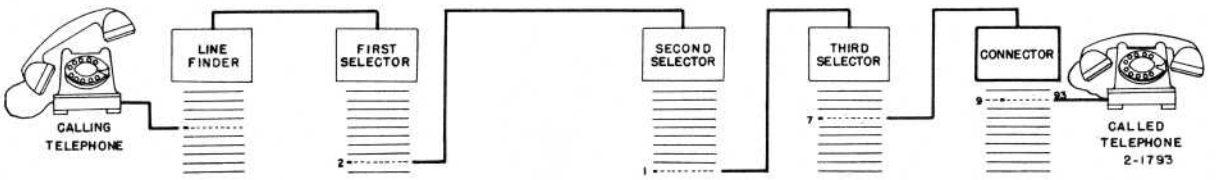
Sketch 3
Calling Subscriber Dials the First Digit of the Numerical Code - 1

On the dialing of the next digit (1), the second selector switch takes one vertical step and hunts across the first level for an idle trunk to a third selector switch.



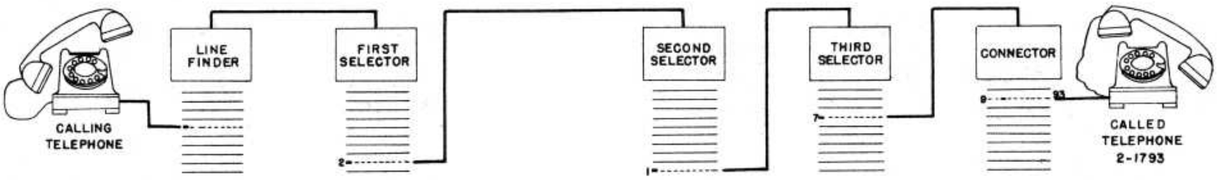
Sketch 4
Calling Subscriber Dials the Second Digit of the Numerical Code - 7

The dialed digit seven causes the third selector switch to take seven vertical steps and then hunt across the seventh level for an idle trunk to a connector switch.



Sketch 5
Calling Subscriber Dials the Third and Fourth
Digits of the Numerical Code - 93

This connector switch has been chosen by the first three digits as the one having access to one hundred terminals of which the called subscriber is one. The calling subscriber next dials 9. The connector switch steps vertically just as does a selector switch, but since it is now required to seize the terminals of a particular line on the ninth level rather than to choose an idle trunk from a group, it does not hunt over this level. As the subscriber dials the last digit 3, the connector switch takes three steps in a rotary direction to the terminals of the called line. A line test is made and if the line is found idle the connector switch places ringing current on the called subscriber line. If the line is found busy the connector places a busy tone on the calling subscriber line.



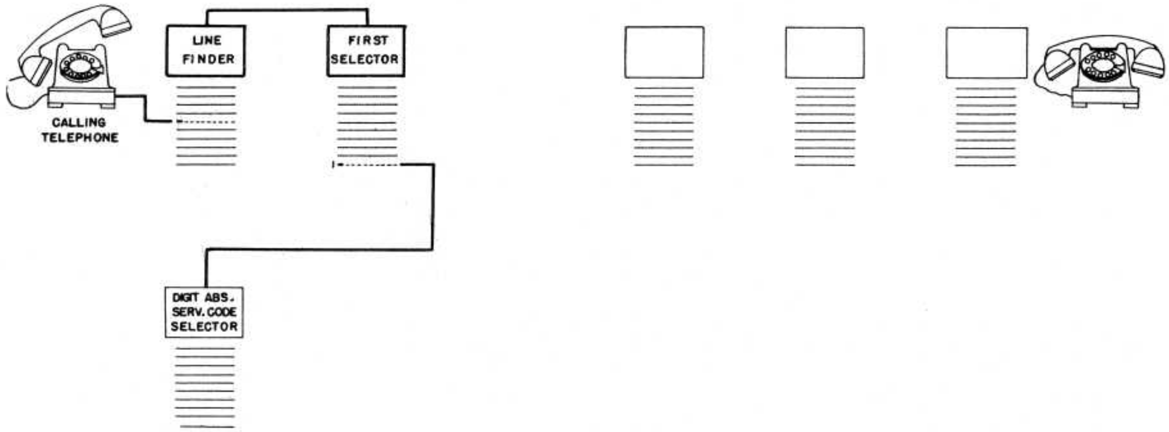
Sketch 6
Subscriber Talking Path

As soon as the called subscriber answers by removing the handset, the talking path is completed between the calling and called lines. Talking battery is furnished to both subscribers through the connector switch.

When both subscribers replace their handsets, all switches used for this call return to their normal position ready to be used for completing another call.

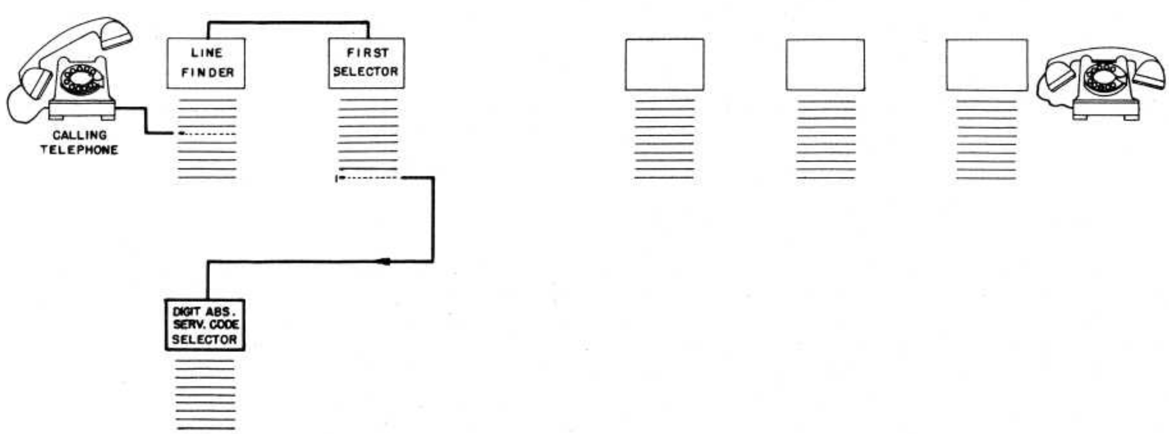
3. Counteracting a Preliminary Pulse

Occasionally a subscriber, after removing the handset, unintentionally sends what is known as a preliminary pulse before he dials the number of the subscriber he wishes to call. This preliminary pulse is generally caused by an accidental depression of the plunger or switch hook on the subscriber's set before the number is dialed. This action monentarily opens and closes the line loop once causing the first selector switch in the central office to take one vertical step and route the call to a digit absorbing service code selector switch. Dial tone is thus removed from the calling subscriber's line, and not hearing the dial tone, the subscriber should replace the handset. However, should he start dialing the desired number (2-1793), it is necessary to warn him that his call will fail. Therefore, when the first digit (2) is dialed, the digit absorbing selector switch steps to level 2, automatically cuts in, rotates to the 11th rotary position and returns a busy tone to the subscriber. If he is unaware of this and continues dialing the last four digits, (1793) no switch action will result and those digits will be lost. It will then be necessary for the subscriber to replace his handset to restore these switches to normal and start over in order to make his call.



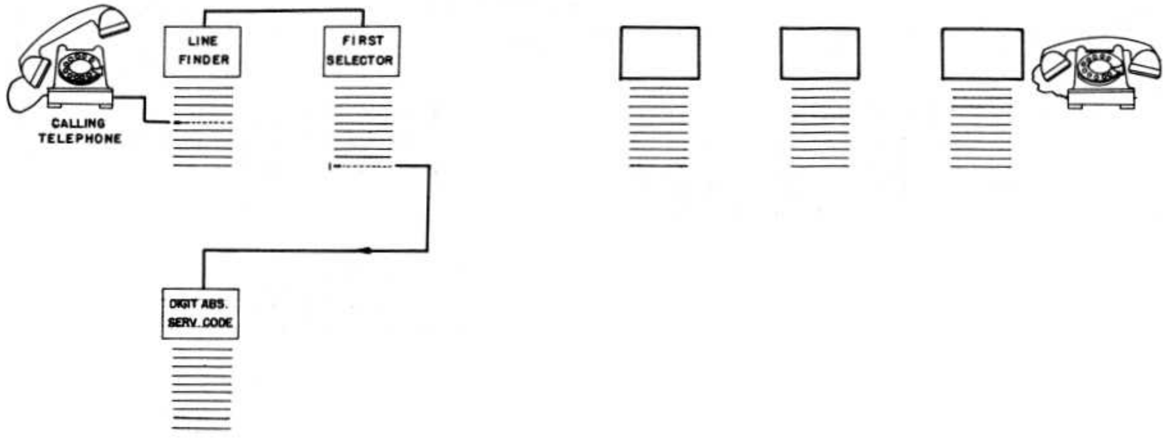
Sketch 7
Calling Subscriber Unintentionally Sends Preliminary Pulse

If the calling subscriber dials 2-1793 preceded by a preliminary pulse, or in other words 12-1793, the first selector switch will respond to digit one (1) and step vertically one step and hunt across the level to find an idle trunk to a digit absorbing service code selector switch.



Sketch 8
Calling Subscriber Dials the Office Code - 2

When digit 2 is dialed the digit absorbing service code selector switch makes 2 vertical steps, hunts across the level to the 11th rotary position and returns busy tone to the subscriber.

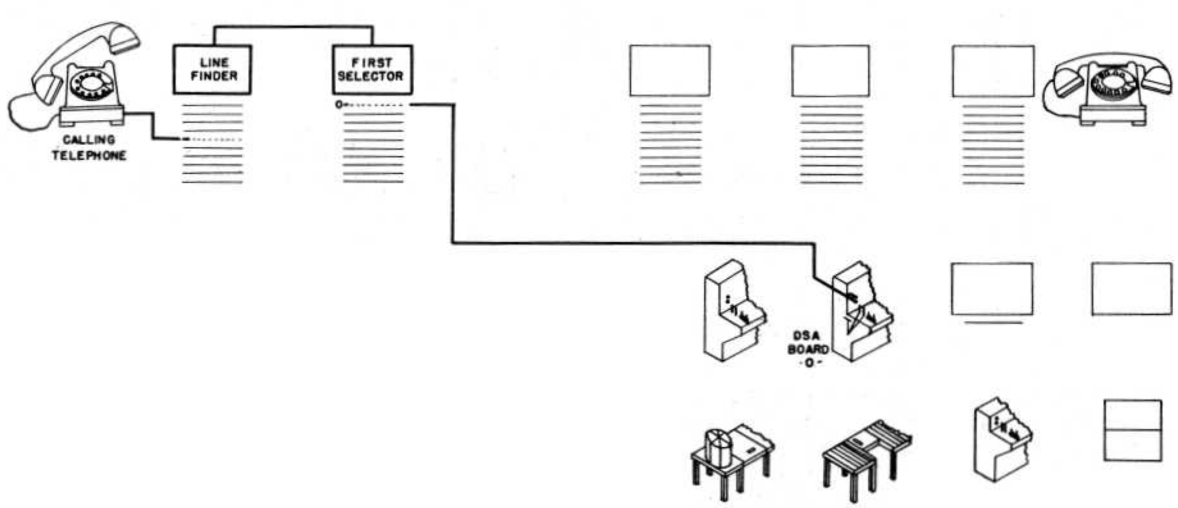


Sketch 9
Calling Subscriber Dials the Numerical Code (1793)

These four digits when dialed will have no effect on the operation of the digit absorbing service code selector and the subscriber will continue to receive a busy signal. He must replace the handset and start over if he wishes to complete the call.

4. Call to Dial System "A" Switchboard

Dial system "A" (DSA) switchboards are required in step-by-step central offices for all calls which require the services of an operator. Some of these reasons for having an operator always within reach of a subscriber are to handle emergency calls to doctors, hospitals, police or fire stations, and calls on which assistance is necessary due to a subscriber's inability to dial.



Sketch 10
Calling Subscriber Dials for Operator - 0

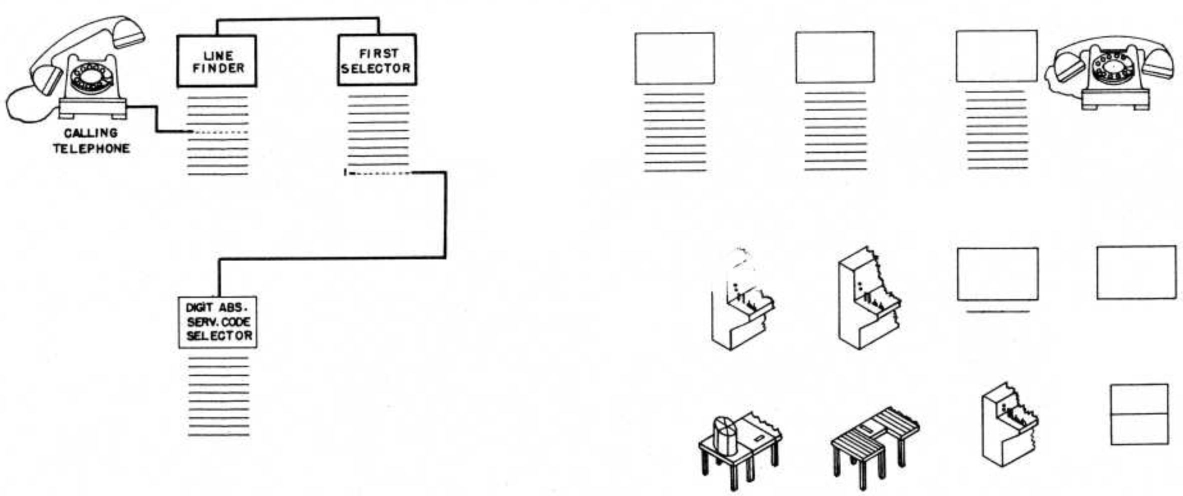
As in the regular call, the removal of the handset causes a line finder to step first vertically and then horizontally to find the calling subscriber. When the dial tone is received from the associate first selector switch the subscriber dials the digit zero (0). The first selector switch makes 10 vertical steps and then hunts across the tenth level for an idle trunk to the dial system "A" switchboard. The operator will then handle the call to its completion.

5. Calls to Toll Switchboards, Desks, and Special Equipment used in Step-by-Step Offices

General

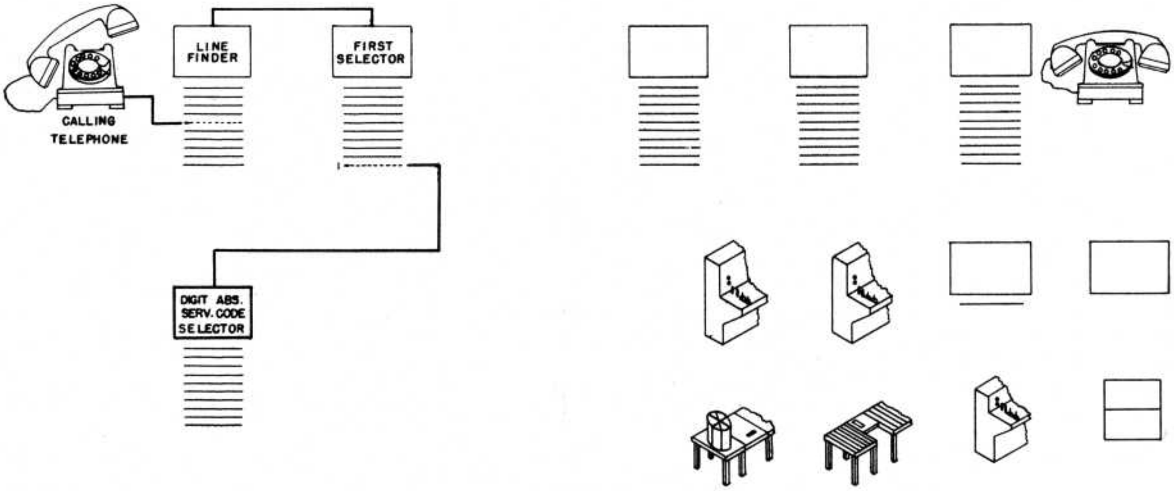
The purpose of the service code switches is to enable the calling subscriber to gain access to the toll board, information desk, repair service desk, reverting call equipment, etc., and to give a telephone repair man access to the test desk and ringer and dial testing equipment. Calls to these points are made by first dialing the number 11 followed by a third digit as follows:

113 Provides connection to the operators at the information desk, who will furnish information on changed subscriber numbers or new numbers not listed in the directory.
114 Provides connection to the repair clerk at the repair service desk to whom the subscriber may report a telephone out of order, or make any service complaints.
117 Provides a connection whereby a repair man can connect to a test man at a local test desk when repairing trouble on a line.
118 Provides a connection whereby a repair man at a subscriber's station can obtain access to dial and ringer testing equipment.
119 Provides means for completing calls to a subscriber on the same party line.
110 Provides a connection to the toll operator at the toll board, who will complete any call that must be handled on a toll charge basis.



Sketch 11
Calling Subscriber Dials First Digit - 1

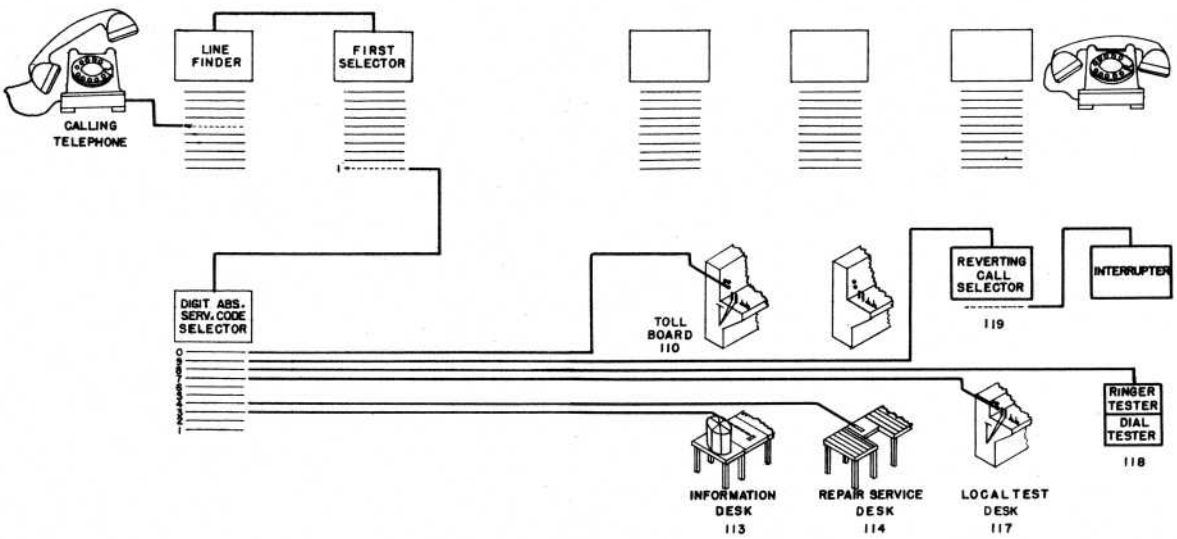
As in a regular call the removal of the handset causes a line finder switch to step first vertically and then horizontally to find the calling subscriber line. When the dial tone is received from the associated first selector switch the subscriber dials the digit (1). The first selector switch makes one vertical step and then hunts across the first level for an idle trunk to a digit absorbing service code selector switch.



Sketch 12

Calling Subscriber Dials Second Digit - 1

On the dialing of the second digit (1), the digit absorbing service code selector switch makes one vertical step, releases and returns to normal to await the next digit.



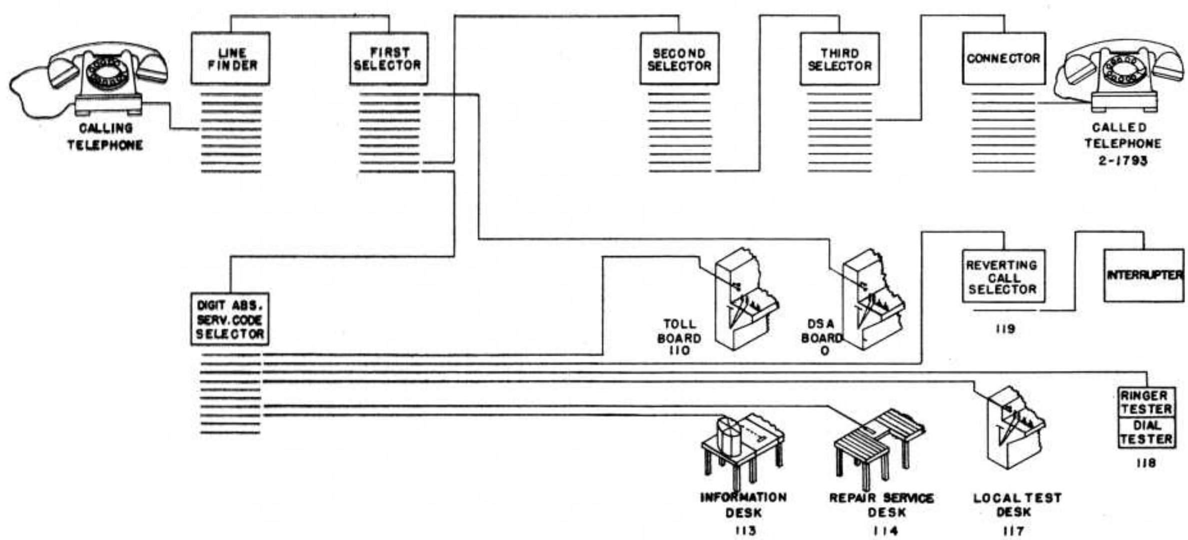
Sketch 13

Calling Subscriber Dials Third Digit - 3,4,7.8,9, or 0

The dialing of the third digit steps the digit absorbing service code selector switch to the level having trunks to the desks, switchboard or testing equipment to be connected to -

3 - Information Desk
4 - Repair Service Desk
7 - Test Desk
8 - Ringer and Dial Testing Equipment
9 - Reverting Call Selector (Party Line Ringing)
0 - Toll Board

If a preliminary pulse is accidentally sent on a call to an operator or the special equipment, the number recorded would be 111 plus 3,4,7,8,9, or 0. Routing the call through the digit absorbing service code selector to the proper destination.



Sketch 14
Switches, Switchboards, and Desks used in a Step-by-Step Dial System

SECTION 6. POWER

The purpose of the telephone power plant is to furnish electrical energy, of the required character and in proper amount, and available one hundred percent of the time.

In order to meet the vital need of ever-ready power, it is necessary in telephone power plants to arrange for some primary power source which is usually a commercial electric service from outside. The services are investigated with care to determine their reliability and in some cases, two services from separate power houses are brought into the telephone building. Where a single service is used, a local diesel engine with associated alternator is provided as a reserve.

The above primary supplies are used to drive direct coupled A.C. Motor - D.C. Generator Sets which provide the basic voltage for the 48 volt supply used to operate the mechanical switches, relays, etc. and also to furnish the talking battery required in the system. The output voltage from these generator sets is also used to charge storage batteries which are continuously connected across the power leads acting as a ballast or filter during normal operation and as a reserve to operate the telephone equipment in case of primary voltage failure. Common practice and experience have resulted in batteries of certain sizes being provided, these sizes being sufficient to carry the exchange load for intervals ranging from a few hours to several days, depending upon conditions. These present practices have been successful in maintaining continuous power supply, and central offices generally throughout the country have given service even during periods of storm, fire or other calamities. Central Office batteries may be either the lead lined wood tank, glass jar as shown in Figure 34 or rubber jar type used in the latest installations.

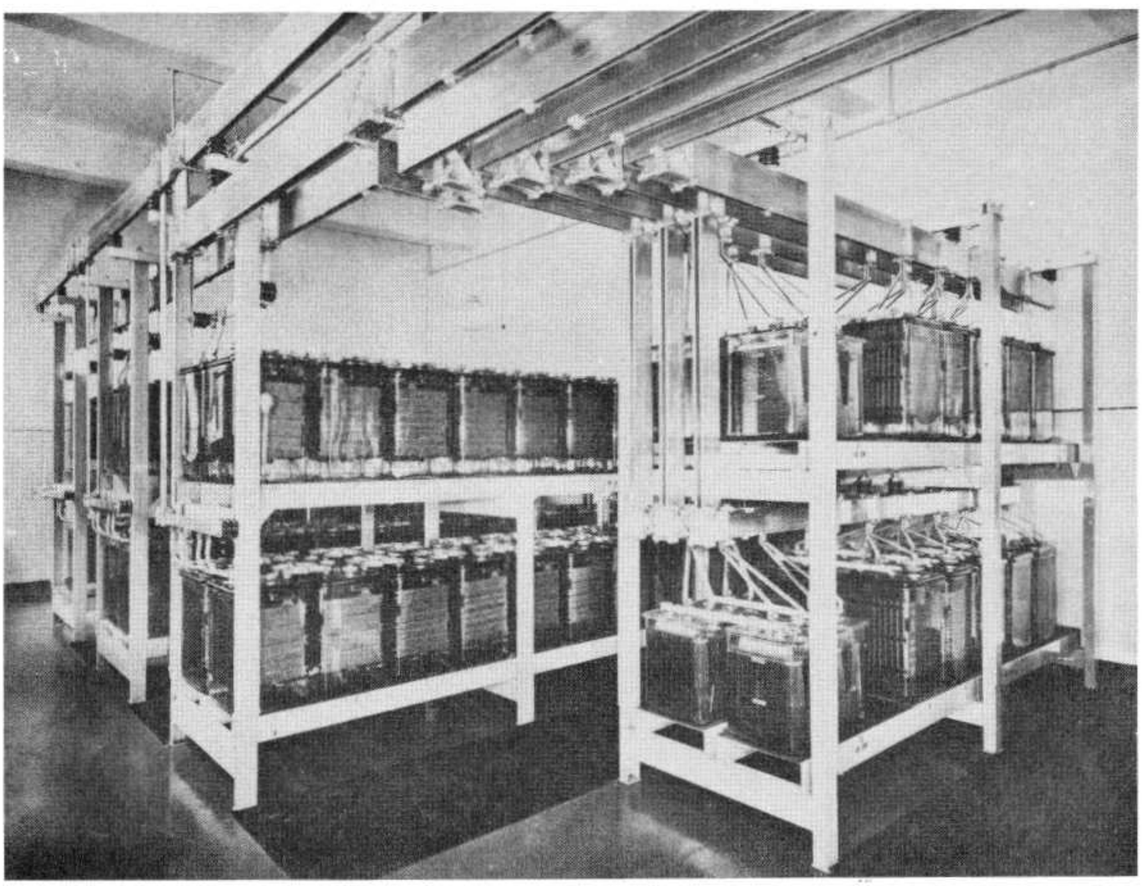


Figure 34 - Central Office Batteries

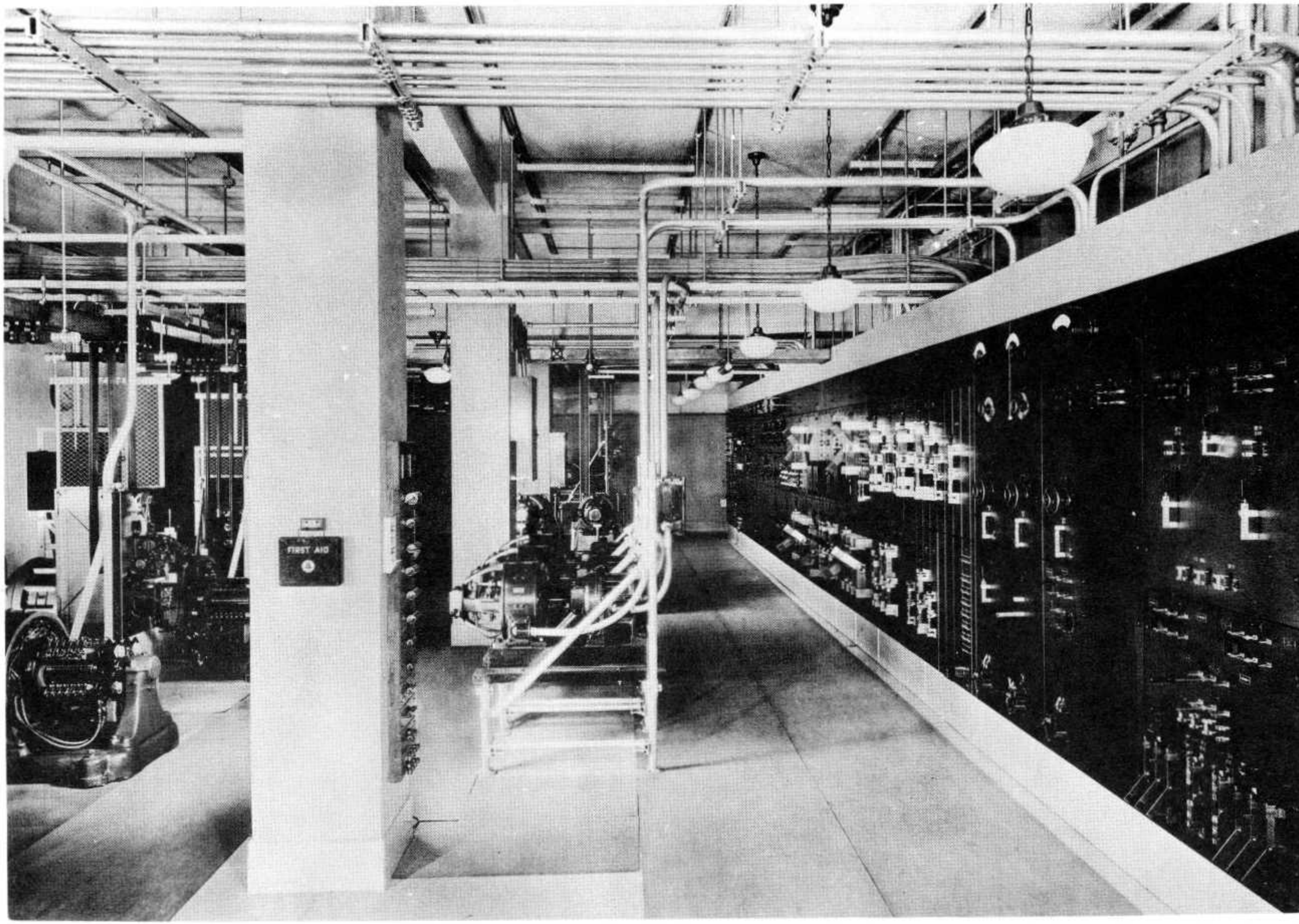


Figure 35 - Typical Power Room in a Step-by-Step Office

Figure 35 shows a typical power plant as might be found in any step-by-step dial office. Power protection panels, with their protective devices, are provided when the primary power is supplied over aerial lines and there is a possibility of service interruptions due to lightning or transformer breakdown. Safto-fuse cabinets are provided to make a shock proof switch cabinet when it is necessary to replace a fuse or open a circuit in the primary power supply system. A.C. Motors and D.C. Generator Sets as mentioned in the preceding paragraph are used to furnish the 48 volt supply and to charge the batteries. Inasmuch as commercial generators are now being used it is necessary to filter out noises caused by these machines and prevent their getting to the line. Electrolytic condensers (capacitance) and choke coils (inductance) are supplied for this purpose. Ringing and coin control machines run by AC or DC motors, are provided for signalling purposes and to generate the tones used in the system. Meters for checking the current and voltage and switches for transferring the battery circuits and ringing machine circuits to the telephone system are mounted on the power panels (Fig. 35). Tungar Copper Oxide or Selenium rectifiers are usually supplied to charge the smaller miscellaneous batteries used in the central office.

The layout of power equipment in a central office is arranged to provide easy accessibility for maintenance and to allow proper facilities to care for future growth.

SECTION 7. SXS CIRCUIT OPERATION

1. The Dial

The only difference between automatic and manual equipment apparent to the subscriber is the dial located at the instrument on his premises. It is for this reason that automatic systems are universally known as "dial" systems. The purpose of the dial is, of course, to enable a subscriber to control the automatic equipment so that a connection will be completed to the number he is calling. When the subscriber removes his receiver from the switchhook the circuit is completed through the switchhook contacts in series with a relay in the central office, as shown in Fig. A. One of the functions of the subscriber's dial with the receiver off the switchhook is to open this circuit a specified number of times and by means of these open circuits or "pulses" to give the automatic equipment the proper information. The dial is provided with a series of finger holes, each of which is numbered. The subscriber places his finger in one of these holes and carries it to the back stop, after which the dial restores to normal under the influence of a governor which regulates its speed. As the dial restores to normal it opens the circuit a number of times equal to the number on the finger hole which was selected by the subscriber. Thus, dialing "2" opens the circuit twice; dialing "5" opens it five times. It should be noticed also that dialing "zero" opens the circuit ten times. The opening and closing of the circuit alternately operates and releases a relay which has been placed in series with the subscriber's line.

A pulse cycle consists of the time required for one open circuit and one closed circuit in the series of pulses sent out as the dial restores to normal. The open circuit is approximately 60% of the total pulsing time. This is to insure the positive release of the pulsing relay in the automatic equipment at the central office.

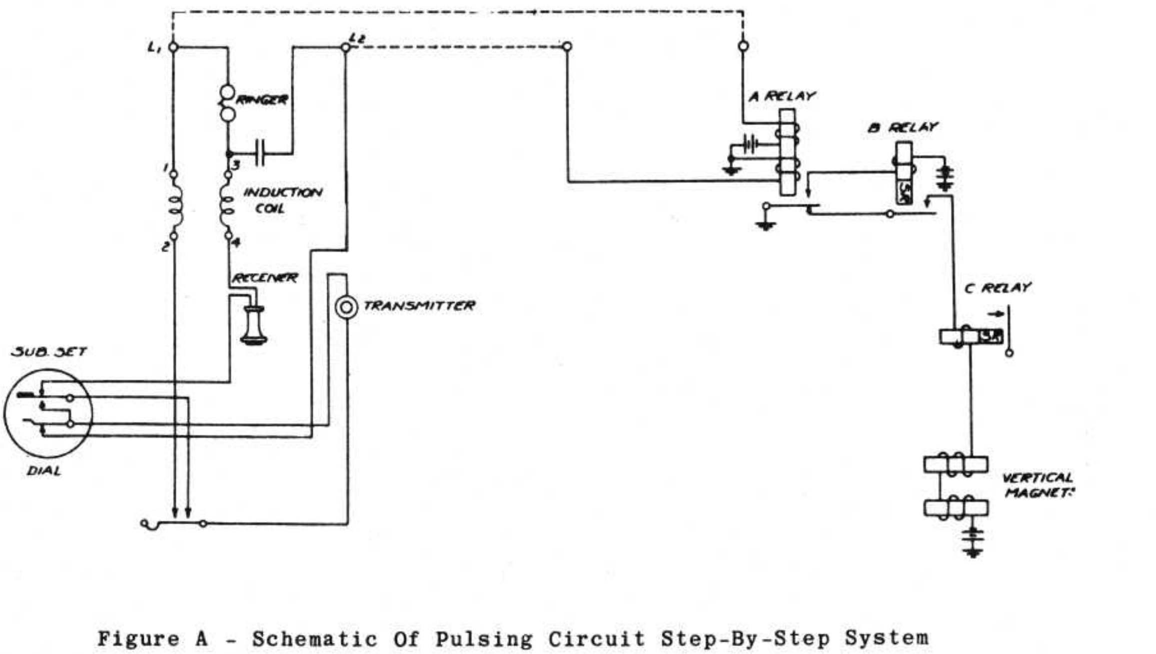


Figure A - Schematic Of Pulsing Circuit Step-By-Step System

Figure B gives a schematic of a subscriber's station circuit containing a dial. Here the dial is shown in its normal position. The receiver circuit is closed through the contacts shown as "off normal contacts." As soon as the subscriber moves the dial "off normal," the off normal contacts change position so that the receiver circuit is opened to prevent the annoyance of a series of sharp clicks in the subscriber's ear and a short circuit is placed around the transmitter to remove its variable resistance from the dialing circuit. The off normal contacts remain in this condition from the time the subscriber's dial first moves off normal until it has restored under the influence of a governor. The contacts labeled "pulse contacts," however, open and close only while the dial is restoring to normal at a constant speed determined by the governor.

The first series of pulses which come through from the subscriber's dial causes the pulsing relay in the switch to operate and release in synchronism with the pulses and in turn operate and release the vertical magnet. Under the influence of the vertical pawl the switch rises until the brushes are opposite the level determined by the number of pulses sent from the dial. If the switch is a "selector" it will now rotate automatically under the influence of the rotary magnet and pawl until an idle trunk on that level is reached. If it is a "connector" it will wait for the subscriber to dial another digit, in which case it will rotate under the influence of the dial pulses until it reaches the particular set of terminals determined by the last digit.

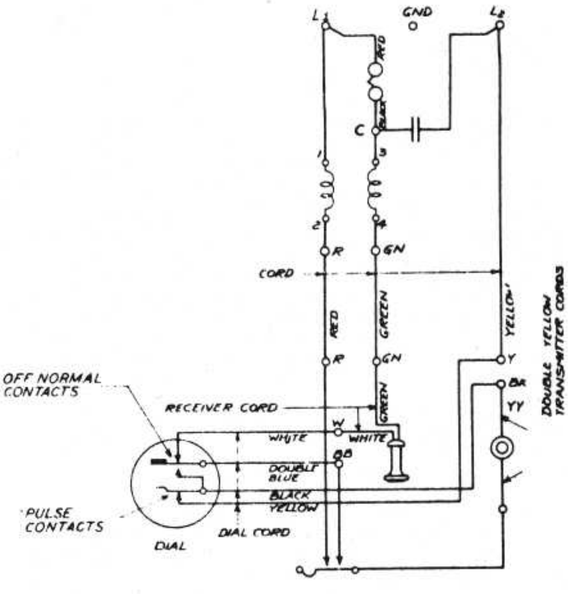


Figure B - Dial Subscriber Station Circuit

The switch is now held in its rotated position by the double dog and held in its vertical position by the fixed dog. Upon release of the switch a magnet is operated (known as the "release magnet") which removes the double dog from engaging the rotary teeth allowing the switch to restore horizontally under the action of a coiled spring in the spring cup. When the horizontal restoration is complete the fixed dog disengages the vertical teeth because of the vertical slot and the shaft restores to normal in a vertical direction by means of gravity.

2. Line Circuits and Line Finders

In the manual system, subscribers' lines are answered by an "A" board operator who is responsible for all of the subscriber lines appearing as answering jacks in her position. In order to establish contact with a calling subscriber who has removed the receiver from the switchhook, an answering cord is placed in the required answering jack as indicated by the lighted line lamp. In the step-by-step system the answering cord of the "A" board operator in the manual system is replaced by a step-by-step switch known as a line finder. The function of the line finder is to make contact with any calling line in a particular group and extend that line to a first selector (to a connector in the 100 line system not described herein), the first selector giving the subscriber dial tone and receiving the first digit dialed by the subscriber.

In the manual system, the number of answering jacks appearing in each "A" board position is dependent upon the calling rate of the lines involved and the load which the "A" board operator is able to carry. In the step-by-step system, lines are in most cases arranged in groups of 200, the number of line finders having access to this group of lines varying with the calling rate.

2.1 200 Point Line Finder

A line finder arranged to serve a 200 line group is illustrated in Fig. 7 and is known as a "200 point" line finder. Each line finder has access to 3 banks of 200 terminals each. The lowest bank contains the tips and rings of 100 lines numbered 11, 12, 13, 14, . . . 19, 10 on the bottom level and 01 to 00 on the top level (see Fig. C). It should be noticed that the tenth terminal on the top level is numbered "00" because the switch steps vertically ten times and horizontally ten times to reach it. The middle bank carries a second 100 lines the terminals of which are numbered 111 to 110 on the bottom level and 101 to 100 on the top level. The top bank carries the sleeve terminals of the entire group of 200 lines, the sleeves 11 to 10 and 101 to 110 being arranged on the bottom level and 01 to 00 and 101 to 100 on the top level. The purpose of the sleeve bank is to permit the line relay of a calling line to put battery on its corresponding sleeve terminal to stop the line finder as it sweeps across the row of terminals. The line finder shaft carries three sets of brushes, one to make contact in each bank.

A vertical commutator consisting of 10 segments is arranged at the side of the line finder shaft so that as the shaft rises a commutator brush makes contact with the first segment when the line finder brushes are opposite the first level of the banks, the second segment when they are opposite the second level, etc. The line finder circuit is so arranged that, as soon as any line relay in the group of 200 lines is operated, one of the line finders serving the group will commence to step up and will continue stepping up until it meets a commutator segment that is grounded. There are 20 lines on each level and each "sub-group" of 20 lines has access to a common sub-group relay which may be operated by any line relay in the sub-group. The operation of this sub-group relay grounds the commutator segment corresponding to the level on which these 20 lines appear. This will cause the line finder to stop its vertical motion at the level on which the calling line appears.

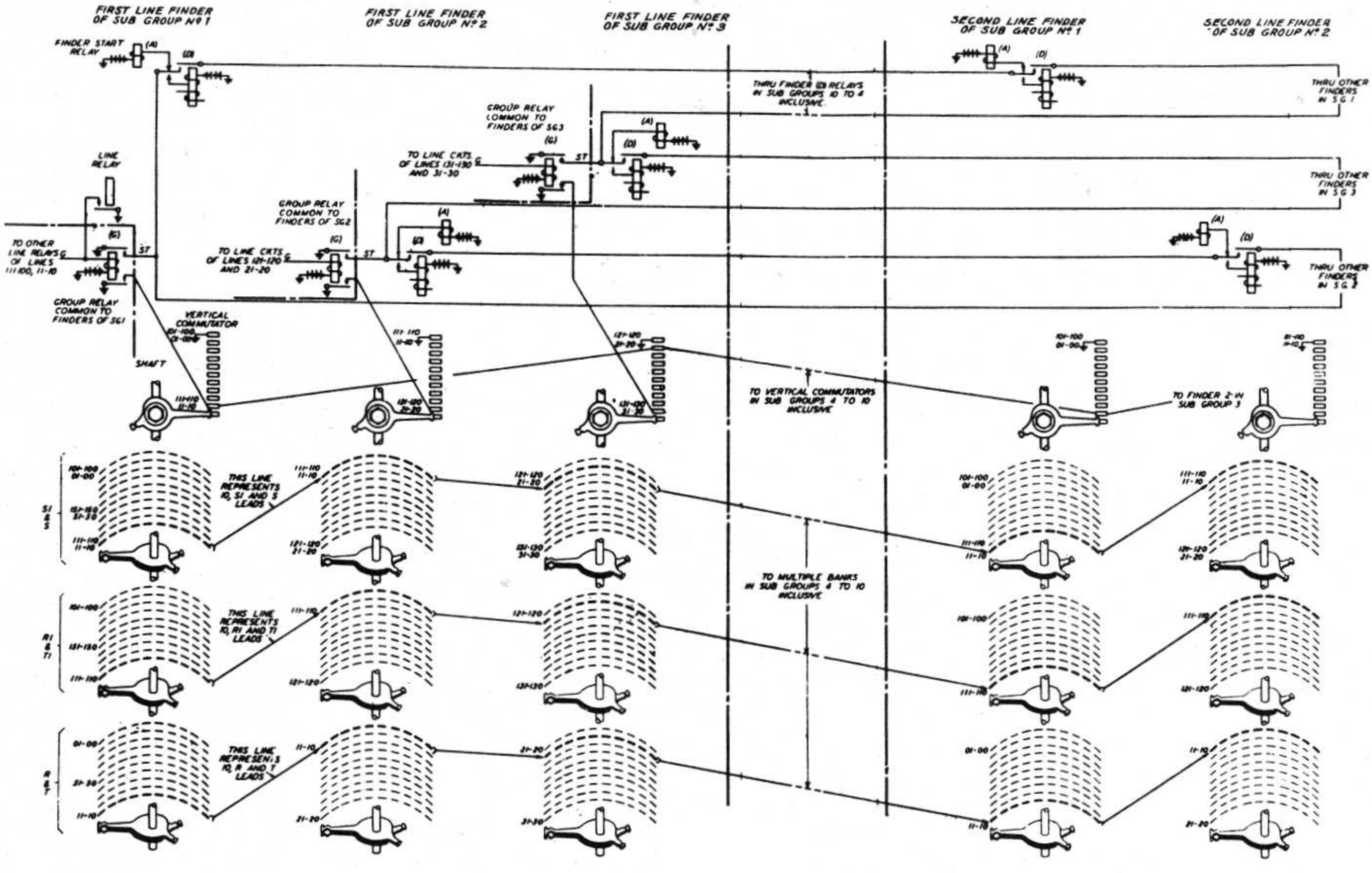


Figure C - Allotment Of Line Finders And Multiple Bank And Communication Multiple Slip

After the line finder has stepped up to the proper level it will, of its own accord, begin to step over the terminals of that level, testing the sleeve terminals in the top bank, two at a time, as it goes along. As soon as it finds a sleeve terminal with battery on it from the operated line relay it will stop with its tip and ring brushes on the tip and ring of that line in order to extend that line to a first selector. Thus if line 12 is calling commutator segment 1 will be grounded and the line finder will step up to the first level and in on that level to the second terminal. After the line finder has stopped on a given set of terminals it connects the brushes in the bottom bank or in the middle bank to a first selector, in accordance with which of the two sleeves in the upper bank has the battery condition.

2.2 Slip Wiring of Line Finder Banks and Commutators

Obviously it takes a certain amount of time for a line finder to rise to the higher levels of its banks and cut into those levels until it finds the terminals of the calling line. The ideal condition would be to have the calling line on the first level of the line finder bank in every case, so that the line finder would have to step up only one level and then cut into that level to find the calling line. This would mean that the subscriber would receive dial tone from the first selector with a minimum amount of waiting. It is not possible to achieve this ideal condition for every call, but the hunting time for line finders is considerably decreased by "slipping" the line finder multiple as shown on Fig. C.

Suppose that a group of 200 lines is served by 20 line finders. In this case lines 11 to 10 appear on the first level of the lower bank of the first line finder of sub-group 1, and lines 111 to 110 on the bottom level of the middle bank of this line finder. However, these lines are wired to the top (or tenth) levels of the banks on the first line finder of sub-group 2 and to the ninth levels of the first line finder of sub-group 3, the eight levels of the first line finder of sub-group 4, etc., and appear again on the first levels of the second line finder of sub-group 1. This means that the first and second line finders of sub-group 1, are "first choice" for the use of lines 11 to 10 and 111 to 110 since these two line finders have this group of 20 lines on their first levels. Likewise the first and second line finders of sub-group 2 are first choice to lines 21 to 20 and 121 to 120, and the first and second line finders of sub-group 3 for lines 31 to 30 and 131 to 130. The wiring to the corresponding commutator segments is slipped in a corresponding manner.

2.3 Allotment of Line Finders

Fig. C illustrates the method of alloting line finders. The operation of the sub-group relay of a sub-group of 20 lines does two things. First, it places a ground on the commutator segment corresponding to the level in which the group of 20 lines appears on the line finder banks. Second, it grounds a start lead which operates a "start" relay in the line finder that is to be used for the call, causing it to step up and hunt for the grounded commutator segment.

Tracing the start lead from the sub-group relay in sub-group No. 1, we arrive at the back contacts of the (D) relay in the first line finders of the sub-group (which has the lines in sub-group No. 1 on its first level) and thence on to the winding of the "start" relay (A). If, however, this line finder is busy on a call the (D) relay will be operated and the start lead will be extended to the back contacts of the (D) relay of the second line finder of the sub-group. If this line finder is also busy the (D) relay will be operated and the start lead will be extended to the other line finders in sub-group No. 1 If all finders in the sub-group are busy the start lead is extended to the first line finder in sub-group No. 10 since the line finders of this group have lines 11 to 10 and 111 to 110 on their second levels. The process of allotment thereupon continues as necessary through the line finders in sub-group No. 10, sub-group No. 9, etc., the last choice line finders for the No. 1 sub-group of lines being the line finder in sub-group No. 2, since these line finders have sub-group No. 1 lines on their top levels.

By means of this bank-to-bank slip on line finder multiples, each group of 20 lines is given equal preference in being chosen by line finders. If 20 line finders are provided to serve a group of 200 lines there are two first choice line finders per sub-group. If 30 line finders serve the group of 200 lines there are three first choice line finders per sub-group, three second choice, three third choice, etc. This insures that the waiting time for dial tone will be kept down to a minimum.

If it should so happen that all line finders are busy at the time a subscriber removes his receiver from the switchhook, of course he will not be connected to a first selector, will not receive dial tone and will not be able to make his call until some line finder becomes idle. This is comparable to the custom in manual offices of providing only that number of cord circuits in an "A" board position which is required to handle just a little less than the rush hour load.

The line and line finder equipment required to serve a group of 200 lines is mounted together in one equipment unit, as illustrated in Fig. 22, consisting of the required number of line finders with their banks, commutators and jack wiring, the line circuits with their associated wiring, the sub-group circuits required for each group of 20 lines and the relays required for the common group of 200 lines. This equipment unit is shop-wired and may be shipped from the factory ready to be mounted upon a line finder frame as shown in Fig. 23.

3. Selectors and Connectors

Figure D shows a 200 line SxS system using selectors. Each line finder being capable of selecting any calling line in a group of 200. Each line finder is wired to a "selector." The chief difference between a selector and a connector is that the selector will move up to the specified level under the influence of the customer's dial and will then proceed to find an idle trunk on that level of its own accord. The connector, steps up to the correct level under the influence of the customer's dial and finds the proper terminal in this level in accordance with a second set of pulses from the dial. In a 200 line system two groups of connectors would be required, each having access to 100 lines. Since it will be necessary for the customer to dial two digits in order to control whatever connector is used on the call, an additional digit must be dialed to determine in which group of connectors the call will be completed. The digit will be dialed into the selector. In order to cause the selector to choose the right group of connectors, the connectors having access to one group of 100 lines will be wired to one level of the selector, say the fourth, and the other group of connectors to another level of the selector, say the eighth. Thus, if the customer dials as his first digit a four, the selector will step up to its fourth level and will hunt along that level for an idle connector having access to the lines 400 to 499. If his first digit is an eight, the selector will step up to the eighth level and will choose an idle connector having access to the numbers 800 to 899. In addition, trunks may be provided on the tenth level of the selector to an assistance operator if required.

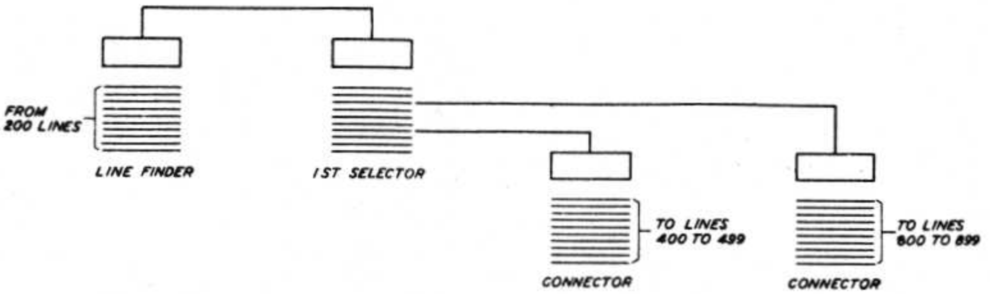


Figure D - 200 Line Step-By-Step System

The presence of the one selector in the train of switches presents the possibility of increasing the size of this step-by-step office to 1000 lines, providing a separate group of connectors is wired to each level of the selector. The number of selectors required with their banks in multiple will be determined by the number of line finders required to handle the calling rate from each group of 200 lines. For a 1000 line office the calling lines will be divided as before into groups of 200 lines, each group of lines being served by its own line finders. The line finders of all groups will, however, be wired to selectors having their banks in multiple so that a subscriber in one group of lines, having gained access to a selector by means of line finder action, will have access to actually the same connectors as a calling subscriber in any other group.

In the event that any level of the selector is required for trunks to other than connectors, the total number of lines which it will be possible to serve will be reduced by 100 for each level required for trunks to other than connectors.

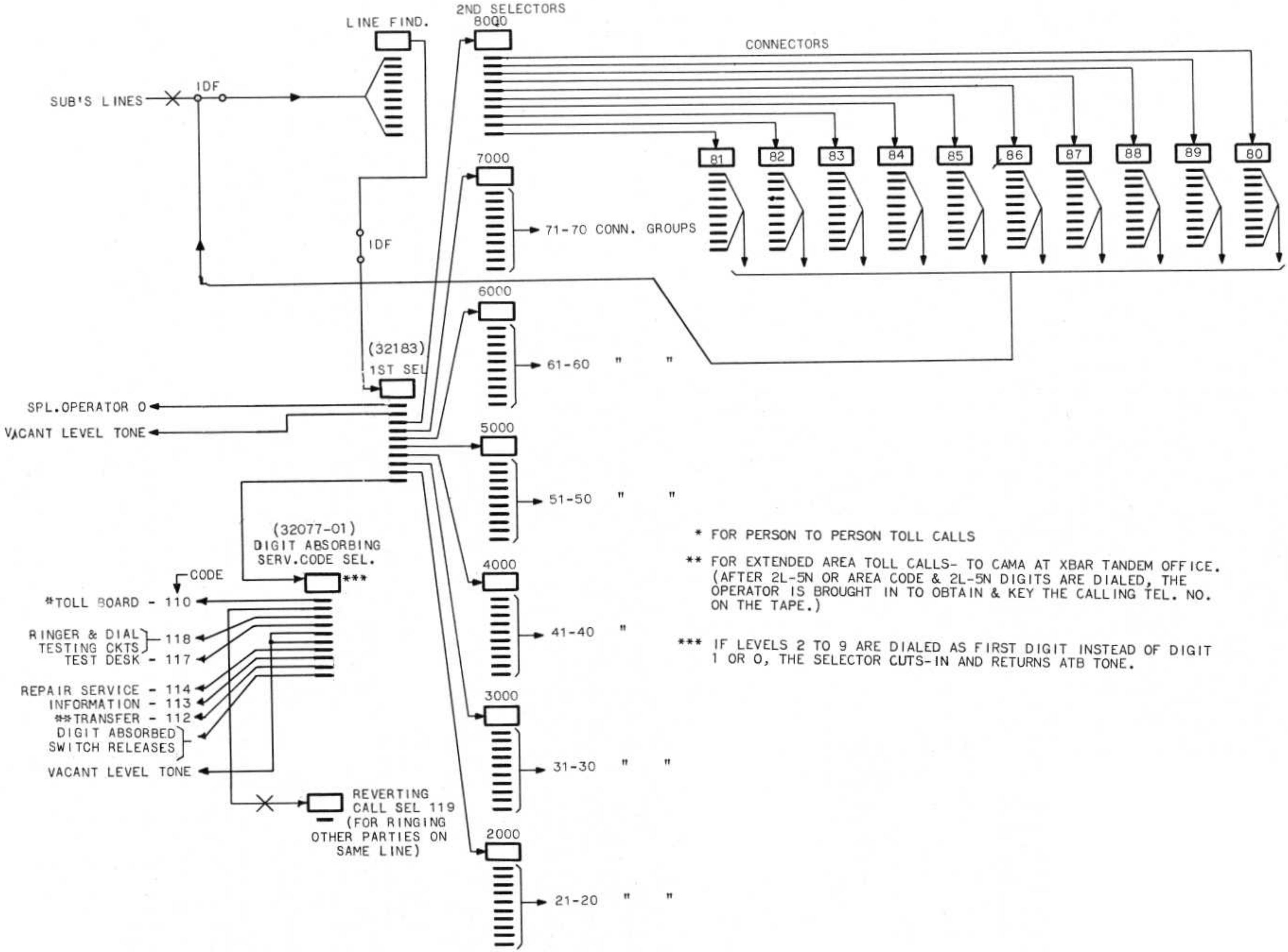
The addition of a second selector in the trunk of switches required for the completion of each call permits the size of the office to grow beyond 1000 lines. Figure E illustrates the switches required to serve a four-digit office with 7000 terminals equipped. This system makes use of 200 point line finders as before, first selectors to choose the particular 1000 lines in which the call is to be completed, and second selectors to choose the particular 100 lines (or rather the particular group of connectors) in which the call is to be completed.

Referring to Figure E assume that the number to which a call is to be completed is 8195. The method of completing the call will be as follows:

When the customer removes his receiver from the switchhook, an idle line finder in the group serving the particular line will attach itself to the calling line and extend it to the first selector.

The customer receives dial tone from the first selector.

The customer dials 8 as his first digit, and the first selector steps up to the eighth level.



* FOR PERSON TO PERSON TOLL CALLS

** FOR EXTENDED AREA TOLL CALLS- TO CAMA AT XBAR TANDEM OFFICE. (AFTER 2L-5N OR AREA CODE & 2L-5N DIGITS ARE DIALED, THE OPERATOR IS BROUGHT IN TO OBTAIN & KEY THE CALLING TEL. NO. ON THE TAPE.)

*** IF LEVELS 2 TO 9 ARE DIALED AS FIRST DIGIT INSTEAD OF DIGIT 1 OR 0, THE SELECTOR CUTS-IN AND RETURNS ATB TONE.

Figure E - Step-By-Step 4-Digit Office 7000 Lines Equipped

The first selector hunts for an idle trunk to the 8000 group of second selectors, of which there are ten on its eighth level.

The customer dials a 1 as his second digit and the second selector steps up to its first level.

The second selector hunts for an idle connector in the 8100 group by testing the terminals on its first level.

The customer dials a 9 as his third digit and an idle connector steps up to its ninth level under the influence of the dial pulses.

The fourth and last digit dialed by the customer is a 5 which causes the connector to step to the fifth terminal on its ninth level which represents the terminal of the line 8195.

The called party's bell is rung by the connector until the called party answers.

The line finder, first selector, second selector and connector chosen for the call remain operated until the conclusion of the conversation.

When both parties hang up all switches restore to normal.

3.1 Digit Absorbing and Blocking

NOTE: Digit absorbing is used to absorb digits dialed which are not required, by preventing the switch to cut-in and hunt for an idle trunk and causing the selector to release.

Blocking is used to indicate by returning tone to the subscriber that an irregularity in dialing has occurred.

3.11 Selector levels may be arranged to absorb or block for purposes such as:

(a) Absorb digits of an office code which are not required, but were established in connection with the introduction of 2L-5N numbering for nationwide toll dialing.

(b) Restricted service on levels of selectors serving certain classes of telephone service.

(c) Absorb all or some office code digits prior to expected growth of the central office which will include additional traffic channels requiring second or third selectors.

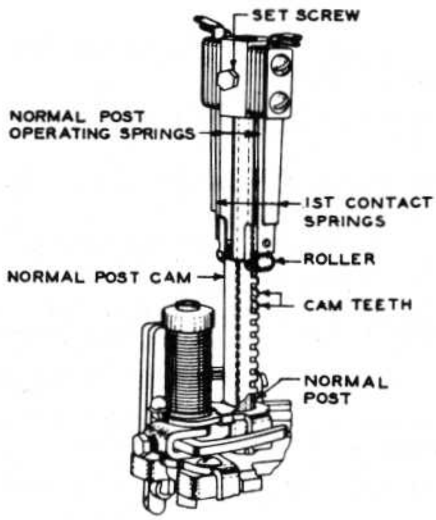
(d) Provide tone on vacant selector levels.

3.111 Circuit options to provide digit absorbing and blocking involve the use of a normal post spring assembly per Figure E-1 above the vertical shaft of the selector.

Cam teeth are bent outward to engage the roller end of left and/or right normal post springs for specified levels, Figure E1 shows teeth for levels eight and nine bent to engage and operate "right NPS."

3.112 Digit Absorbing levels may be arranged to absorb and release the selector as follows:

- Absorb Initial digit
- " First two digits
- " digits repeatedly
- " " " unless a level arranged to absorb "once only" has been previously dialed which may unlock all levels as on selector SD-30976-01, SD-55242-01 and SD-55062-01.
- Absorb on the first and second digit and cut-in and trunk hunt on the third digit as on selector SD-32183-01.



NOTE: Cam teeth for levels 8 and 9 are bent outward to engage roller for operating "Right" normal post springs.

Figure E1 - Normal Post Springs On Selector

3.113 An illustration showing a possible arrangement of the levels of a 2-digit absorbing selector used as the first selector in the train follows:

Assumed requirements:

To permit dialing and completion to the "635," "636," and "638" (local) offices, to adjacent "423" and "679" offices, to all city offices (codes 2XX) and to the "345" and "346" adjacent second fringe offices via a "34" tandem, and to deny dialing to the "659" and "668" non-contiguous fringe offices.

1st 2nd & 3rd Sel

Digit Dialed

Lev	1st	2nd	3rd	
0	C	B	C	Opr
9	B	B	C	"679" Office
8	B	B	C	4th Sel (638 Local Office)
7	C	A	C	Vacant
6	A	B	C	4th Sel (636 Local Office)
5	B	B	C	4th Sel (635 Local Office)
4	A	C	C	"345" and "346" Office via 34 Tandem
3	A	A	C	"423" Office
2	C	A	C	City Office (Codes 2XX)
1	C	A	C	Service Code Sel (For service codes 11X)

A = Absorbs once

B = Blocks (denies) and returns "no such number" tone

C = Cuts through

C	C	C	Other combinations of treatments, not used in above illustration, but which are available.
B	A	C	
B	C	C	

3.114 Blocking: This term usually denotes that switch does not cut-in when the level dialed is reached, but returns "no-such-number" tone. The other type of "blocking" allows the switch to cut-in and rotate to the eleventh rotary position and return "paths-busy" tone. Following are various forms of blocking:

(a) Levels Arranged To Block On First Or Second Digit: The switch steps to level dialed "blocks" and returns tone.

(b) Levels arranged to rotate to 11th rotary step and provide all trunks busy tone (120 IPM); unless a previous digit dialed a level which absorbs initial digit "once only," as on selector SD-30976-01.

(c) Levéls Arranged To Absorb On First Digit and Block On Second Digit: When the first digit of such a level is dialed the switch steps to level dialed and restores. When the second digit is dialed the switch steps to level dialed, "blocks" and returns tone.

3.12 Digit Absorbing Service Code Selectors

Service code selectors such as SD-32077-01 are provided to enable the customer to gain access to Operator, Long Distance, Repair Service, Information and other service trunks, also to dispose of calls on which the subscribers call was inadvertantly preceded by a "preliminary pulsė" as described in Method of Operation Section 5.

Figure E shows the path of such calls via the service code selector.

3.2 Connectors

Figures 28 and 33 illustrate a typical connector switch. There is little to distinguish this switch in appearance from other step-by-step switches. It has a larger number of relays associated with it than does a selector because it has more duties to perform on a given call. First of all, the connector is required to step both vertically and horizontally under the influence of the subscriber's dial in order to select a particular terminal representing the line being called. In addition, it must ring the called subscriber's bell, maintain supervision over the call in order to signal the other switches in the train when both subscribers have hung up and, on a local call, supply talking battery to both subscribers.

In the event that a connector finds the called line busy, there will be a ground on the sleeve terminal. This will set up a circuit condition which will cause a busy tone to be returned to the calling subscriber.

Figures 29 and 30 show a typical connector shelf and frame. Each "shelf" of connectors on the frame is arranged to serve a separate group of 100 lines. The connector frame illustrated is equipped with five to ten connectors for each 100 lines. The first is wired as a test connector and is used by the maintenance forces for testing lines. The remaining connectors are used for completing calls by subscribers, in each group of 100 lines. Under heavier traffic conditions more connectors would be provided. The maximum number of connectors per shelf is eleven including the test connector. Where more than ten are required for subscriber traffic to a group of 100 lines, two or more shelves may be multipled together, providing an additional 5 or 10 connectors per 100 lines.

Figure F illustrates how the various frames are cabled together. The subscriber's lines are wired to the banks of both line finders and connectors. The jacks of line finders are wired to the jacks of first selectors, the connections, however, going through the I.D.F. providing flexibility for the changing of the particular first selector wired to a given line finder. The banks of first selectors are wired to the jacks of second selectors, and the banks of second selectors are wired to the jacks of connectors.

4. Trunking Problems In Step-By-Step Offices

The discussion in Paragraph 3 in connection with the 4 digit office with 7000 terminals equipped assumed that no other offices were required in the area. In certain areas where more than one central office is required, the interoffice trunk problems may become quite complex. This section will outline methods of using selector levels to provide trunks to other offices in exchange areas with interoffice trunking problems of varying complexity.

4.1 5-Digit Operation

In exchange areas where there are few central offices, say 3 or 4, the trunks to other offices may be reached directly from the banks of the first selectors. In a case of this kind the first selector bank terminals will correspond directly to the out trunk multiple found on the "A" board in manual offices. The subscriber will be required to dial only one digit to determine in which office his call is to be completed. One level of all first selectors will be required for each office to which trunks are to be provided. This condition is illustrated by Figure G which shows trunks to other offices on levels 5 and 7 of the first selectors. Since it is customary to require the customer to dial 0 in order to obtain a special service operator, the tenth level of the first selectors will be required for trunks to an assistance operator. The first level will be wired to auxiliary first selectors in order to guard against preliminary impulses and to provide access to the service code switches.

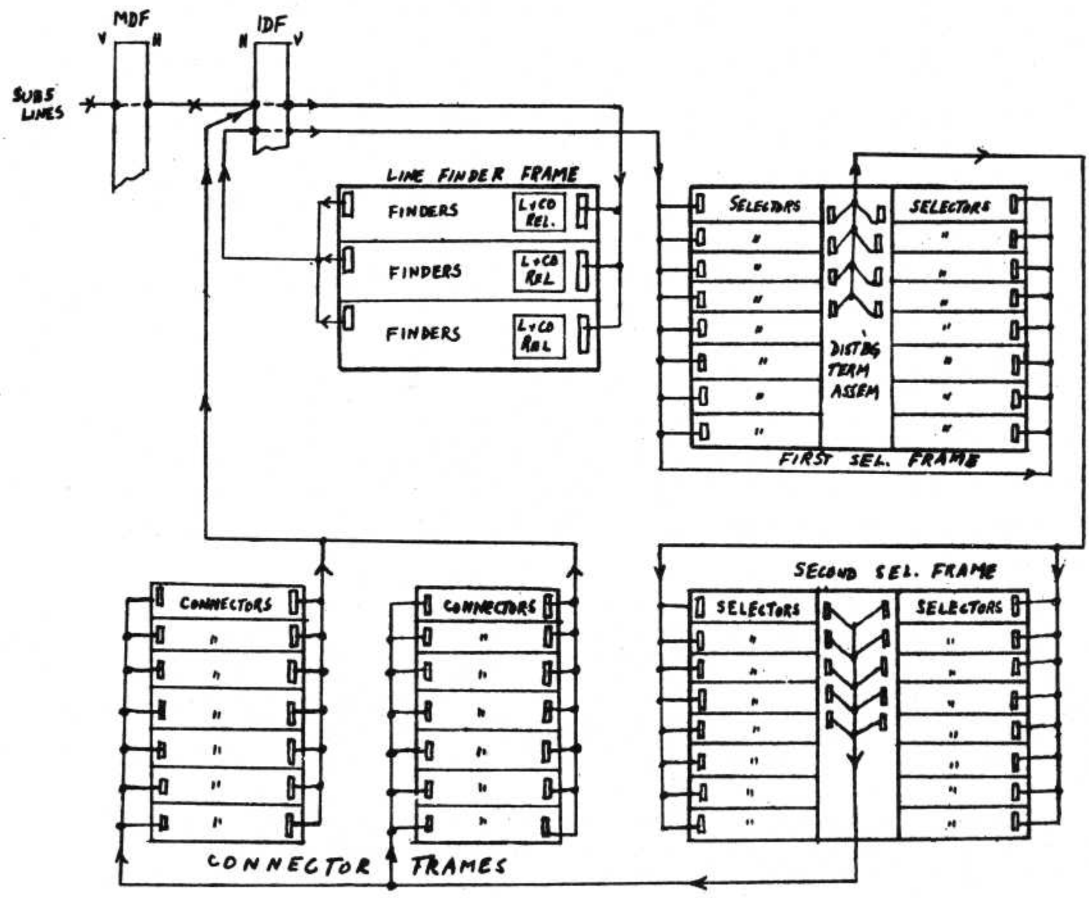


Figure F - Cabling Schematic Of Regular Switch Train

Figure G indicates that, in a 5-digit system, trunks to local second selectors are also taken off one of the levels of the first selectors, the level being determined by the first letter of the local office code. The first digit dialed by the customer will therefore determine whether the call is to be completed in his own office through local second selectors or in some other office over interoffice trunks. If the call is to be completed in his own office the first selector will choose a trunk to a local second selector. The second digit dialed by the customer (which will cause a second selector to step up to the required level) will choose the proper third selector and thus determine in which 1000 numbers the call is to be completed. Trunks incoming from other step-by-step offices in the area will terminate on incoming second selectors whose banks are multipled with those of the local second selectors.

4.2 6-Digit Operation

Where the number of central offices in an exchange area is greater than the number of available levels on first selectors, two digits must be dialed by the customer to determine in which office his call will be completed. This condition is illustrated by Figure H. In this case trunks to other offices will be taken off the banks of second selectors, trunks to all offices having the first digit in common being taken off the various levels of the same group of second selectors. In this case, third selectors are used to determine in which 1000 terminals a call through the local office is to be completed and incoming trunks from other offices will terminate on incoming third selectors with their banks in multiple with those of the local third selectors.

Trunks to 0 operator and to auxiliary first selectors will be taken off the tenth and first levels of the first selectors as before.

4.3 Graded Multiple

In previous discussions of selectors and selector levels it has been pointed out that while the selector is responsible for finding an idle trunk upon any given level, its choice of trunks on that level is limited to 10. This limitation in the size of a trunk group to which any given selector has access presents a different problem than does the outgoing

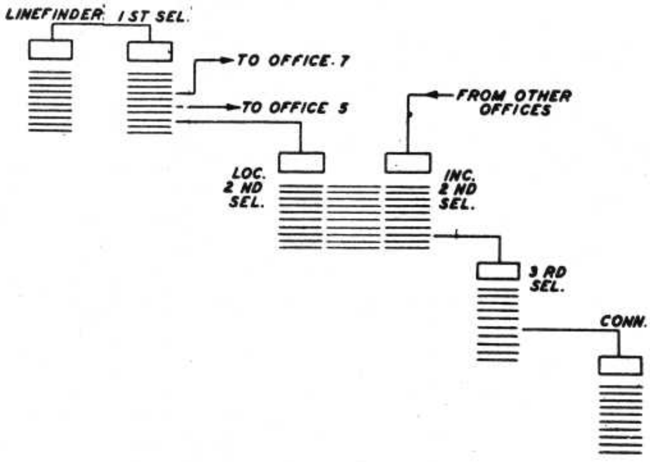


Figure G - "Step-By-Step System 5 Digit"

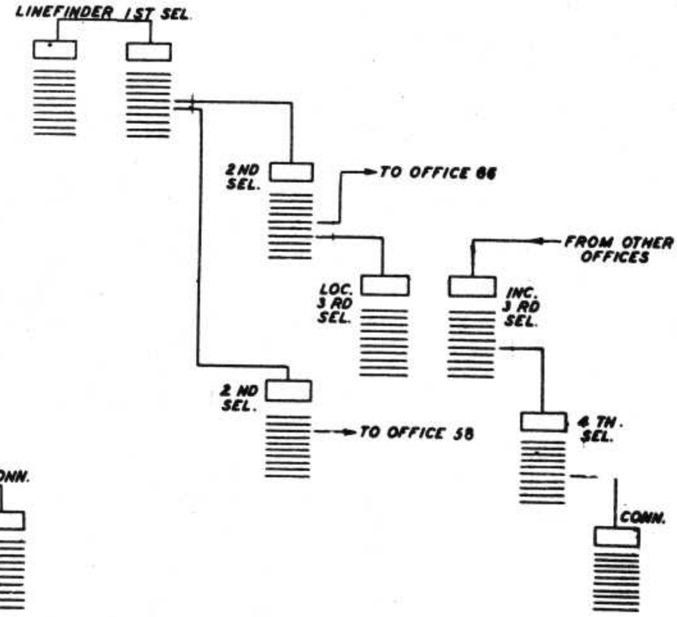
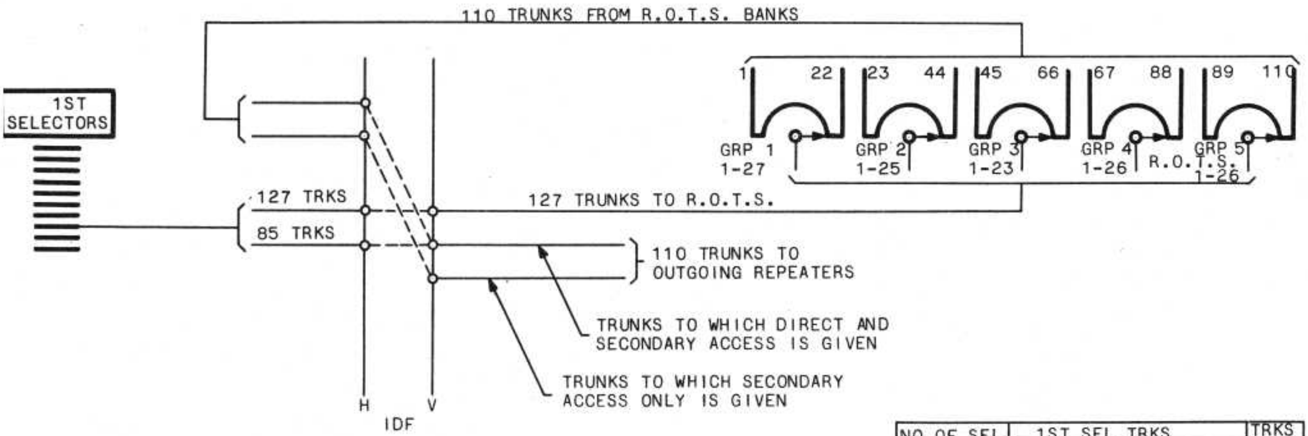


Figure H - "Step-By-Step System 6 Digit"

trunk multiple in the manual "A" board. Any given "A" operator on an "A" board has access to all trunks to any other office regardless of the size of the trunk group. In step-by-step operation, however, where a trunk group to another office or to a succeeding group of switches in the local office consists of more than 10 trunks, other provisions must be made for efficient use of those trunks. This is done in part by what is known as "Graded Multiple." Without graded multiple, trunks in the step-by-step system would always have to be supplied in multiples of ten which might be uneconomical. With graded multiple, however, 40 selectors can be made to use, say, 13 trunks effectively.

In order to explain what graded multiple is, it is first necessary to understand how selectors are arranged with respect to each other and how their banks are wired. In step-by-step central offices each selector frame is arranged to mount 16 shelves of 20 selectors each, making a total of 320 selectors per frame. Each selector frame consists of two bays, each mounting 8 shelves of 20 selectors each. The 20 selectors on each shelf are arranged in two groups of 10 selectors each. Each selector in a group of 10 has its banks multipled directly to the banks of every other selector in the group. Each group of 10 selectors in addition has its banks wired to a long terminal strip which is mounted in the center of the frame between the two bays of selectors. (See Figures 25, 26 and 27). Since there are 32 groups of 10 selectors each mounted on the frame, there are 32 of these terminal strips mounted one directly below the other down the center portion of a fully equipped frame. Each terminal strip therefore represents the 100 terminals of 10 selectors multipled together and these terminal strips are so arranged that each terminal, by means of an insulated vertical wire strap may be wired to the corresponding terminal of the terminal strip of any or all groups of 10 selectors on the frame. It is thus possible to multiple the banks of any one group of 10 selectors with those of any other group or groups as required. In addition to the bank terminal strips, the distributing terminal assembly bay includes two vertical rows of terminal strips on which switchboard cable to other frames is terminated. These outgoing circuits are associated with terminals on the bank terminal strips by means of jumper wires.

It does not always follow that the number of trunks to be considered in estimating traffic will be in multiples of 10. For example, cases may occur where 40 selectors are required to have access to a total of 13 trunks on a given level. In cases of this type graded multiple is used. In graded multiple certain trunks are termed first choice trunks and are not multipled together through all the groups of 10 selectors. If it is desirable to multiple the ten terminals of a given level of four different groups of 10 selectors each, on 13 trunks, one trunk will be connected to the first terminal of each group and these terminals will not be multipled together. The remaining 9 terminals of each of the four groups will be multipled together and connected to 9 trunks. Each group will then have one trunk which it alone uses and nine which it uses in common with three other groups. In graded multiple terms, the first trunks are termed "individual" trunks, while the remaining trunks are referred to as "common" since they are offered for the common use of all the selectors in all four groups.



NOTE -
DIRECT ACCESS TRUNKS ARE CROSS-CONNECTED DIRECT TO REPEATERS. SECONDARY ACCESS TRUNKS ARE CROSS-CONNECTED TO ROTARY OUT TRUNK SWITCHES, THE BANKS OF WHICH ARE CABLED TO THE HIDF AND CROSS-CONNECTED TO REPEATERS.

NO OF SEL SUB GRPS	1ST SEL TRKS PER SUB GRP	TOTAL	TRKS TO REP
14	12	168	
1	10	10	
2	12	24	
1	10	10	
		212	110

DIRECT TRKS TO REP-85 (40% OF 212)
TRKS TO R.O.T.S.-127 (60% OF 212)
GROUPS-5

Figure I - Application Of Rotary Out Trunk Switches

In order to reduce the hunting period and also to reduce the wear on switches, a reversal is usually introduced in the strapping. For example, assume 40 selectors having access to 10 trunks on a given level. Four groups of 10 selectors each are required and the first 2 groups will be multipled together straight and the last two groups will be multipled together straight with a complete reversal between the second and third groups for trunks 1 to 9. The tenth terminal is always multipled straight for all divisions in the group for last trunk busy registration.

4.4 Repeaters

In order to establish connection between two step-by-step offices not in the same building it is necessary to furnish an auxiliary circuit known as an "outgoing repeater" in each trunk circuit, at the originating office. The purpose of this repeater is to connect the three wire circuit from the selector banks to the two trunk conductors which run between offices; to repeat the dial pulses to the switches in the distant office; to hold the switches in the originating office operated during the call; to furnish talking battery to the calling subscriber, and to enable the connector in the distant office to supervise the calling line. It is also necessary to furnish a repeater of the same general type in each trunk from step-by-step to manual offices.

The average outgoing repeater will not retransmit the dial pulses with the same precision that a dial gives. Usually the switches in the distant office will operate satisfactorily on the repeated pulses. Where a trunk is very long however, the distortion of the pulses will be increased to a point where the distant switches will no longer function. In this case, a special repeater, called a "pulse correcting" repeater is added at the incoming end of the trunk. This repeater replaces the distorted incoming pulses by new pulses which will operate the switches satisfactorily.

4.5 Rotary Out Trunk Switches

Trunks to other offices must be carried in outside plant and where the distance is at all great it is highly desirable to keep the number of trunks between offices down to a minimum. As we have seen, the principle of graded multiple assists in accomplishing this purpose. Another device which considerably reduces the number of outgoing trunks provided from a group of selectors is known as the rotary out trunk switch. The mechanism used for the preselector is known as a 206 type selector and differs radically from the regular step-by-step mechanism. This selector is a rotary switch with brushes which have access to 22 sets of terminals and are so arranged that as soon as one set of brushes leaves the last set of terminals, a second set of brushes reengages the first set of terminals. The brushes are mounted on a shaft or rotor which is driven by a ratchet and pawl mechanism actuated by a magnet. Any trunk terminating in the brushes of such a switch will therefore have access to 22 outgoing terminals or trunks. Figure I indicates how these preselecting R.O.T.S.'s are used.

Outgoing trunks are connected to the banks of these switches and trunks from the banks of step-by-step selectors to the brushes. The term R.O.T.S. indicates that at any time when the switch is not in use it will rotate to the terminals of an idle outgoing trunk and rest there so that if the trunk incoming to the switch is chosen by a selector, an idle trunk out of the switch will be immediately available.

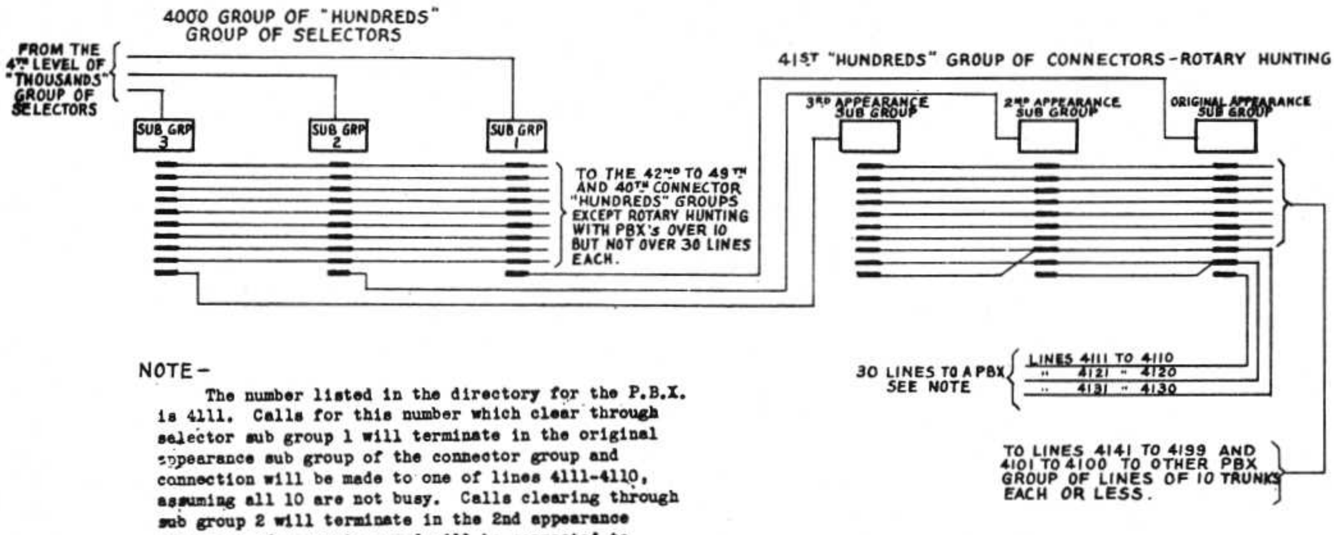
In order to illustrate the use of rotary out trunk switches, assume that a group of trunks to a given office is outgoing from a certain level of several groups of first selectors. When outtrunk switches are used, forty per cent of these trunks outgoing from the first selector levels are connected directly to trunks outgoing to the distant office. These "direct access" trunks will be located on the lower numbered terminals of the selector levels so that if a first selector finds an idle trunk in the lower numbered terminals of the level it will usually be one of these direct access trunks. The direct access trunks will therefore carry all the traffic during the light load of the day.

The remaining 60% of the trunks from selector levels are cabled direct to the brushes of rotary out trunk switches. All trunks outgoing to the office in question, including the direct access trunks, will be wired to the outgoing terminals of the R.O.T.S. During the peak load periods of the day when the direct access trunks will no longer carry the traffic the first selectors will choose trunks to the R.O.T.S.'s which will previously have chosen an idle trunk to the distant office. This use of R.O.T.S.'s results in a very considerable reduction of the number of outgoing trunks required.

4.6 Private Branch Exhange Trunks

Business houses requiring private branch exchanges or small switchboards for handling their own private telephone business usually require a number of trunks from connector terminals. Usually the connector terminals representing the trunks to various business houses will be segregated into one or more groups of 100 connector terminals and the connectors serving these groups will be "rotary hunting" in that they will hunt over a group of trunks to a private branch exchange if the first happens to be busy. The trunks in each group must be arranged in sequence so that when the listed number is called, if the first trunk is busy the connector will automatically hunt over other trunks to the same P.B.X. on the same level. Since the calling rate to business house lines is usually higher than is normal for the rest of the office, special size groups of connectors will usually be required to serve 100 such lines.

If less than 10 trunks are required to a given P.B.X. several small groups of P.B.X. trunks may be placed on the same connector level. The listed number will be dialed in each case and the connector will step to the first trunk of a group under the influence of the dial and hunt over only those trunks on the level associated with the particular listed number. If all trunks are busy, a circuit condition on the last terminal of the group causes the connector to send back the busy signal in the usual manner. The only restriction is that the trunks in a given group must have consecutive telephone numbers.



NOTE -

The number listed in the directory for the P.B.X. is 4111. Calls for this number which clear through selector sub group 1 will terminate in the original appearance sub group of the connector group and connection will be made to one of lines 4111-4110, assuming all 10 are not busy. Calls clearing through sub group 2 will terminate in the 2nd appearance sub group of connectors and will be connected to one of lines 4121-4120. Likewise, calls clearing through sub group 3 will terminate in lines 4131-4130.

Figure J - Multiple Slip Arrangement For Connector Groups Serving PBX Groups Over 10 Terminals

In the event that the number of trunks to a given private branch exchange exceeds ten, various methods have been devised to give equal access to all trunks from connector levels. Figure J illustrates one arrangement whereby this is made possible.

Assuming for purposes of illustration that the P.B.X. 100 group is the forty-first hundred, the bottom row of terminals on the connector bank would normally be lines 4111 to 4110, the lines on the second level 4121 to 4120 and on the third level 4131 to 4130. Assume also that all 30 of these connector terminals are required to serve a group of trunks to a private branch exchange. The first group of connectors will have the first three levels arranged as we have just stated. The second group of connectors will have lines 4121 to 4120 on both the first and the second levels with lines 4131 to 4130 on the third level. The third group of connectors will have lines 4131 to 4130 on the first and third levels with lines 4121 to 4120 on the second level.

The number that will be dialed to obtain any one of these trunks will be 4111. If this call is to be completed through the first group of connectors, the particular connector will step up to the first level and will thereupon hunt over lines 4111 to 4110 for an idle trunk to the P.B.X. If a connector in the second group is used for the call, it will step up to the first level and hunt over lines 4121 to 4120 and if a connector in the third group is used, it will hunt over the lines 4131 to 4130. In this manner access is provided to each of the trunks in the group of the private branch exchange.

A connector equipped to serve a larger group of P.B.X. trunks is known as a level hunting connector. The trunks are connected to the various levels consecutively. The listed number is the first terminal on the first level. This type of connector will hunt completely over the first level, restore to normal if there is no idle trunk on that level and then by means of a commutator and a "recording switch," which is mounted on the connector, will step to the second level and hunt over that. This is continued over the various levels until an idle terminal is reached or until all trunks have been tested.

<u>NOTE</u>: Step-By-Step Dial System Pamphlet No. 37 is canceled and is replaced by "Lesson No. 3 The Step-By-Step Dial Telephone System" and this section No. 7.

R. E. RAHMES

Engineer of Installation