THE PANEL DIAL TELEPHONE SYSTEM

Telephone Systems Training

COURSE: CENTRAL OFFICE EQUIPMENT

LESSON NO. 4

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

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Section 1. History and Development

The invention of the telephone in 1876 by Alexander Graham Bell opened the way for development in the electrical transmission of speech by wire. In the early stages of this development, the tendency was constantly toward the substitution of automatic devices for some of the operations performed by telephone operators. As accomplishment in this direction became more marked, research was begun into the question of eliminating the operators entirely by the substitution of electrically controlled machinery.

In this connection it may be interesting to note that as far back as 1879, only about three years after Alexander Graham Bell's invention of the telephone, an application for patent was filed which covered the first attempt at the automatic switching of telephone lines. This patent was granted to Connolly, Connolly, and McTighe for a very crude and inefficient device. Although not successful, it was the beginning of a long line of research and invention.

Since then, inventor after inventor has attacked the problem until about 2,500 patents have been issued by the United States Patent Office relating to mechanical switching telephone systems and equipment, and at the present time such patents are being issued at the rate of approximately one every three days. In addition hundreds of patents have been issued to inventors in foreign countries, notably in Germany, France, and Great Britain. Many of the inventions are crude in concept, and are entirely uncommercial in their adaptability to the telephone industry, and might be termed mere paper inventions. This, however, is true of all branches of the arts and sciences since many invent who have little skill in mechanics or little knowledge of the art or science into which they have delved. However, many inventions in the art of automatic telephony, which in themselves are impracticable and seemingly in the nature of patent monstrosities, possess the nucleus of basic principles of mechanical switching.

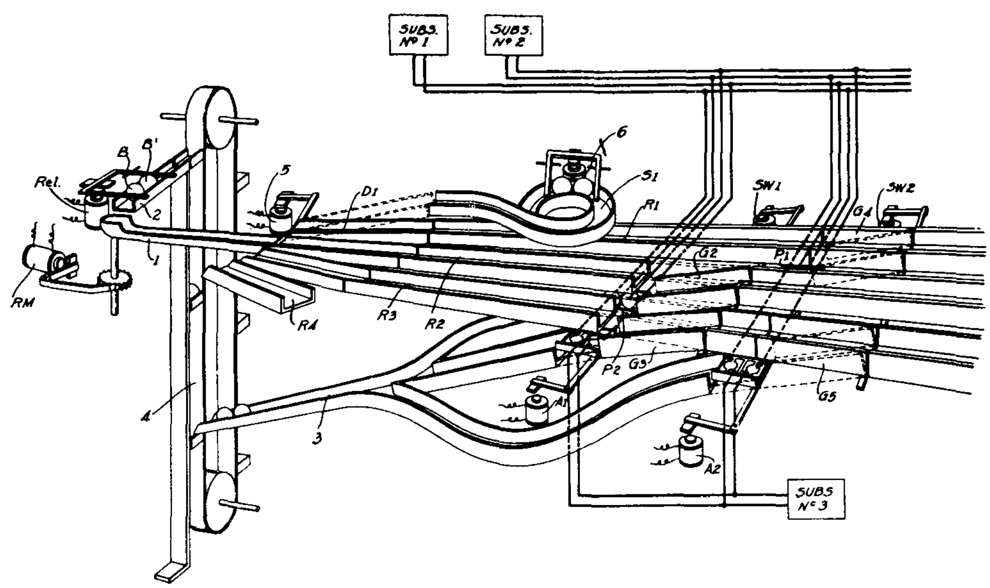


Fig. 1 Callender Mechanical Switching System

One of the most unique of the early suggestions is found in the patent to Callender, granted in January, 1894. Probably every child has arranged run-ways and watched marbles roll to various receptacles. This childhood game has been ingeniously utilized by the inventor for establishing telephone connections. How this was accomplished is shown fragmentarily in Fig. 1, from which most of the electrical circuits have been omitted for clarity and in which only two of the possible ten subscriber lines have been shown. Briefly, the method of making connections is to route steel balls from a storage rack, by means of magnetic devices, into inclined troughs.

The Bell System became actively engaged in the development of automatic switching equipment about 1900. The Rotary System, one of its earliest accomplishments, was so named because the switches had rotary motion only. This system was never used in this country.

The Bell System was not satisfied merely with a mechanical system, but it had in view a much broader purpose. Its object was to produce mechanical central office equipment for commercial manufacture and operation that would reduce manual operations with their attendant errors to a minimum, and at the same time meet the complex service requirements of the largest cities. The problem was a tremendously difficult one due to the size of some of the exchange areas involved, and to the necessity for transition equipment. Before an automatic switching system can be widely employed it not only has to work properly within itself, but means have to be devised whereby it can be made to work successfully with existing manually operated systems. If we consider that the New York Metropolitan area, which in 1919 had a total of about 828,000 telephone lines served from 86 central office units and is conservatively expected to grow to 2,700,000 lines served from 225 central office units in 1950, it may be possible to gain some conception of the magnitude of the project.

Each subscriber in this colossal system must be able to reach every other subscriber. Due to the large area covered, a great number of city calls involve extra charges. This means that such calls must be supervised, timed and ticketed. Nor should it be forgotten that many classes of service are demanded by the public: flat rate, message rate, coin box, and pay station.

Add to this, single-party, two-party and four-party service; then picture a densely populated surrounding country involving several hundred cities and towns from which come and to which go thousands of messages each day, all of which must be recorded, supervised, and timed, and it becomes clear that the problem of producing switching equipment flexible and versatile enough to perform sufficient work to replace enough operators to warrant its existence, is not one that can be solved except after years of development work.

When the development of suitable equipment had been brought to a point where it seemed possible definitely to plan its application, a detailed survey of existing conditions was made. A careful study of the service requirements of large cities indicated that since a great number of calls from one station to another had to be supervised, timed and ticketed, which of course meant that a considerable number of operators would be needed, the most practical procedure would be to retain the "A" operators, before whom the subscriber lines terminate, to perform these functions and to introduce mechanical equipment under the operator's control, whereby they could set up any desired connection, either in their own office or in any other office in the city. The scheme had several advantages among which were: It kept the telephone at the subscriber station the same as in manual, a standard common battery instrument; it would, when generally installed, eliminate the "B" operators at all offices and with them the troublesome "call wire" then in use; it made it possible for the "A" operators to handle a greater number of calls than they could on a manual basis; it permitted the "A" operators to supervise, time and ticket those calls which required such service; and it kept the control of the mechanical equipment in the hands of trained operators who could be supervised.

A small trial installation of this semi-mechanical equipment (partly manual and partly mechanical) having been made in 1910 in the Western Electric Company, West Street Laboratories, and such defects as could be detected weeded out, it was decided that a trial installation of this system should be made on a scale large enough to test its feasibility as a system under such conditions as would be encountered in a city of some size. It was also necessary to test further the practicability of the mechanism. It was realized that much of the data obtained on the performance of the equipment would apply equally well whether it was to be controlled by operators in a semi-mechanical system or by the subscribers in a full mechanical system. Accordingly, in 1914 a large installation of semi-mechanical equipment was started in the city of Newark, New Jersey, and arranged to serve three offices, Mulberry, Waverly, and Branch Brook. The Mulberry and Waverly units were completed first, but the Branch Brook unit was not cut into service until 1917. The equipment was designed to provide service between the three semi-mechanical offices; two-way service between all other manual offices in the city and the three semi-mechanical units; and regular service to outside points from and to any of the semi-mechanical units.

In the trial installation the central office equipment was of the "panel" type with which connections are made by power driven equipment. Brushes are driven up or down in front of groups of terminals in flat panels or banks which make connection with these terminals. Equipment is located on frames as shown in Fig. 2.

These trial offices are the only semi-mechanical panel dial offices ever to be installed; subsequent installations all being of the full mechanical type.

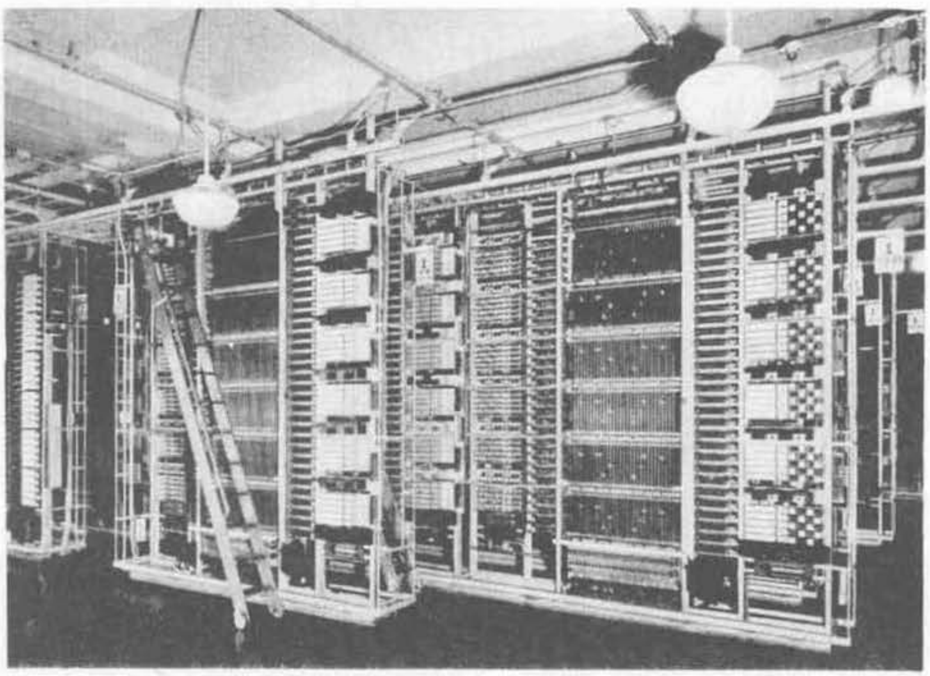


Fig. 2 Typical Panel Dial System Frames

The results obtained from the trial installations indicated that the system was entirely operative and that the equipment, while requiring certain minor modifications, was practical and successful. It also established accurately what could be expected in the way of economies on such a system when compared with a manual or full mechanical system, and on the basis of labor conditions being the same as when the semi-mechanical system was conceived, it was more economical than the manual system and compared favorably with a full mechanical system.

During 1917 the Bell System planned to proceed with the introduction of panel dial equipment on the following basis: Semi-mechanical systems in large multi-office areas, such as New York, Chicago, Boston and Philadelphia; full mechanical systems in smaller multi-office areas such as Detroit, Milwaukee, St. Louis and Cleveland. Then the World War came along with its unprecedented effect on labor conditions throughout the country. The annual cost of operating a single position of switchboard increased enormously. This increase in cost was in turn accompanied by a serious shortage of operators and a marked decrease in the period that an operator remained in the employ of a telephone company. These conditions, together with the fact that a satisfactory numbering scheme had been worked out for large cities, led to the adoption (1918-1920) of the full-mechanical panel dial system for both large and small multi-office areas. In addition, the Bell System decided to install full mechanical step-by-step equipment in certain single and multi-office areas where the use of this equipment would be advantageous.

Another phase of the problem which concerns the telephone company and the public is that of employing a sufficient number of girls to work as operators even when labor conditions are quite normal. In 1910 the New York Telephone Company was using a force of operators equal to 9 1/2% of the total number of girls in the New York Metropolitan area who met the qualifications which they set up for satisfactory operators. In 1920, their force was equal to 19% of all who met such qualifications; and according to their best forecasts, their requirement in 1930 would have been equivalent to 43% if their expansion had been taken care of by manual equipment. It is obvious that such rapidly increasing requirements could be filled only by the keenest competition with others employing similar grades of labor, and that the rates of pay would reach almost prohibitive heights. It is also clear that the rates of pay of one particular class of labor cannot be so very greatly increased without having a similar reaction upon all classes of female labor. Every means must be provided, therefore, to prevent such an abnormal increase, and this additional factor gave further impetus to panel dial installations.

The following table shows the yearly increase of panel dial lines in service since 1923. A "line" ordinarily takes care of one subscriber, and frequently serves two or four subscribers. There may be instances, too, in which a number of lines connect a central office to a large hotel or office building where a great many dial telephones are in use. Therefore, lines do not give a true picture of the number of dial telephones actually in use, but determine the amount of equipment located in a central office for handling traffic. For instance, the capacity of every central office is 10,000 lines. This means that there are 10,000 "paths" into the office which can supply service to perhaps 20,000 to 30,000 dial telephone users.

PANEL DIAL LINES

1923	100,030	1930	1,235,111	1937	2,148,650	1944	3,060,513
1924	251,652	1931	1,462,175	1938	2,314,120	1945	3,161,023
1925	427,767	1932	1,614,105	1939	2,442,972	1946	3,332,150
1926	542,958	1933	1,701,988	1940	2,667,911	1947	3,394,518
1927	673,583	1934	1,781,060	1941	2,783,301	1948	3,401,808
1928	797,655	1935	1,863,218	1942	2,857,811	1949	3,461,245
1929	992,639	1936	1,983,647	1943	3,001,148	1950	3,517,149
						1951	3,559,740

1952 Lines 3,613,026 Subscribers 7,006,458

The installation of full-mechanical panel dial central offices started in 1920 and continued extensively until 1938. In that year a new dial system known as "Crossbar" was brought out to be installed in all areas where panel ordinarily would be used. While crossbar equipment is now being installed in large cities wherever manual offices are being changed to dial or new offices are required, panel equipment is still being added to existing panel offices. The following is a partial list of some 27 cities that have panel dial office installations.

New York, N. Y.	Detroit, Mich.
Chicago, Ill.	Washington, D. C.
San Francisco, Cal.	Cleveland, Ohio
Brooklyn, N. Y.	St. Louis, Mo.
Philadelphia, Pa.	Buffalo, N. Y.
Pittsburgh, Pa.	Baltimore, Md.
Seattle, Wash.	Patterson, N. Y.
Boston, Mass.	Omaha, Neb.
Kansas City, Mo.	Cincinnati, Ohio

It may be interesting to know that the panel dial and crossbar dial systems have been so developed that both of these systems as well as manual may be used in the same city at the same time.

Section 2. The 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.

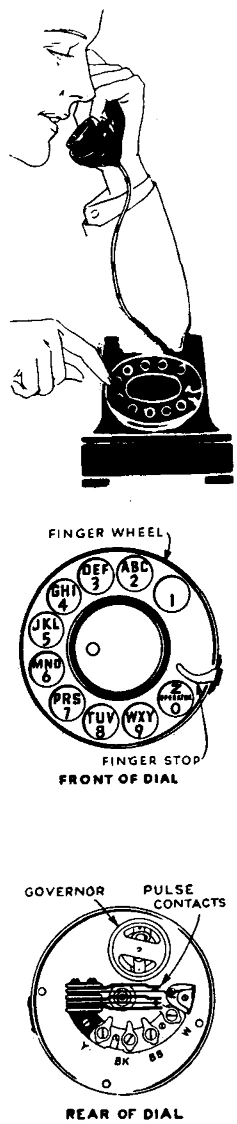


Fig. 3 Dial

Since an electro-mechanical switch cannot respond to the voice of the subscriber as an operator can, each subscriber equipment includes a "dial" (Fig. 3), 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. 4) would be some form of an electro-mechanical switch electrically connected to the subscriber line, the 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 subscriber 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 telephone 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. 5. 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. The second rotation of the dial operates the selector arm of the second switch. To insure that the second switch is operated by the second rotation of the dial and the first switch not moved, a slow release relay is included in the circuit. 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 dial telephone systems.

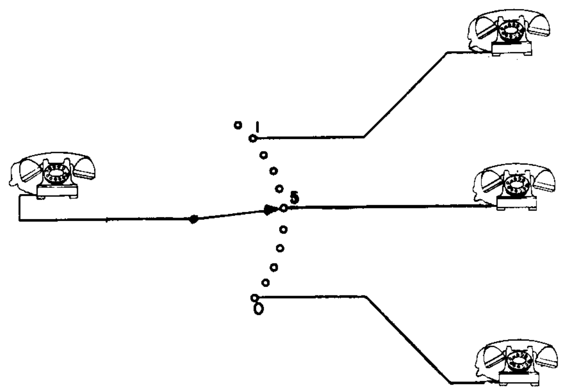


Fig. 4

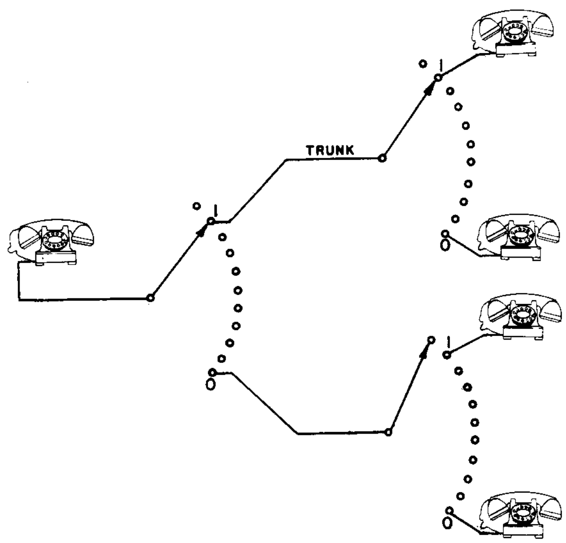


Fig. 5

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 of these switches is provided for a group of subscriber lines, the lines being connected to the terminals of the switch bank. The switch is so designed that when a subscriber lifts his receiver, the 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 a 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. 6 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. 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. 6. 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.

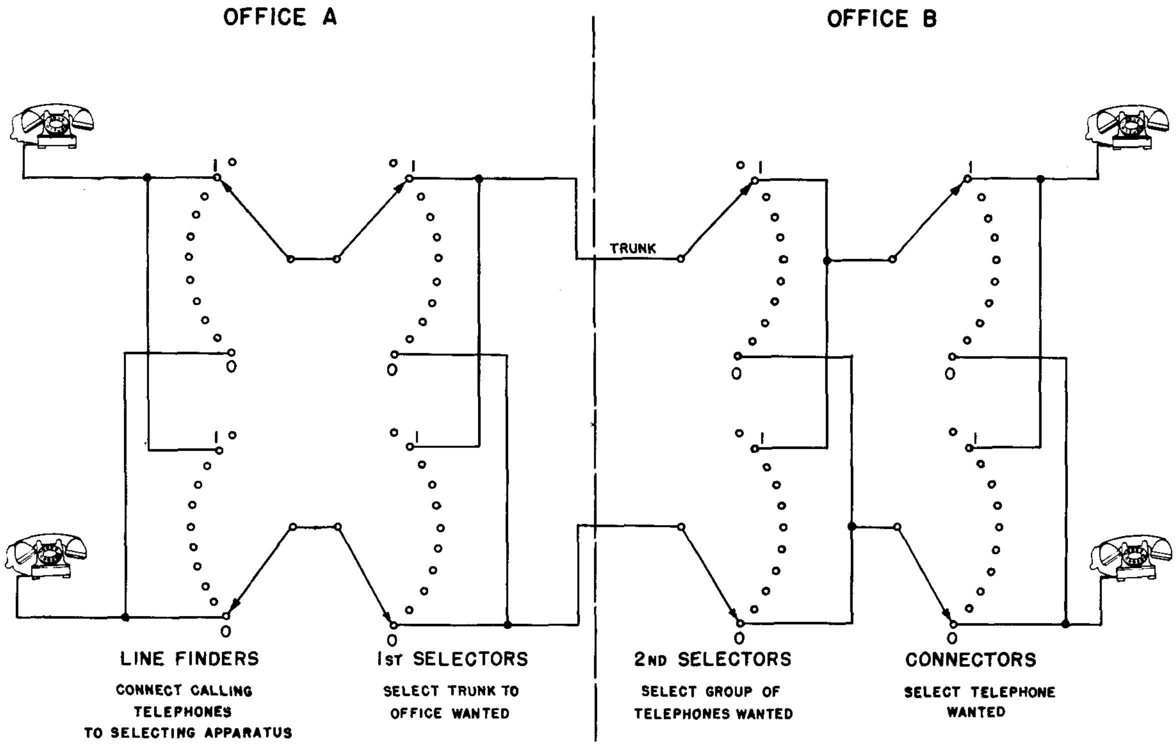


Fig. 6

If all trunks in one of these small groups become busy, a selector hunting in that group will not be able to complete the call, although there might still be idle trunks in other groups. Could all of these trunks be put in one group so that each selector could hunt over all of them it would always be possible for every selector to complete a call so long as any trunk was idle. One group of twenty trunks will in this way handle more than twice as much traffic as a group of ten trunks. Where a large number of trunks is required to each office, the advantages of equipment so constructed that the selectors can hunt over large groups of trunks are apparent. The realization of this, coupled with the fact that trunking systems in the larger cities are necessarily complex, was largely responsible for the development of the panel dial type selector.

The panel dial system equipment is so constructed that the selector may hunt over a group of trunks as large as ninety if desired or this may be split up into groups of 5, 10, 20, 30, etc., so as to supply the proper number of trunks for efficient service.

When a trunk group of over ten is used, it is necessary to abandon direct control by the subscriber dial, since it is not mechanically practical. The time interval required in moving the selector over a group of 90 trunks might be so great that it would exceed the interval between the dialing of two digits, and the second digit would be dialed before the first had been registered in the selector. If a selector were choosing the fourth group of trunks in a bank, it might be necessary for it to jump ten trunks at the first step, twenty at the next, and possibly forty at the third step. This would be a very difficult matter to arrange. Other reasons for abandoning direct control will appear as the system is considered in more detail.

When direct control is abandoned, there is no longer any object in having the selectors move by steps, and since the equipment, to work over such large groups of trunks, is necessarily somewhat large and heavy, it is found more practical to move the selectors by means of an electric motor which will provide ample power and positive motion. In addition to the abandonment of direct control, it is necessary, in such a large and complicated installation as that required in a large city, to abandon also numerical selection, for it is often impractical to make the group of trunks desired when, say, the digit "9" is dialed, the ninth group of trunks. If it is necessary to reach the fifth group of trunks when the digit "9" is dialed, some means must be provided to move the selector over five groups, although the dialing actually breaks and makes the subscriber line circuit nine times. It will be seen later that there are also other reasons for doing away with numerical selection.

Having abandoned direct control and numerical selection, the digits which the subscriber dials have no direct relation to the groups of trunks to which the various selectors move in completing his call and the selectors do not move in unison with his dialing. Therefore, it is necessary to provide equipment which will receive the dialing from the subscriber, record it, hold it, change it as necessary, and transmit it to the various selectors so as to control their movements and direct them to the proper setting. This mechanical operator, or intelligence of the system, is called the "sender."

The principles of panel dial switching are shown diagramatically in Fig. 7. The terminals over which the selectors move are arranged in flat vertical rows rather than in arcs, and the selectors are moved by electric motors rather than by electro-magnets. There is no direct control of selections by the subscriber dial, but rather, the dialing is registered in, and the movement of the selectors is controlled by the sender. This allows for greater flexibility and a more complex and extensive trunking arrangement than is possible with the use of direct control.

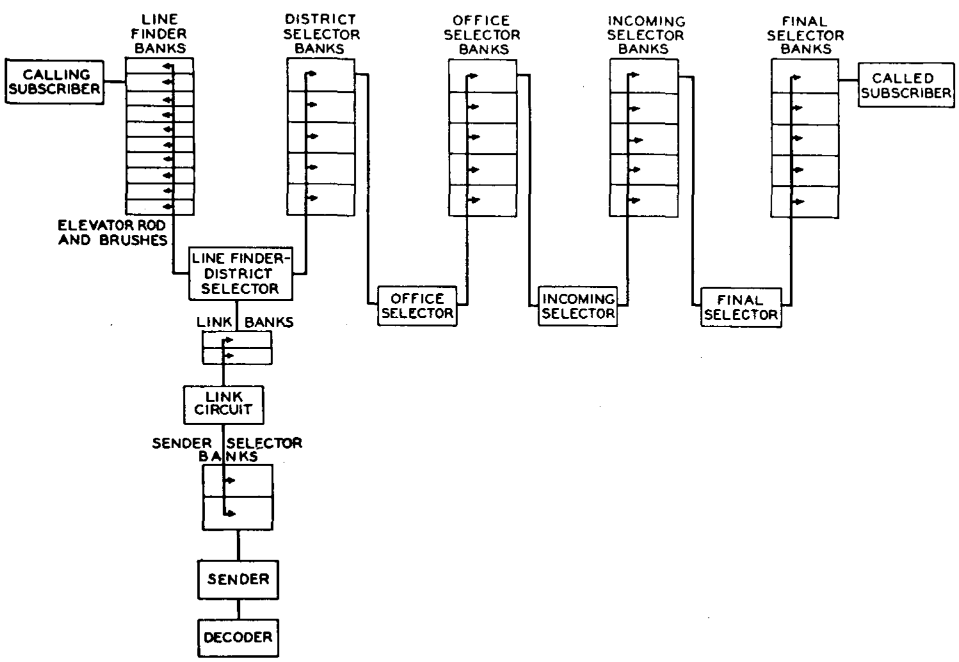


Fig. 7 Principles of Panel Dial Switching

Section 3. Equipment

Panel dial frame equipment consists essentially of the following: friction roll drive, clutches, racks, drive motor, multiple banks, brush or selector rods, multiple brushes, trip rods and trip fingers, commutators, commutator brushes, sequence switches, relays, resistances, condensers, fuses, interrupters, and rotary selector switches. The amount and type of equipment on a particular frame is determined by the function of that frame in the system. Fig. 8 shows an installation of a typical selector frame, fully equipped.

In order to understand the operation of the panel dial system, it is necessary first to study the mechanical details of the various pieces of equipment which are mounted on the frames in the panel dial office.

Connections are made by power driven equipment, brushes mounted on selector or brush rods being driven up and down in front of groups of terminals, arranged in flat panels or banks.

Selector frames provide capacity for mounting five banks of multiple terminals, one bank above the other, and 60 sets of selecting or multiple brushes. Terminals on these banks project on both the front and rear, and consequently, multiple brushes are placed on both sides of the banks, 30 sets on the front and 30 sets on the rear. Multiple brushes, one for each multiple bank, are mounted on hollow rods which move up and down, carrying them over the multiple bank terminals. The movement of these selector or brush rods is controlled by a friction roll drive, located below the bottom bank. The lower part of the selector rod connects to a rack, which is associated with a clutch, mounted in front of the friction roll drive. The brush rod movement is controlled by the rack through the action of the clutch which forces the rack against the moving friction roll. The friction roll drive provides two rolls for the front of the frame, and two for the rear. The two rolls in each pair rotate in opposite directions, thus providing for both the upward and downward movement of the selector rod. Another type selector frame has the friction roll drive arranged with three rolls, both front and rear, designed to provide two different speeds upward.

The multiple bank (Fig. 9) consists of a number of long narrow strips of brass, or in some cases bronze, and strips of insulating paper, superimposed alternately on one another and held together under compression in a metal framework of flat rectangular shape, and mounted vertically in a panel dial frame. The insulating paper strips are impregnated and coated with an asphaltum compound. Each brass strip is formed with contact lugs or terminals projecting along its two edges, with which the brushes on the selector rod make contact. Ordinarily, multiple banks are associated with 3-wire circuits (trunks or lines). Three brass strips are then required in the bank for each line or trunk, the lower one supplying the "sleeve" terminal, the middle one the "ring" terminal, and the upper one the "tip" terminal. Each brass strip is so formed that it has 30 contact terminals on each edge, so located along the strip that when the strips are in place in the bank the various sets of terminals appear in the form of thirty "columns" on each face of the bank corresponding in lateral position to the 30 selecting mechanisms for which each side of the selector frame makes provision. Each of the 30 columns is composed of three vertical rows of individual terminals; that is, one row of tip terminals (left), one row of sleeve terminals (center), and one row of ring terminals (right), thus providing 100 sets of terminals in each column.

To guide the brushes along the proper path as they are lifted from their normal position below the bank, six die-cast combs are mounted on each side (front and rear) of the horizontal frame bar. Each comb provides prongs or teeth for guiding five brushes. To perform a similar guiding function at the top of the bank, should any of the brushes travel beyond their normal

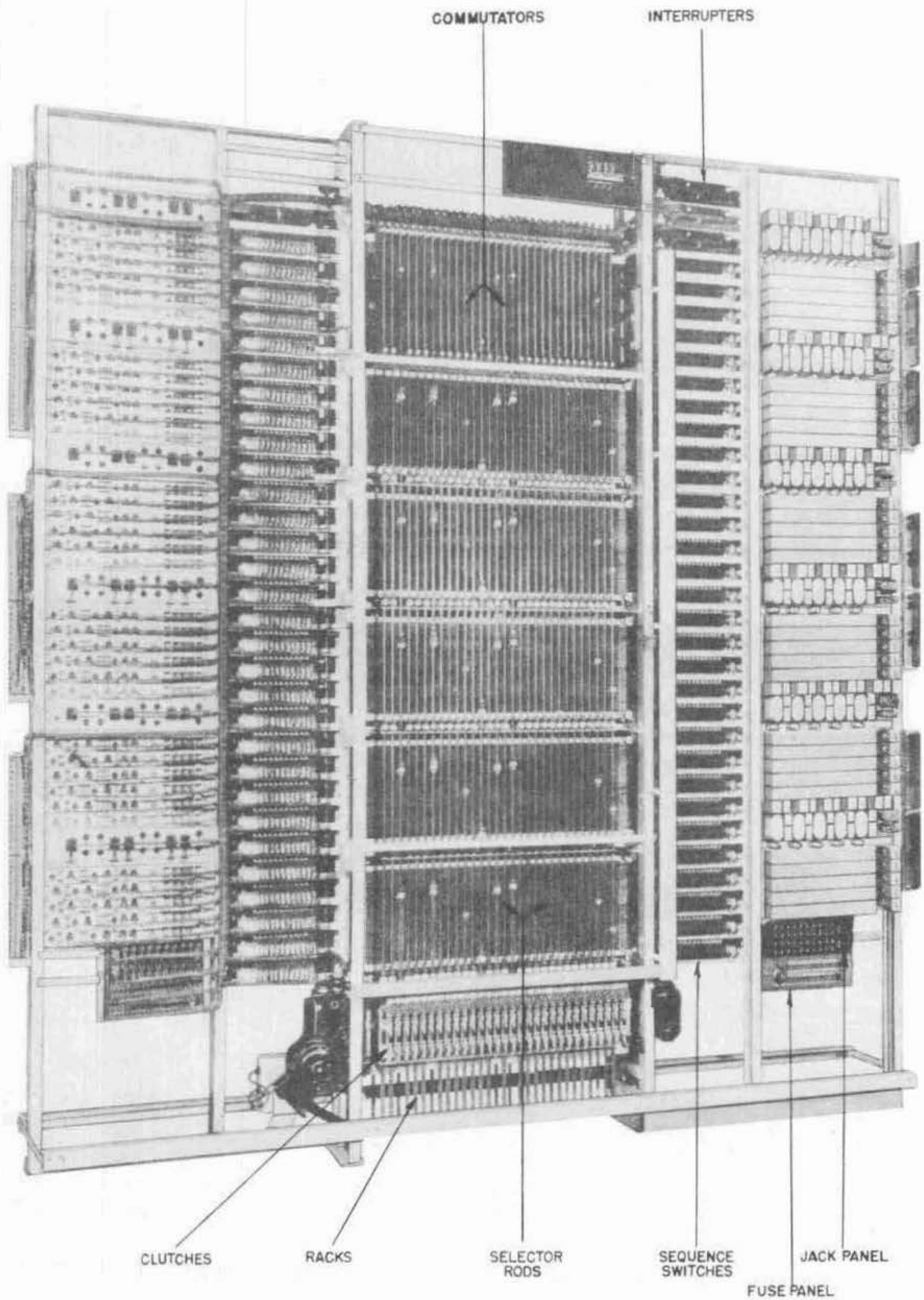


Fig. 8 Typical Panel Dial Selector Frame

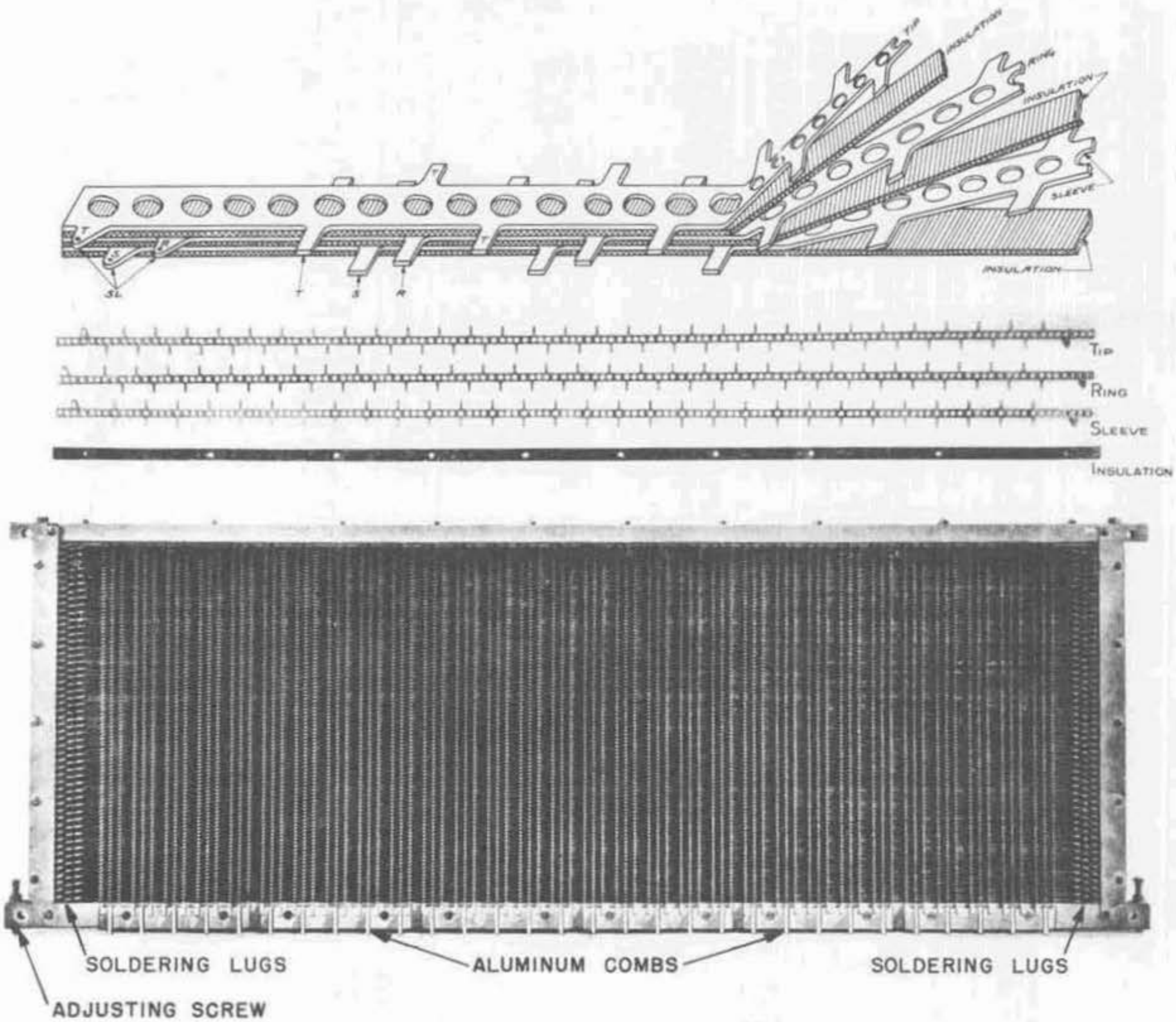


Fig. 9 Panel Multiple Bank

range, eight of the punched bank strips, without paper insulation, are mounted just below the top horizontal frame bar. The total pileup of a bank thus consists of 308 metal strips and 302 paper strips.

Multiple banks in a line finder frame are made up somewhat differently. One additional terminal, known as the "hunt" terminal, is added to each set, making 4, and the columns contain 40 sets.

Fig. 10 shows the relation between a multiple brush and bank terminals.

Multiple brushes (Fig. 11) consist of a set of springs with contacts at the tip ends, a trip lever, and a resetting lever. Brushes are mounted on a selector rod, one brush for each multiple bank in the associated frame. The brush contacts wipe over and make contact with the bank terminals when the brush is tripped, as the selector rod is raised or lowered. The springs of the brush are so arranged that the inner two contacts make a sliding connection on both sides of the sleeve (center) bank terminal, and the two outer spring contacts make connection with the outer part of the tip and ring bank terminals. Brushes on a selector rod are connected in multiple, and only one brush on any one selector rod is used at any one time, the others remaining idle. The tripping mechanism trips only the brush in use, while the springs of the idle brushes remain in the untripped or normal position, so that their spring contacts do not engage with the bank terminals as the selector rod moves up and down.

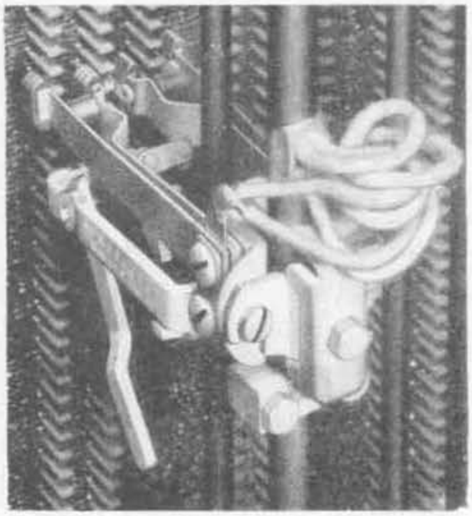


Fig. 10 Multiple Brush and Bank Terminal Relationship

The "selector rod" is a hollow piece of brass tubing, in general approximately 1/4 inch in diameter and 7 feet long, although in some cases the length will vary. Multiple brushes are attached to the selector rod, one brush for each multiple bank of the associated frame. A commutator brush is attached to the upper end of the rod, and

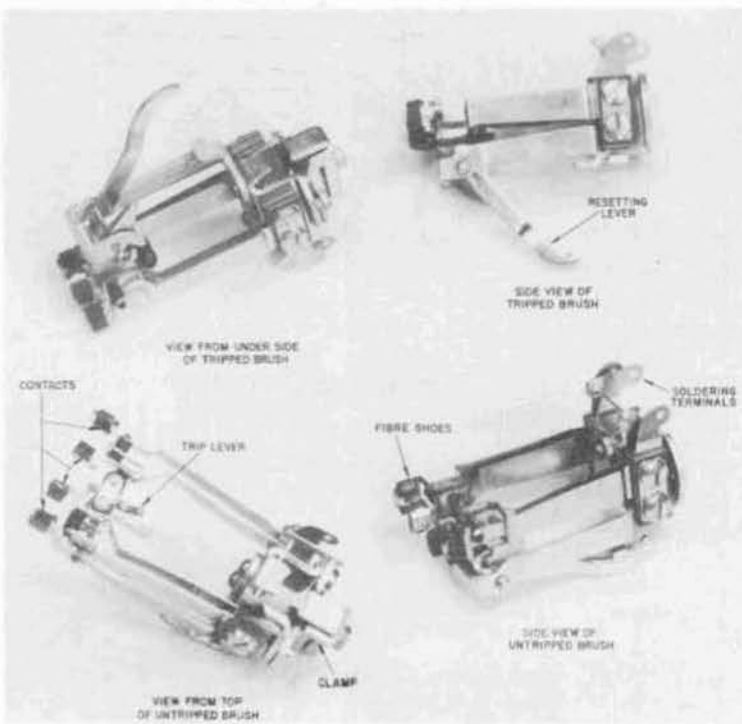


Fig. 11 Multiple Brush Assemblies

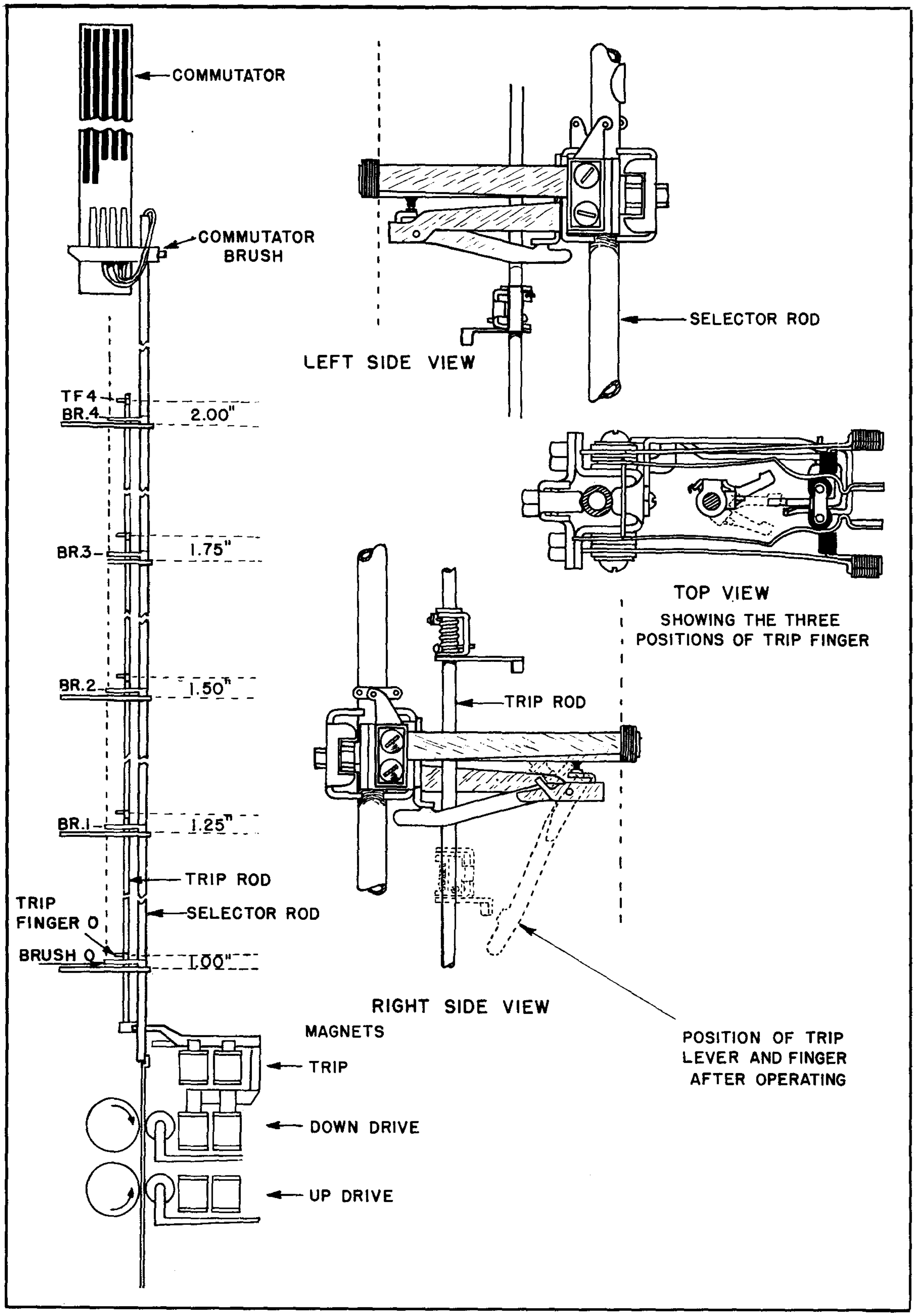


Fig. 12 Relationship between Trip and Brush Mechanism

a rack to the lower end. Selector rods are mounted vertically on both front and rear of various frames, the total capacity being 30 on each side, although it is only under heavy traffic conditions, that the full capacity of a frame is required.

The trip rod is a brass rod about 1/8 inch in diameter and 6 feet long, mounted vertically between the banks and the selector rod. It is located in definite relationship to the position of its associated selector rod, and held in this position by means of a number of clamps, fastened to both itself and the selector rod. One trip rod is furnished for each selector rod. A lug arrangement is attached to the lower end of the trip rod, which together with an armature on the clutch trip magnet, provides rotary motion to the trip rod. A spring is so arranged that the trip rod assumes its normal position after being operated and released by the trip magnet. Trip fingers are attached to the trip rod, one finger for each brush on the associated selector rod, so placed with respect to the brush location, that only one brush on a rod will be tripped at any one time, the other brushes remaining in their normal position, due to the "offset" spacing location of the other trip fingers. Fig. 12 shows the relationship between trip and brush mechanisms.

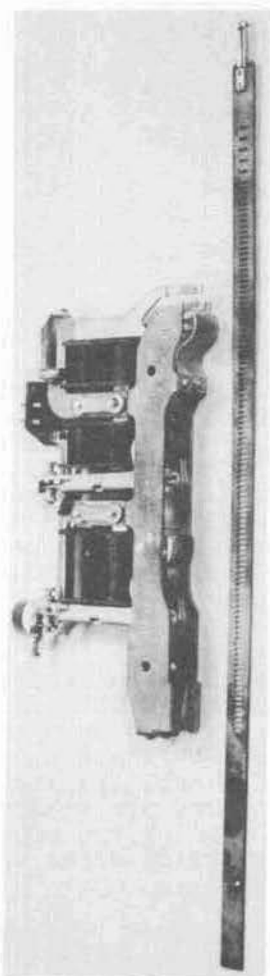


Fig. 13 Clutch

The rack, attached to the lower end of the selector rod, is a flat bronze strip with narrow rectangular slots. The distance between the slots is the same as that between successive terminals in a bank, except for five slots at the top of the rack which are used in connection with the tripping of the brushes. A pawl on the clutch engages the rack slots, and after a selector rod has raised the brush to the proper level, it holds the rod at that point. The rack provides the means of raising and lowering the selector rods, in conjunction with the friction roll drive.

The clutch (Fig. 13) consists of an iron framework supporting from two to four double spool magnets, associated armatures equipped with rollers, a pawl, and a terminal strip. Clutches are mounted directly in front of the friction roll drive, both front and rear of the frame, with one clutch required for each selector rod. The top magnets, except for those few cases where brush tripping is not required or performed in some other way, are the trip magnets. The next lower set are the down drive magnets. Third are the normal or up-drive magnets for high speed, and the bottom on frames requiring it, are the up-drive magnets for low speed. A roller arm which carries the roller, and an armature pivoted at the same fulcrum as the roller arm, provides the motion to force the roller against the rack, which in turn is forced into contact with the friction roll drive, to move the selector rod. The pawl holds the rack at the desired point. The armature of the down drive magnets, when operated, releases the pawl, and the roller forces the rack against the friction roll, causing the selector rod to return to its normal position. Comparatively little pressure is required to drive the rack down because it would fall by gravity when the pawl is lifted if it is not restrained. The down drive acts merely to check the speed of the selector rod in returning to its normal position.

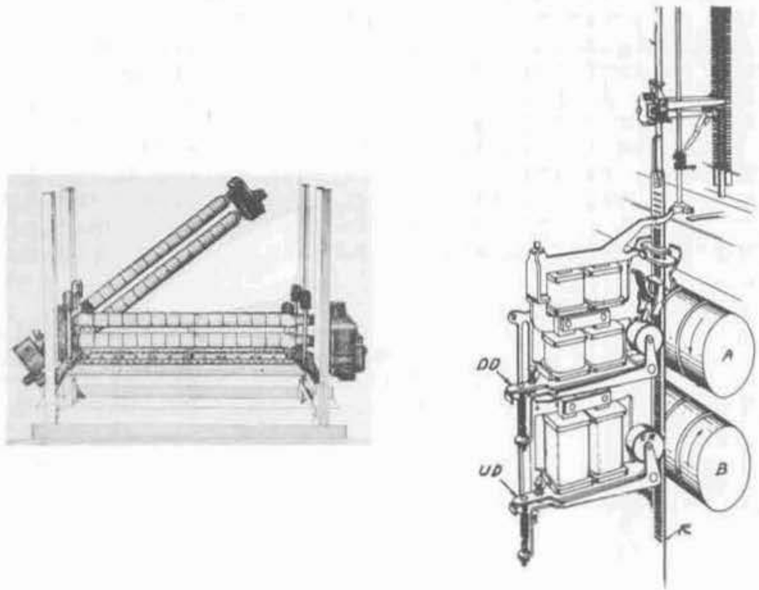


Fig. 14 Friction Roll Drive

The friction roll drive (Fig. 14) is located at the bottom of the center bay of a frame just beneath the multiple banks. Two sets of rolls are furnished, one for each side of the frame. Each set has two rolls mounted one above the other and rotating in opposite directions. On the final selector frame, a set consists of three rolls, two rotating at different speeds in the same direction. The rolls consist of a cork composition glued to a steel shaft and grooved at regular intervals to allow for expansion and contraction. Energizing one of the clutch magnets will press the associated rack against one of the cork rolls, the friction between the two causing the rack to move up or down, depending on which cork roll it is forced against.

Friction roll drives are equipped with a duplex motor, so constructed as to operate on two independent sources of power, either alternating current supplied from the city mains, or direct current supplied from the 48 volt office battery. This feature is most desirable since the brushes used in setting up connections are moved up or down by means of the friction roll drive. Should these rolls cease to rotate even for a short time, all calls being dialed into the exchange would be lost and those being set up would be delayed. These duplex motors are so arranged that one motor will drive the friction rolls on one side of two adjacent frames, and a second motor will drive those on the opposite sides of the two frames.

The commutator (Fig. 15) consists of several brass contact bars, imbedded individually in a hard rubber insulating material. The brass bars are made up either as continuous bars or as a series of segments, providing either a continuing connection or a series of interrupted connections, as brush springs slide over them. The hard rubber insulated bars or segments

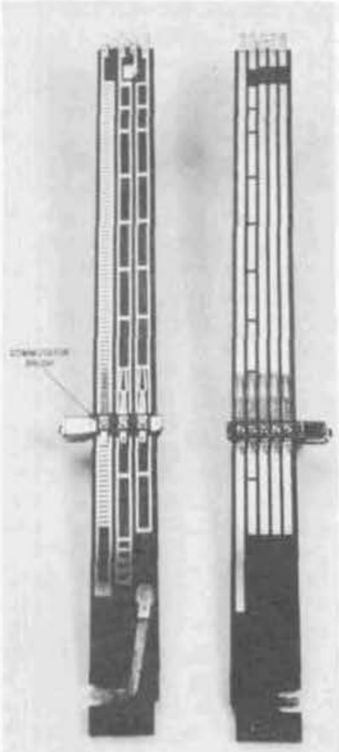


Fig. 15 Commutator

are then imbedded on either side of a strip of phenol fibre insulating material. The upper ends of most of the segments or bars extend above the phenol fibre strip, terminating in lugs, where wiring connections are made. One commutator is required for each selector rod.

A commutator brush assembly is mounted on the upper end of each selector rod, one brush assembly being associated with each commutator. The brush frame mounts five brushes or springs on one side, and either three or four on the other, depending on the type. The brush springs are so tensioned that they make contact with the commutator segments at all times, and provide either intermittent or continuous connections as the selector rod moves up and down.

A sequence switch (Figs. 16 & 17) consists of a switch frame, shaft, cams, cam designations, brush assemblies, index wheel, driven disc and flexible spider, and a drive magnet. The frame provides mounting space for the various assemblies which make up the switch. The shaft, square in shape with a key along one side, serves for mounting and rotat-

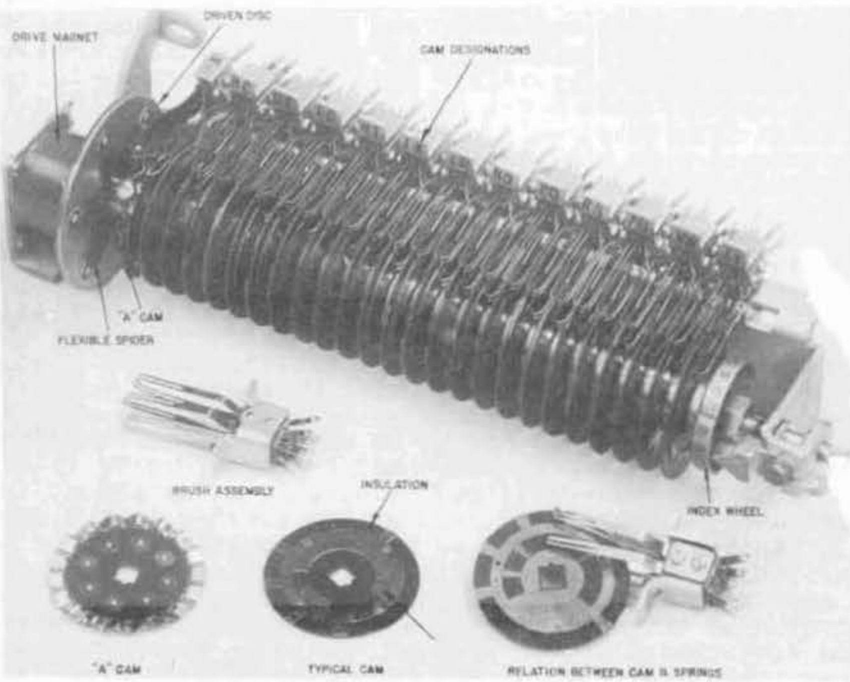


Fig. 16 Sequence Switch Assembly

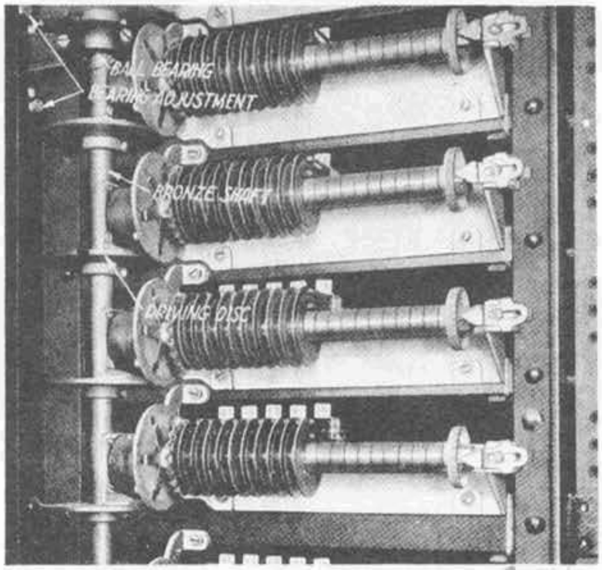


Fig. 17 Sequence Switches Mounted on a Selector Frame

ing the cams. In general, cams consist of two phosphor-bronze plates, separated by a phenol fibre insulating disc, with the two plates riveted together to hold them in place and to provide an electrical connection. A square portion of the center of the cam is cut out with a slot on one side, so that they may be mounted on the shaft in the proper position. Certain type cams have the phosphor-bronze plates overlaid with silver to provide a better connection between cam and associated brush. These silver-overlaid cams are being used in all cases where a sequence switch provides a connection in the talking path of a call completed between any two subscribers. Cams are designated by letter, beginning with the second cam from the drive end of the switch which is designated "B", and continuing alphabetically to the right. The first cam at the drive end of the switch is constructed differently, being fluted or notched on its outer circumference, and called the "A" cam, although not designated as such on the designation plates. A spring roller is associated with this cam, which aids in rotating and provides means for centering and holding the cams on the switch in any desired position. A complete revolution of a cam is associated with 18 different cam positions, indicated by a number index wheel located at the end of the switch opposite the drive end. The metal plates of the cams are cut out with irregular notches along both the outer and inner circumferences. Associated brush assemblies containing four brushes, the ends of which are split, thus providing two contacts per brush and insuring a better connection, are so arranged that they follow the outer and inner circumferences of the cam, two brushes to each side. The only exception to this is the "A" cam, which has brushes associated only with one side of the cam. As the shaft is rotated, the brushes make and break electrical contact with the metal plates of the cam, these makes and breaks being controlled by the particular notching of each plate. In certain positions of the switch, brushes will make contact with the metal portion of the cam, while in other positions, that part of the plate may be cut out or notched so that the associated brush spring will be riding on the insulating disc which separates the metal plates. In the first case, an electrical connection is provided between cam and brush, while in the latter case, the connection is open. By this means, various combinations of open and closed connections may be provided by each cam on a switch, through one complete rotation of its 18 positions. Since one of these switches will accommodate as many as 24 cams with four brushes associated with each cam, there may be 96 separate wire connections to the switch, which by rotating can be connected or disconnected in 18 different arrangements and each arrangement may be capable of an almost infinite number of variations by changing the size of the notches in the metal plates of the cams. Contacts may be made or broken simultaneously or separated by an exact time interval, which is a difficult problem to perform by means of relays. An iron disc attached to a flexible bronze spider is mounted in a vertical position on the switch shaft at the drive end. An electro-magnet is associated with this disc, so mounted that when the magnet is energized it will attract the lower part of the spider-mounted driving disc, and bring it in contact with another iron disc, mounted horizontally on a vertical

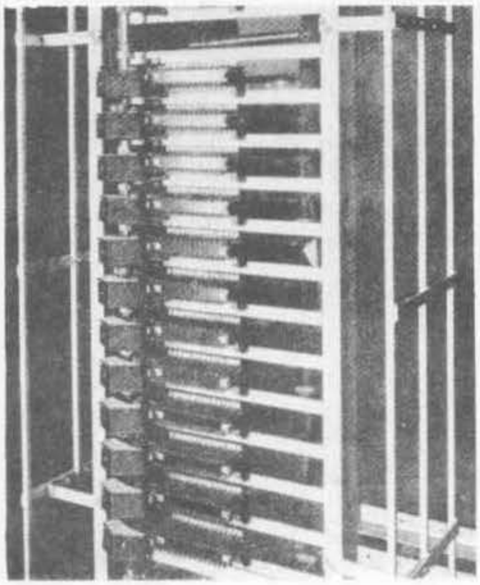


Fig. 18 Interrupters
Mounted on Frame

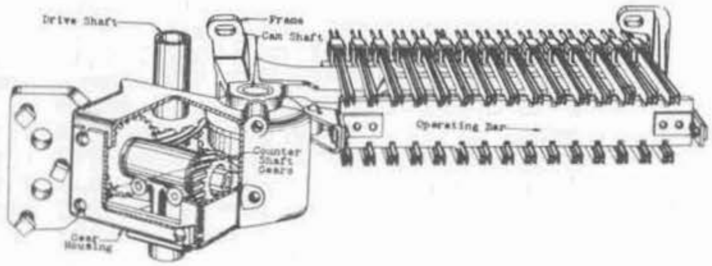


Fig. 19 Interrupters

shaft, continuously rotating, so located that power is applied to rotate the sequence switch. The rotary movement of the switch is under control of the magnet, and rotation may be either continuous or intermittent. Rotation of the switch from one of its 18 positions to the next one, requires a momentary energization of the magnet, which starts the movement, and the action of the "A" cam and its associated spring roller provide the centering feature. The action involved in the rotation of a switch is both electrical and mechanical.

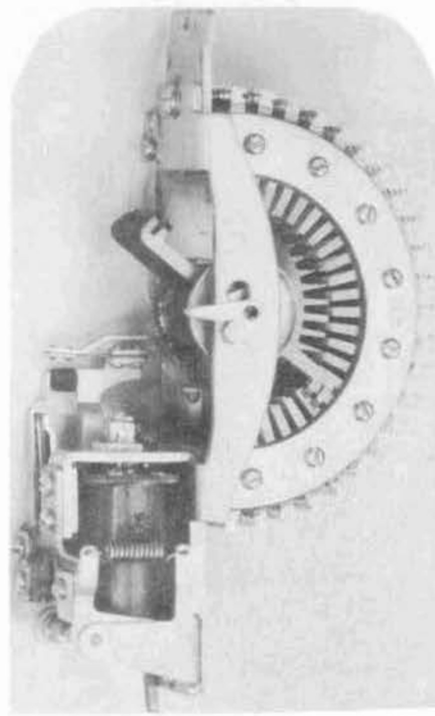
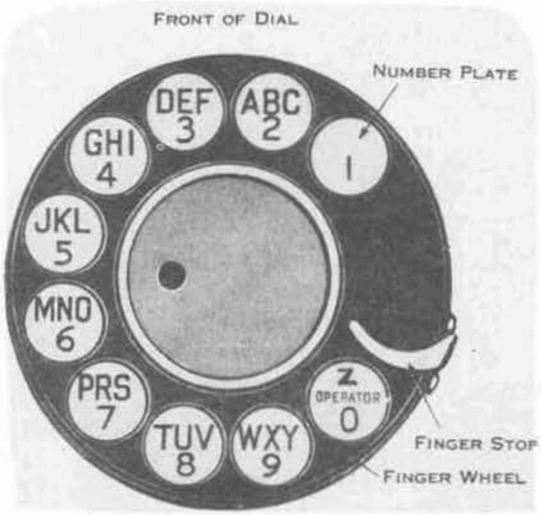


Fig. 20 Selector Switch

The bar type interrupter (Figs. 18 and 19) consists of a steel frame carrying at its left end a cam gear arranged to be continuously driven by another gear mounted on the sequence switch vertical drive shaft; a horizontal bar which is notched out so as to actuate the operating springs; and from several to a maximum of thirty sets of contact springs. In operation, the horizontal bar is driven back and forth, opening and closing the contact springs as required. The purpose of the interrupter is to supply interrupted currents with definite make and break periods, and is used largely where measuring of time or flashing of lamps is involved.

The rotary type selector switch (Fig. 20) rotates a set of double-ended brushes over a semi-circular bank of terminals associated with the selector. The bank has a capacity for 6 arcs, each arc containing 23 terminals. This switch is generally used in connection with circuits requiring timing and selecting features.

The dial (Fig. 21) is a mechanical device by means of which a subscriber may indicate to the central office equipment the connection he desires. The dial when operated by the subscriber mechanically generates electrical impulses, which actuate the equipment in the central office. The impulses are nothing more than interruptions of a direct current. When dialing a letter or number, the finger is placed in the slot above the letter or number to be dialed, and the finger dial rotated clockwise to the finger-stop. The finger dial is then released, causing it to return to its normal position in a counter-clockwise movement. It is during this return to normal movement of the finger-dial that the dial impulses are generated by breaking and making the circuit connecting the subscriber line to the central office equipment. The dial, then, is the device used by the subscriber to indicate to the equipment the central office in which the line he is calling is located, and the number of the party he is calling in that central office.



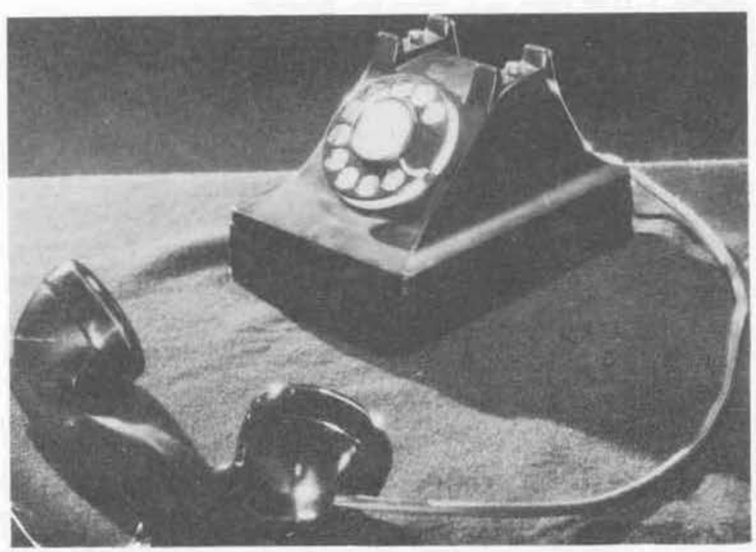


Fig. 21 Subscriber Dial and Handset with Dial

Section 4. Frames

1. Protector Frame

The protector frame (Fig. 22) is made up of comparatively thin bars of iron, mounted vertically, spaced on eight-inch centers, and of a strength to support a weight of 750 pounds per vertical. Stiffness of the verticals is obtained by welded cross pieces forming a ladder-like construction, and by a system of horizontal and diagonal braces. These verticals are installed by fastening to angle irons, one of which is, in turn, fastened to the floor, and the other to the auxiliary framing. Cable racks are mounted on top of the auxiliary framing bars.

Porcelain-carbon protector blocks (lightning arresters) provide protection against lightning discharges and excessive voltage, while heat coils insure that excessive and stray currents will not damage the central office equipment.

Arresters and heat coils are located on protector mountings, which are attached to the vertical bars on each side of the protector frame.

Outside lead-covered cable circuits are connected to the protector mountings.

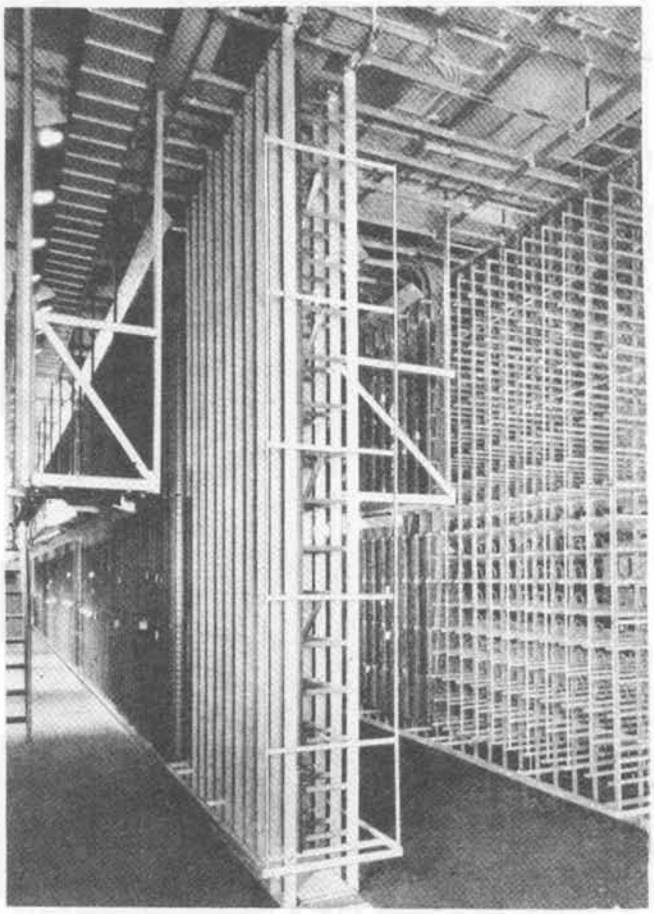


Fig. 22 Protector Frame

2. The Main Distributing Frame

The main distributing frame (MDF) (Fig. 23) consists of angle-iron uprights, installed in the same manner as described previously for the protector frame. Terminal strips are mounted vertically on one side of the MDF while on the other side, strips are mounted horizontally. Subscriber lines are cabled from the protector frame to the vertical side of the MDF and then connected to the terminal strips on the horizontal side by means of jumper wire (Fig.24). Cables connect the horizontal side of this frame to the horizontal side of the intermediate distributing frame. The jumper wire connection between the two sides of the MDF provides a flexible means of changing any subscriber line connection without changing his telephone number in that office. Jumper wire is run through insulated metal rings, which are mounted on the MDF framework midway between the two sides. The purpose of these insulated rings is to assure an orderly arrangement of jumper wires and to provide a rounded surface to prevent damage to the insulation of these wires. Jumper wires consist of a pair corresponding to the two wires of the subscriber line and are covered with flameproof insulation to prevent damage in case of fire.

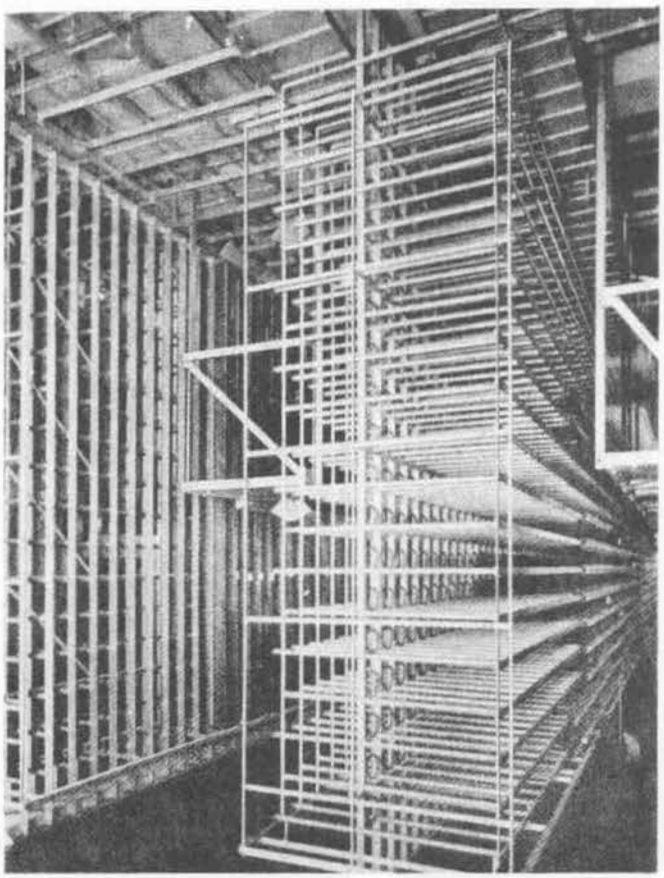


Fig. 23 Main Distributing Frame

3. Intermediate Distributing Frame

The intermediate distributing frame (IDF) has the same general appearance as the MDF. Terminal strips are mounted vertically on one side and horizontally on the other. Jumper wires are used to connect lines from the vertical to the horizontal side in the same manner as on the MDF. Subscriber lines from the final frames and from the horizontal side of the MDF are connected to the horizontal side, and the vertical side connects by cable to the line finder frames.

The purpose of the IDF is to provide means for distributing the operating load to the line finders. A line finder frame may serve up to a maximum of 400 subscribers, the actual number being dependent on the number of calls which the subscribers wish to make at the same time. The number of originating calls which can be handled by a line finder frame is limited at all times. Subscriber lines are connected permanently to the multiple bank terminals, so that if the number of calls being originated by the subscribers in this line finder frame, should suddenly increase, this increased traffic could not be taken care of without rewiring the banks. The IDF provides means for either increasing or decreasing the number of lines served by a line finder frame so that ideal traffic conditions will prevail. Proper distribution of the originating traffic load to each line finder frame is accomplished by relocating jumper wires at the VIDF (Fig. 24).

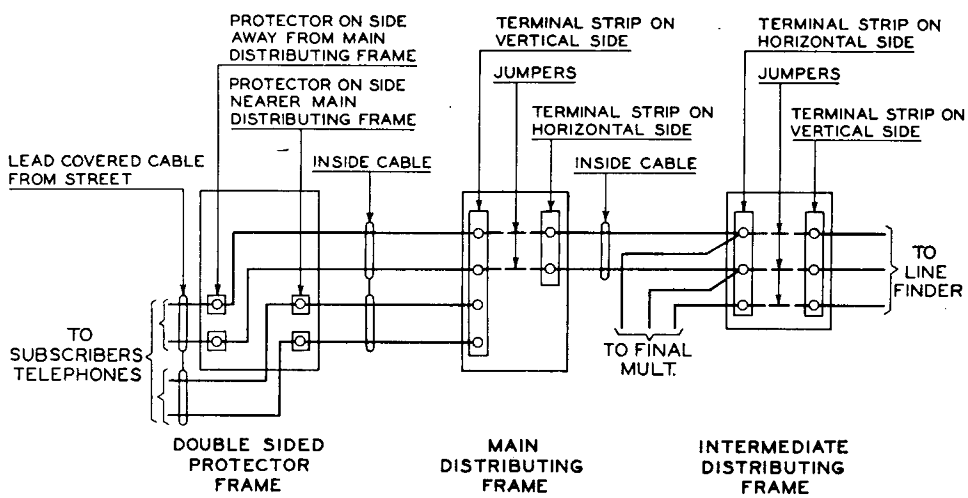


Fig. 24 Distributing Frame Cross Connections

4. Line Finder Frame

The line finder frame (Fig. 25), known as a double-sided type, consists of several angle iron uprights, a base angle, and various supporting cross bars and angles, all welded together in such a way as to form

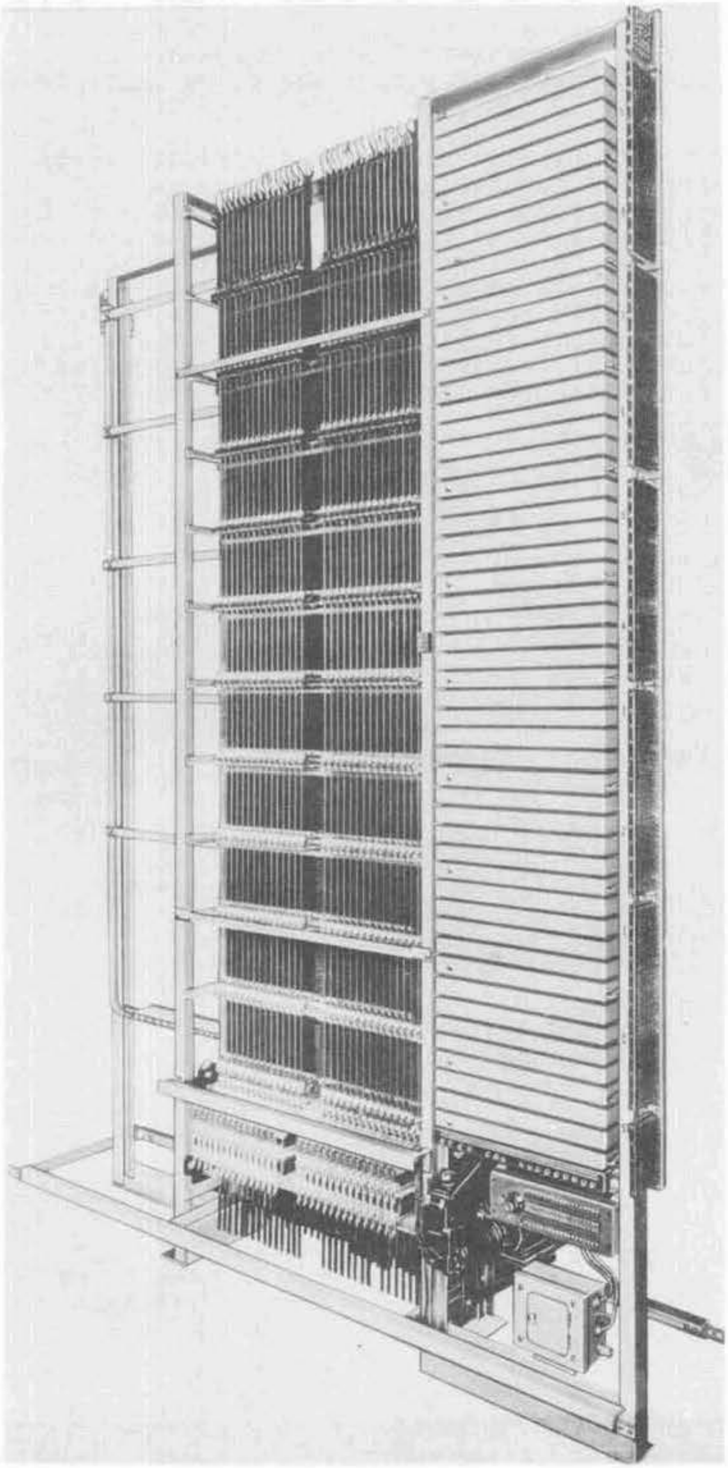


Fig. 25 Line Finder Frame with One Line Relay Bay

either a one, two, or three-bay frame structure. The number of bays is determined by the grouping of line finder selectors. The center bay provides mounting space for a friction roll drive with associated racks and clutches, ten multiple banks, selector rods with brushes, horizontal trip rods, and commutators. Each friction roll drive consists of two sets of rolls, two rolls per set, which operate in opposite directions, providing the upward and downward motion for the selector rods associated with the bay. Tripping mechanism provided on this frame for tripping multiple brushes is somewhat different from that found on other frames, consisting of a horizontal arrangement, two for each of the ten banks, one front and one rear. A horizontal bar is provided with thirty trip fingers, one for each of the brushes associated with that particular bank. Trip magnets at either end of the bar are so arranged that when energized, mechanical motion is applied to rotate the trip rod through part of its circumference so that the trip finger will engage with and trip the brush mechanism.

Multiple banks are constructed in the same manner as described previously, except that the columns are only 40 sets of terminals high, and each set consists of four terminals; tip, ring, sleeve and hunt. Multiple brushes are therefore arranged with four springs, each providing one connection.

In the three-bay line finder frame, a right and a left bay, called line relay bays, are placed next to each side of the center bay, which provide space for mounting line relay and line finder trip circuit equipment, a number of terminal strips, a jack panel, and a fuse panel. With this arrangement, the right bay also contains a duplex motor, and a motor fuse box. In the two-bay arrangement, only one line relay bay is required, placed on the right of the center bay. The one-bay frame is specified under certain conditions of line finder grouping, which does not require a line relay bay.

The "front" of the frame is arbitrarily chosen as that side on which the odd numbered line finder selectors are located.

Subscriber lines are connected to the line finder multiple bank terminals, while the multiple brushes are connected through the line finder equipment to a district selector circuit. The line finder frame equipment is associated with originating traffic, and provides means to find the calling line when a subscriber removes the receiver to originate a call, and associates that line directly with a district selector circuit.

5. District Selector Frame

A district selector frame (Fig. 26) is double-sided and from an equipment standpoint may be composed of five, seven, or nine bays, depending upon the type of frame. The frame consists of angle uprights, a base angle, and various cross bars and angles to provide rigidity and a means for mounting the various equipment parts on the frame.

The center bay contains the friction roll drive, associated clutches and racks (60 for each fully equipped frame, 30 front and 30 rear), selector rods with multiple and commutator brushes attached (60 rods for each fully equipped frame, 30 front and 30 rear with five multiple and one commutator brush per rod), five multiple banks mounted one above the other, and commutators, (60 for a fully equipped frame, 30 front and 30 rear).

Two smaller bays, one on each side of the center bay, provide mounting space for sequence switches and interrupters, and the vertical drive unit required to rotate the switches and operate the interrupters. Mounting space and wiring is provided for a bay capacity of 30 sequence switches and three interrupters. One sequence switch is required for each circuit equipped, the right bay taking care of the odd-numbered circuits associated with the front side of the frame, and the left bay serving the same purpose for the even-numbered circuits on the rear of the frame. The type of frame will determine whether one, two, or three interrupters are to be furnished for each bay. The lower part of one of these bays in each frame also provides mounting space for a motor fuse box and a duplex motor. The two outer bays on the five bay type of frame provide space for mounting relays, resistances, condensers, repeating coils, a jack panel, and a fuse panel. The equipment is mounted on mounting plates, each plate serving one circuit. The seven-bay frames are standard five-bay frames with two bays added, one right and one left, each providing space for additional sequence switch equipment. The nine-bay frames are also standard five-bay frames, with four additional bays, two right and two left, providing mounting space for power driven selector switches, relays, and additional sequence switches.

The standard five-bay frames are used in connection with originating traffic from individual and two party message rate subscriber lines; the seven-bay frames are used in exchange areas arranged for zone and overtime features; and the nine-bay frames are furnished when overtime and coin control features are necessary.

The general purpose of the district selector frame equipment is to connect the calling line with a trunk to an office selector frame or with an outgoing trunk to the central office called.

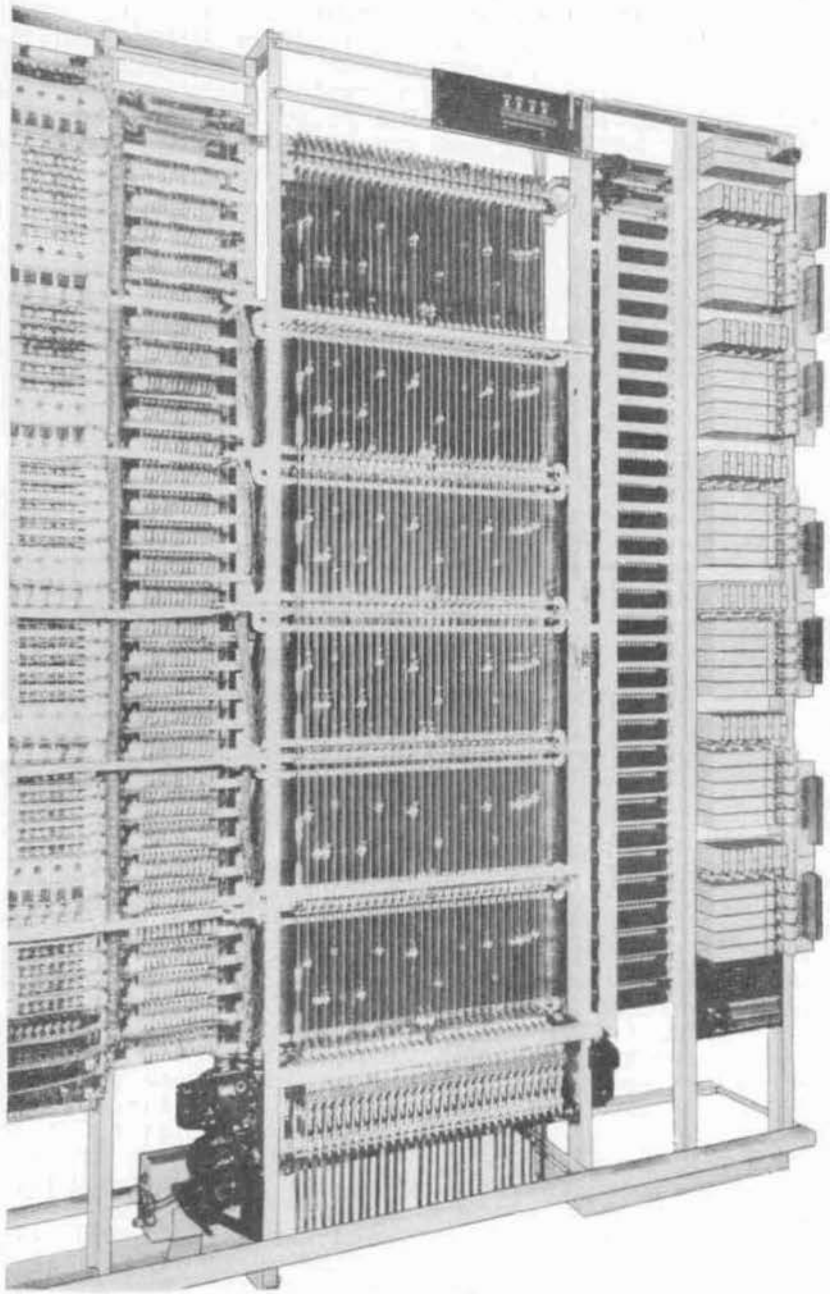


Fig. 26 District Selector Frame

6. Office Selector Frame

An office selector frame is a five-bay structure much on the order of the standard district selector frame, with corresponding equipment and serves as a supplementary frame to the district selector frame in central offices where trunk groups are large. Whenever used, the equipment on this frame serves to select an idle outgoing trunk to the called central office.

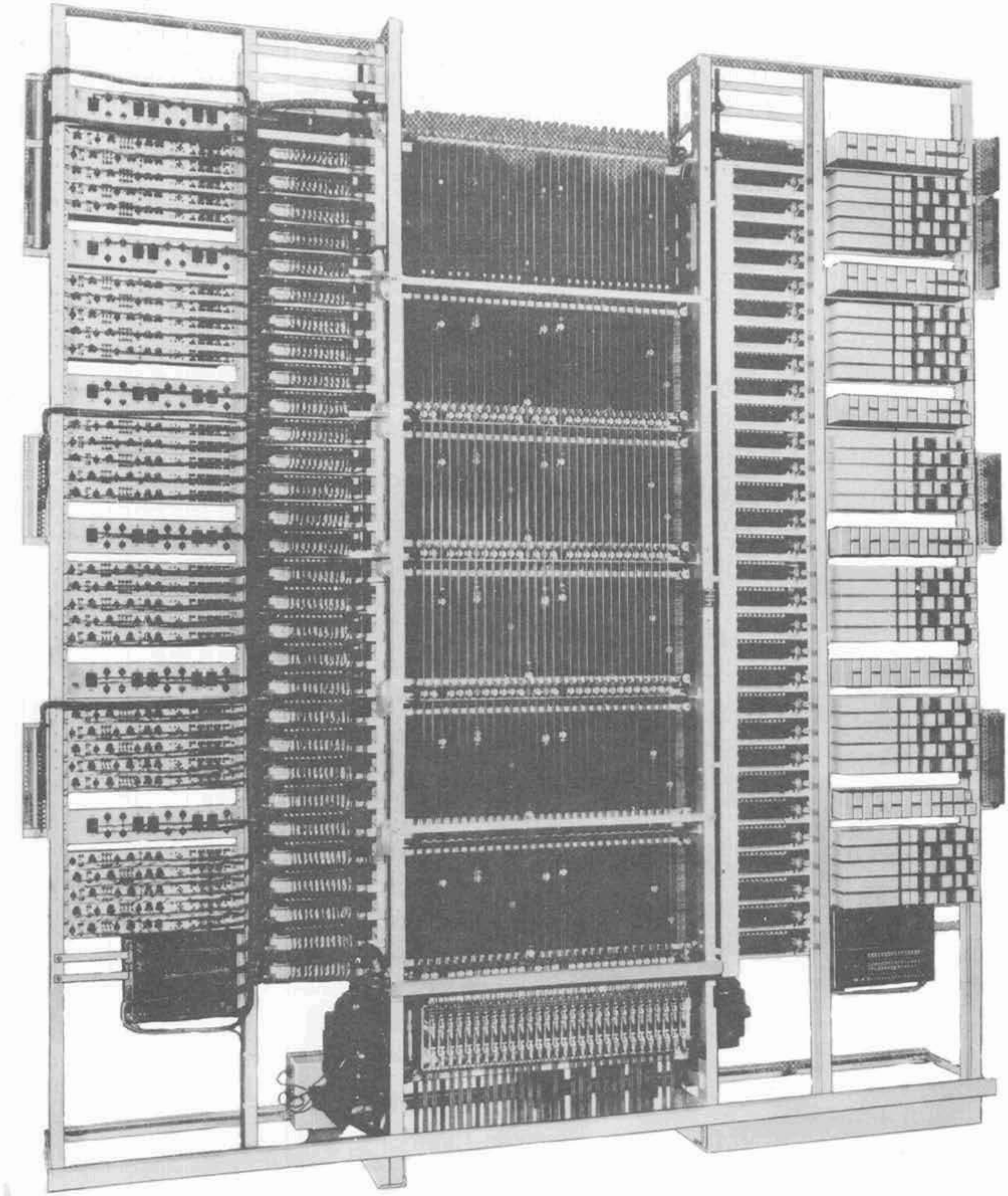


Fig. 27 Incoming Selector Frame

7. <u>Incoming Selector Frame</u>

An incoming selector frame (Fig. 27) corresponds very closely to a standard district selector frame, both in structure and associated equipment. The purpose of an incoming selector frame is to provide a terminating point for the incoming trunks from other offices and the local office as well. The equipment on this frame serves to select an idle trunk to one of a group of

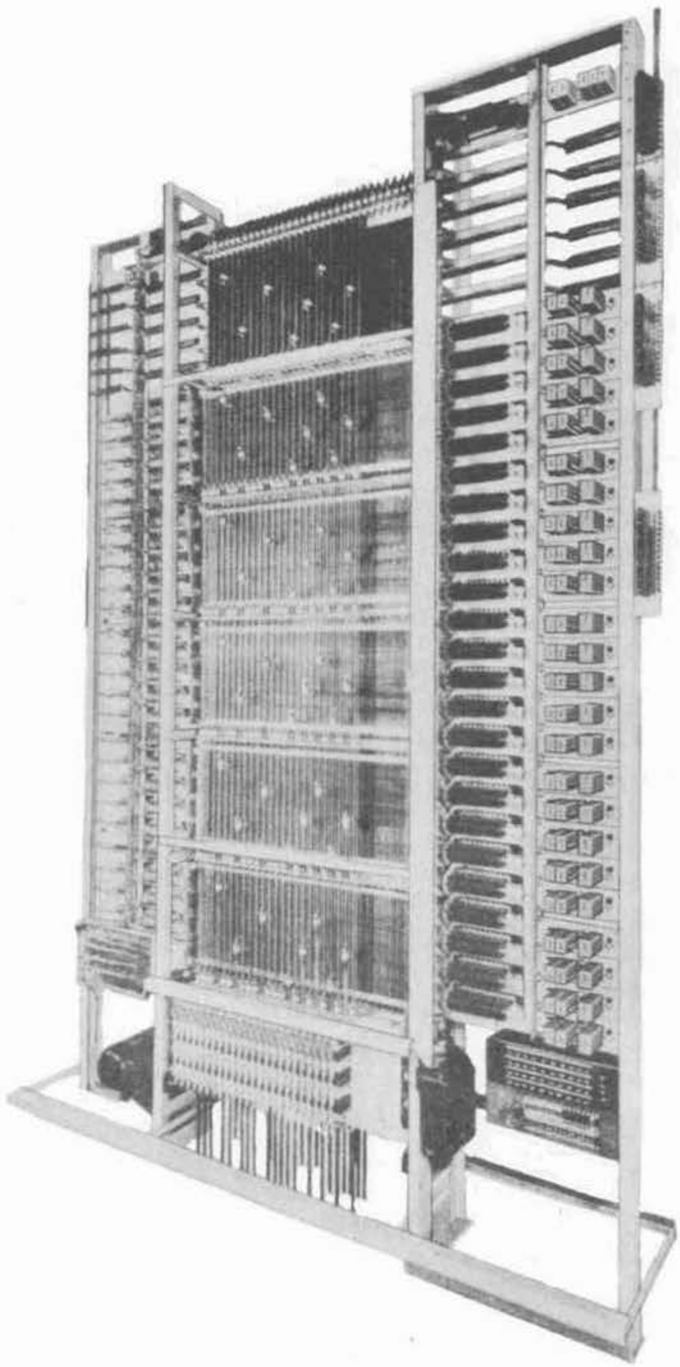


Fig. 28 Final Selector Frame

final selector frames on which the called subscriber line terminates. Incoming frame circuits furnish ringing currents to ring the called party's bell, and also supply talking battery to the called subscriber line.

8. Final Selector Frame

A final selector frame (Fig. 28) is also much like the standard district selector frame, in both structure and equipment, with the clutches and friction roll drive the exceptions. Final frame friction roll drives are provided with three cork rolls per set instead of two. The additional roll provides a slow motion updrive to the selector rods. The clutches are equipped with an additional magnet (slow-updrive) which, when operated, presses the rack against the slow-updrive roll.

Subscriber lines are connected to the final selector frame bank terminals, with the incoming trunks being connected through the selector equipment. Final selector frame equipment provides means for selecting the called line terminals, testing for a busy condition, and connecting the calling line through to the called line.

9. Subscriber Link Frame

A subscriber link frame (Fig. 29) is a double-sided three-bay structure. The center bay contains a friction roll drive with associated racks and clutches, two 100-point multiple banks, commutators, one 54- or 94-point multiple bank, and two different types of selector rods with brushes (30 front and 30 rear). The terminals of the two 100-point banks are connected to subscriber sender circuits, while the terminals of the 54- or 94-point bank are connected to district selector circuits. The commutators are of two different types, each located just above the associated multiple bank or banks. Selector rod assemblies associated with the two 100-point banks are equipped with only two multiple brushes and one commutator brush, are furnished in short length to operate with the two lower banks, and are mounted in the left half of the frame (both front and rear). Selector rod assemblies associated with the 54- or 94-point bank are also only equipped with two multiple brushes (both associated with the one bank) and a commutator brush. These selector rods are located in the right half of the frame (both front and rear), and are of regular length. Drive equipment to raise and lower selector rods is designed for a complement of five multiple brushes on a rod; to offset the weight of the brushes not equipped on the selector rods on this frame, it is necessary to add compensating weights.

The two outer bays each provide space to mount terminal strips, condensers, relays, sequence switches, vertical drive shaft, rotary type selector switches (test connectors), key-jack-and-lamp panel, a fuse panel, a motor fuse box and a duplex motor. The equipment in the right bay is associated with circuits on the front of the frame, and that in the left bay with circuits on the rear of the frame.

The purpose of the subscriber link frame equipment is to pre-select an idle line-finder-district selector circuit and connect to an idle sender circuit.

10. Subscriber Sender Frame

A subscriber sender frame (Fig. 30) consists of two single-sided bays; the right bay mounts the equipment for five sender circuits, vertical drive shaft, thirty sequence switches, two interrupters, terminal strips, a fuse box, a fuse panel, a motor fuse box, and a duplex motor; the left bay also mounts five sender circuits and terminal strips. Sender circuits are furnished in units, two senders with a group of six associated sequence switches being placed in a horizontal framework which is mounted across the two bays of the frame. Five such units are mounted one above the other,

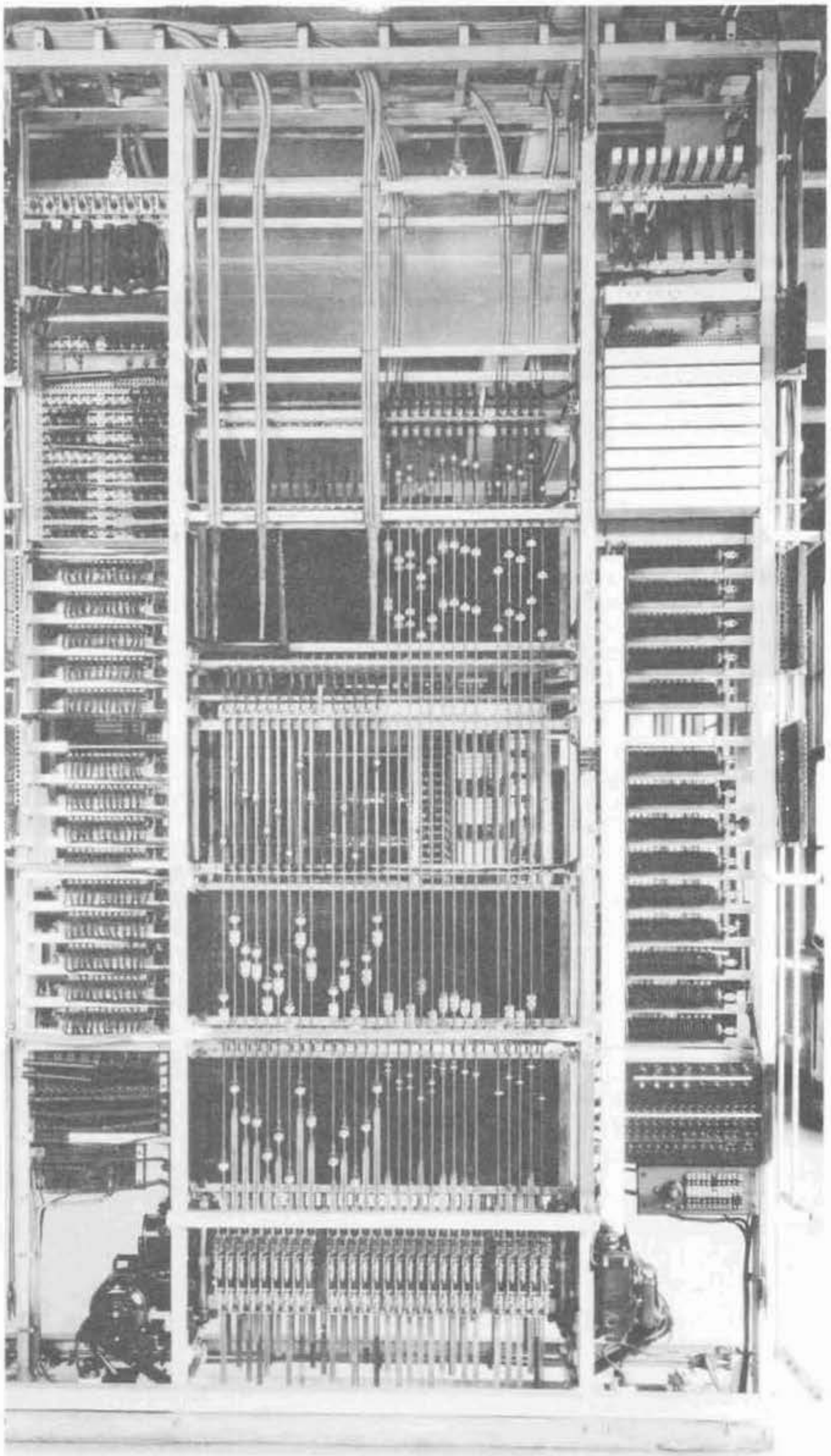
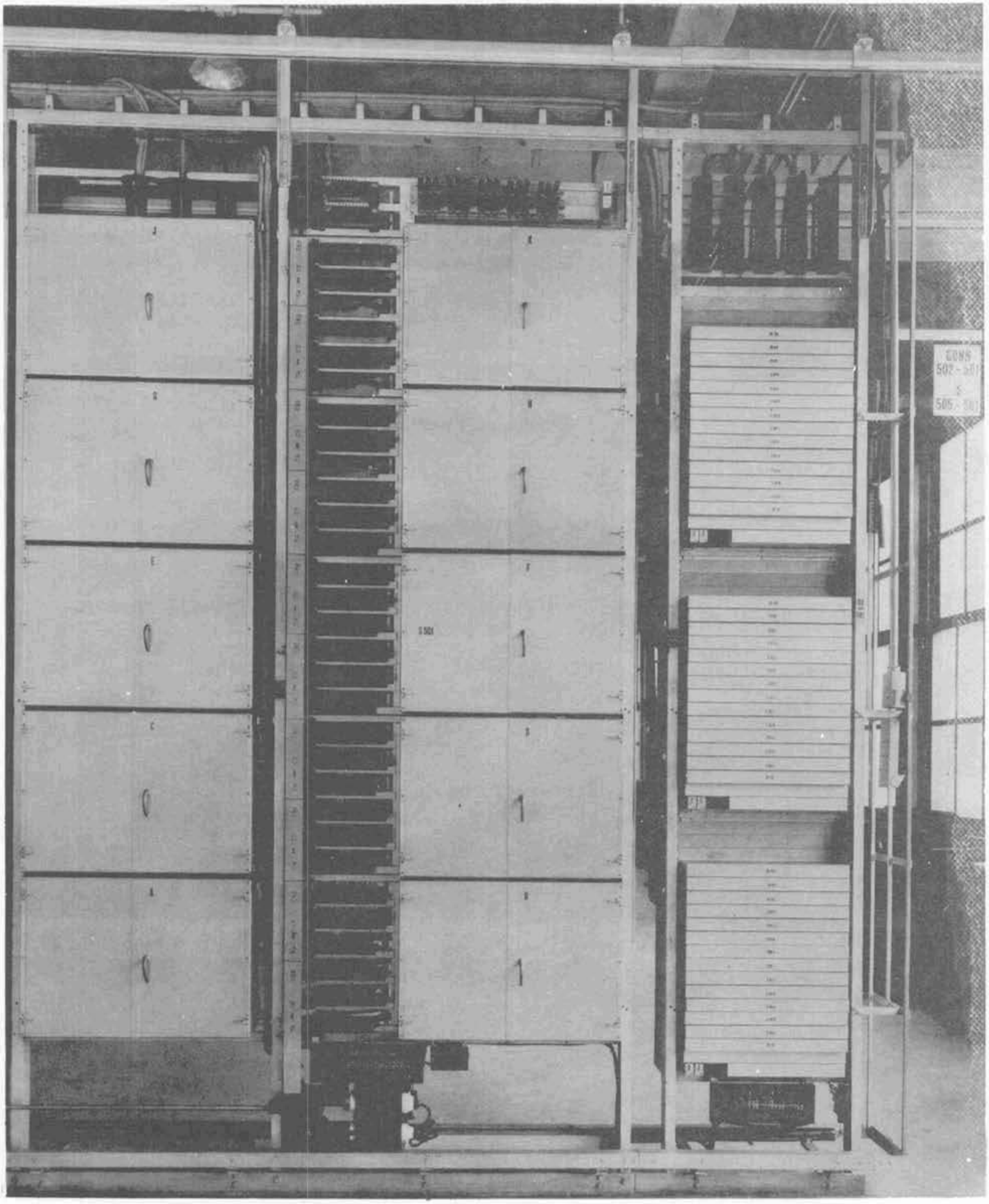


Fig. 29 Subscriber Panel Link Frame



SUBSCRIBER SENDER DECODER CONNECTOR

Fig. 30 Subscriber Sender and Decoder Connector Frame

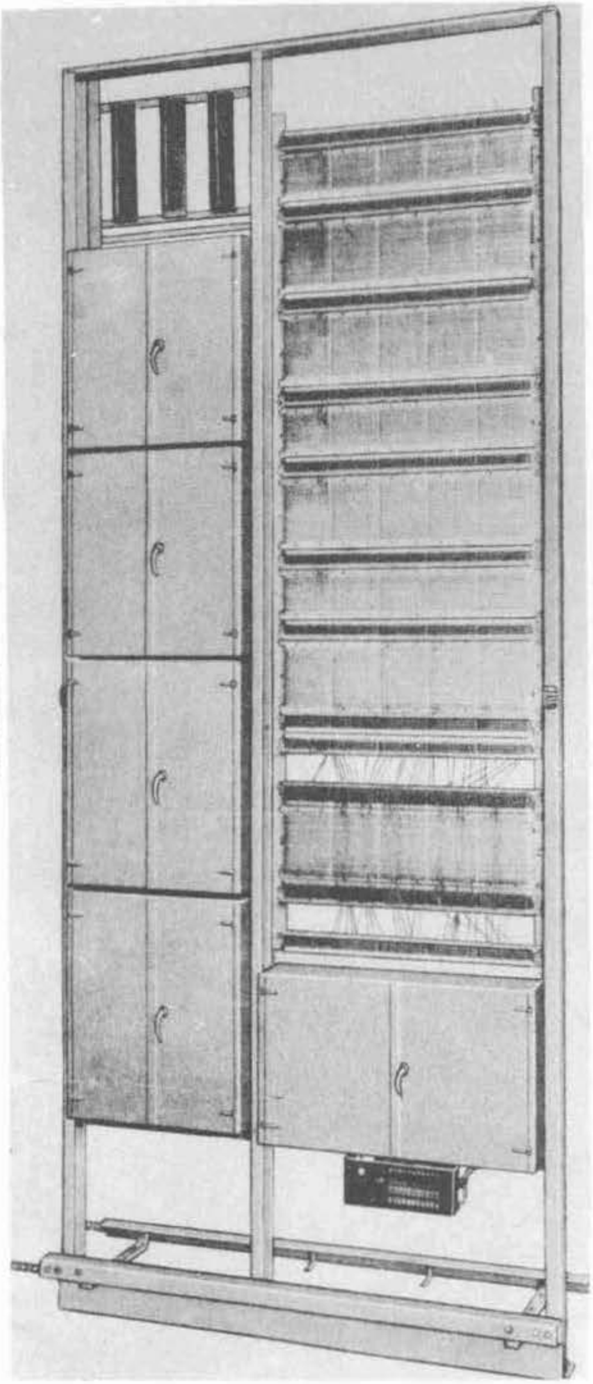


Fig. 31 Decoder Frame

providing a frame capacity of ten sender circuits. Sequence switches are arranged so that the lower three of the first group are associated with the lower left bay sender, and the upper three with the lower sender in the right bay. Sender units consist of miscellaneous relays, resistances, condensers, etc.

The subscriber sender provides the means for controlling the completion of a call. With the decoder, it provides the intelligence for the panel dial system.

11. Decoder Connector Frame

A decoder connector frame (Fig. 30), a single-sided one bay structure, consists of angle uprights, a base angle, terminal strips, a fuse panel, and three decoder connector units. Each unit consists of miscellaneous relays, resistances, condensers, etc., which make up one decoder connector channel or circuit.

Sender circuits are connected to decoder circuits by means of these decoder connector channels, one channel serving ten subscriber sender circuits; therefore, one decoder connector frame is associated with three subscriber sender frames.

12. Decoder Frame

A decoder frame (Fig. 31) is a two-bay single-sided structure made up of angle uprights and a base angle. The left bay contains terminal strips and four relay units (encased). The right bay provides space for cross-connecting type terminal strips, relays, and a fuse panel.

A decoder circuit decodes the office code dialed by the calling subscriber, and furnishes the sender circuit with the proper information for completing the call to the dialed office.

Section 5. Method of Operation

A call between two panel dial subscribers is termed a full mechanical call, since it is handled entirely by mechanical equipment. Figure 32 illustrates the sequence in which the various frames are used to complete a call. Line finder, district, office - (under certain conditions), incoming, and final selector frames carry the talking path. A subscriber link, subscriber sender, decoder connector and decoder frames are also required for the purpose of directing and controlling the movement of the selectors on the above mentioned selector frames.

When the Monroe subscriber (4341) removes the handset, one of the sixty selector rods on the line finder frame, which has been pre-selected by the subscriber link circuit, rises and one of the ten brushes trips and engages his line. At the same time, the subscriber link circuit controls the selection of an idle sender. The sender selected places a dial tone on the subscriber line.

The subscriber, hearing this tone, dials the number desired, MO6 2180 which is registered in the sender.

When the office code MO6 (666) has been dialed into the sender, the decoder connector connects the sender through to an idle decoder. The decoder will then operate and lock a group of relays in the sender. The decoder connector and decoder now release and are available for other calls. The relays which have been operated in the sender, by the decoder, will control the selection of a trunk to Monroe office.

The associated district selector circuit now operates under control of the sender, causing the district selector rod to rise, and stopping it for brush selection, causing it to rise a second time to trip the brush and to find the group of trunks to Monroe office, and then if the first trunk in the group is busy, the selector rod rises a third time to hunt for an idle trunk in this group. (Brush 2, Group 1)

This extends the call to an incoming selector circuit in Monroe office, which then operates under control of the sender, causing the selector rod to rise and stopping it for brush selection, causing it to rise a second time to trip the brush and find the group of trunks to the final frame serving subscribers 2000 to 2499, and if the first trunk is busy, the selector rod rises again to select an idle trunk to a final selector frame circuit. (Brush 1, Group 1)

The final selector circuit now operates under control of the sender, causing the selector rod to rise and stopping it for brush selection, causing it to rise a second time to trip the brush and select the group of lines serving subscribers 2180 to 2189. The brush now rests on the first set of terminals in the group which is connected to line 2180. (Brush 1, Group 8, Terminal 0)

As soon as the final selector brush has found the called subscriber line, the incoming circuit tests the line and if it is idle proceeds to place ringing current on the line to ring the subscriber bell. The sender and subscriber link circuits restore to normal and are again available for other calls.

When the called subscriber removes the receiver, ringing current is automatically disconnected, and the path is closed over which the subscribers converse. When both subscribers disconnect, the equipment held up by the call restores to normal.

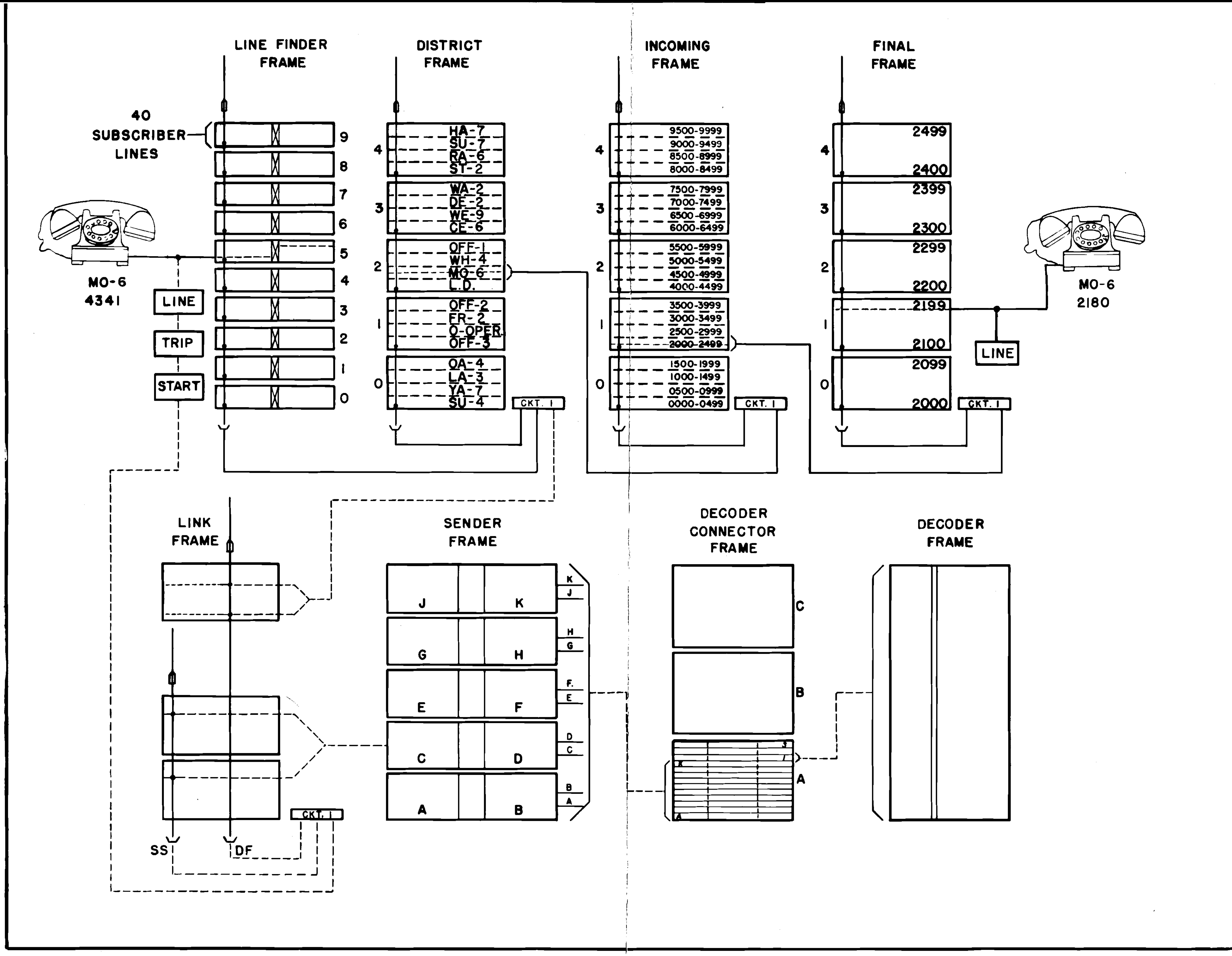


Fig. 32 Sequence of Frames Involved in Completing a Call between Two Subscribers

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 per cent 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, wherever possible, two services connected to different generating stations or systems are brought into the telephone building. In those cases where a single service only can be secured a local means of charging such as an engine generator set may be provided as a reserve for this service.

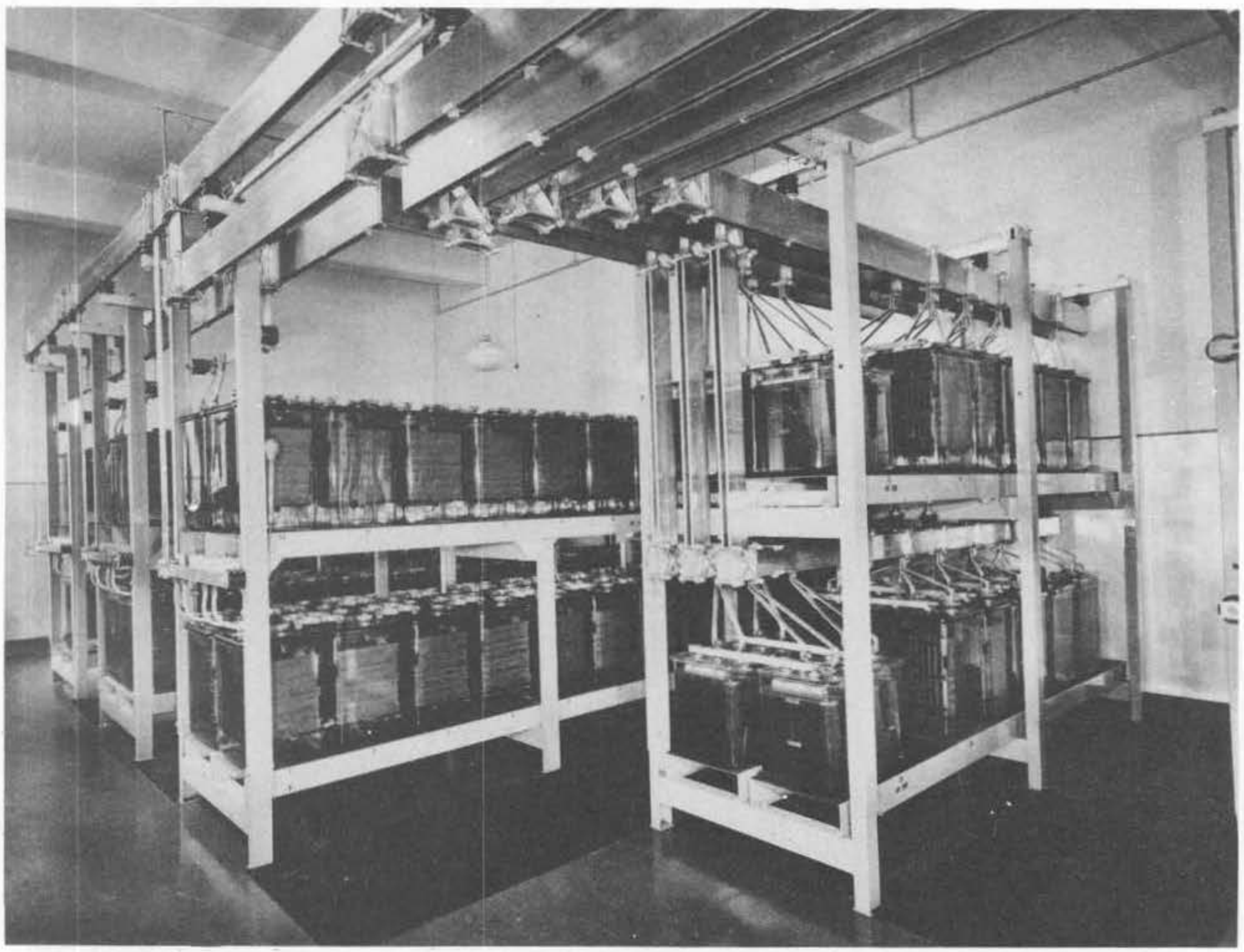


Fig. 33 Central Office Battery

Even with the best commercial power service, short interruptions are experienced; therefore it is necessary to provide another source which shall be available at all times to operate the central office during temporary failures of the outside service. This is accomplished by the use of a storage battery of sufficient capacity to carry the load of the office during failure of the source of power supply, the battery being continuously connected to the circuits so that no interruptions occur. 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. The 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. In a panel dial office, batteries (Fig. 33) supply 24 and 48 volts for talking and 48 volts to operate the equipment.

Fig. 34 shows a typical power plant as might be found in any panel 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 lighting 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. Motor generator sets are supplied for charging the

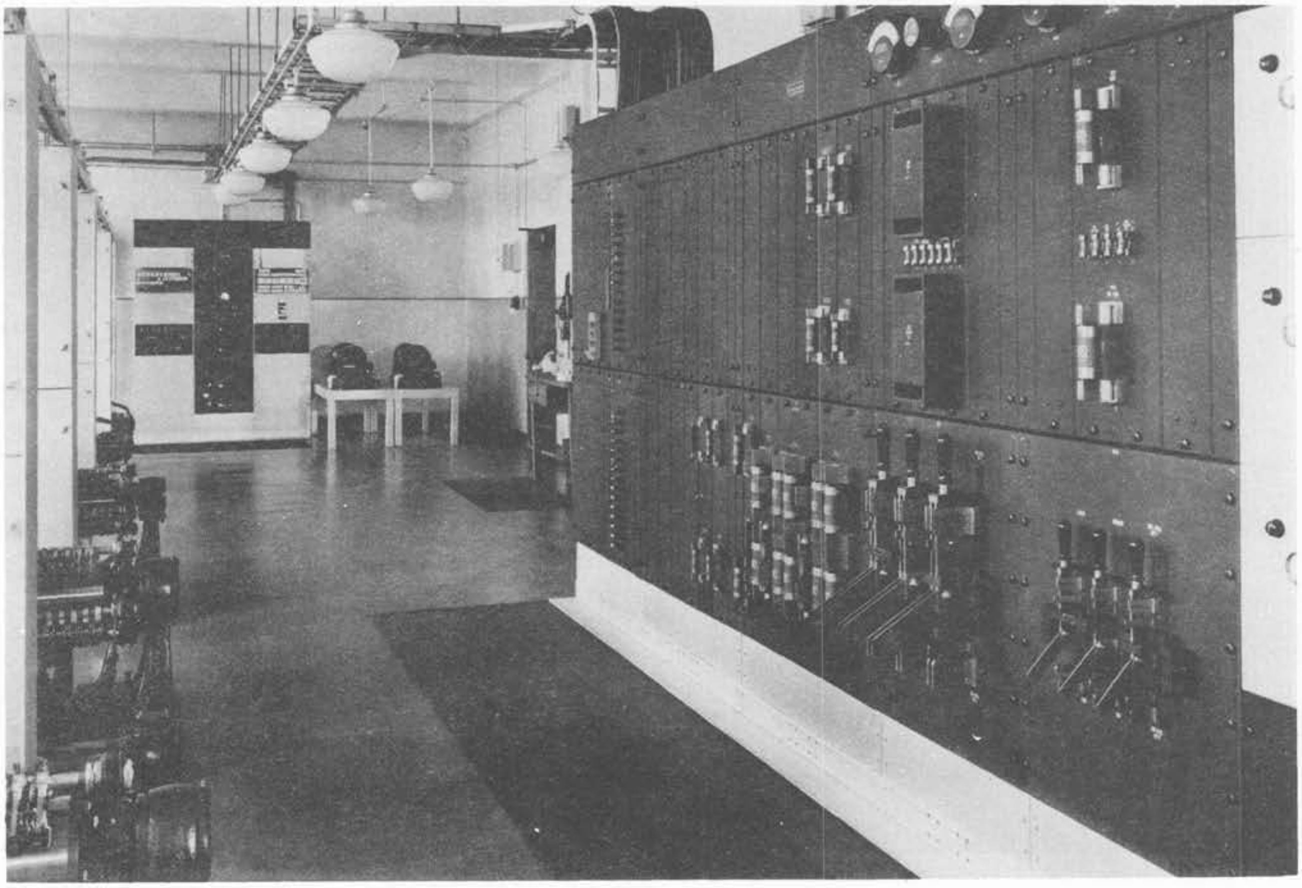


Fig. 34 Power Room

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. This is accomplished by means of electrolytic condensers (capacitance) and choke coils (inductance) supplied for this purpose. An emergency gasoline or Diesel engine and AC generator are provided to supply a source of power if the primary source is interrupted. Ringing and coin control machines, run by AC and 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. Tungar or copper oxide reetifiers are usually supplied to charge the smaller 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.