Bob Kaemper

THE PANEL TYPE DIAL TELEPHONE SYSTEM

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A digest of an illustrated talk given before groups of employees of the New York Telephone Company

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Foreword

This booklet endeavors to explain fully and accurately, and yet in a simple and understandable manner, the operation of the panel type dial telephone system. It has been compiled from information furnished by the American Telephone & Telegraph Company and is designed for the use of students of Telephone Engineering and Telephone Engineers who required a general picture of the apparatus and its functions rather than a detailed description of operation.

The text follows closely that of lectures which the author has delivered to employees of the New York Telephone Company and the description has been confined to the apparatus and circuits used in the larger central offices in the City of New York. Most of the illustrations are already familiar to Telephone Engineers but many of them are new and have been especially designed to emphasize the basic principles upon which the system is founded and to make clear by means of simple diagrams the relations between the various pieces of apparatus which are sometimes not easily understood from even the most carefully written descriptions.

It is hoped that telephone experts will overlook a lack of meticulous accuracy in some of the statements on the ground that simplicity is the more desirable attribute and that those who find the explanations too involved will be equally lenient when the magnitude of the subject is considered.

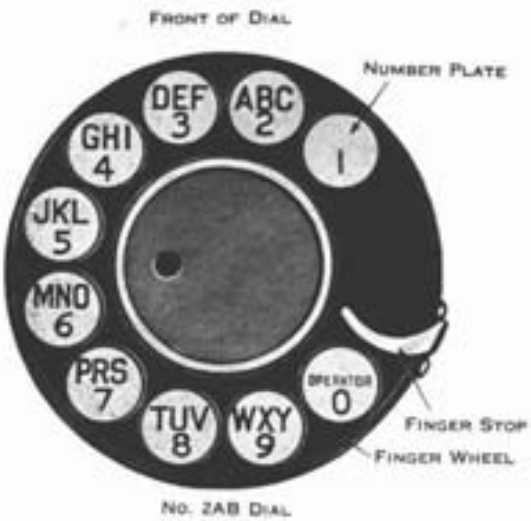
General Principles

In a manual telephone system the subscriber tells 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 to a trunk to a distant office and repeats the number he desires to another operator who selects the line for him. In dial systems, the sequence of operations is somewhat similar but the operations are performed by electromechanical switches.

Since an electromechanical switch cannot respond to the voice of the subscriber as an operator can, it is necessary to provide a means for the subscriber to tell the switches what number he wants. This mechanism is the "dial" (Figures Number 1 and Number 2). Most people are now familiar with the operation of the dial. The subscriber puts his finger in the hole of the dial in which appears the letter or figure which he wishes to tell to the switches, pulls the rotating disc around until his finger strikes the stop and lets go. A spring rotates the disc back to its normal position and in doing so simply opens and closes the circuit of the subscriber's line the number of times indicated by the figure under the hole into which the subscriber puts his finger. It must be remembered that that is all the dial does—it opens and closes the circuit of the subscriber's line a certain number of times. A little governor in the back of the dial controls the speed of the rotating disc and assures that the opening and closing of the circuit is uniform and regular. By performing this operation the proper number of times, the subscriber tells the switches the central office in which the desired line is located and the number of that line. It should be noted that rotating the disc with the finger in the hole marked "zero" opens and closes the circuit ten times, since opening and closing it zero times would mean not opening and closing it at all. This, then, is the way in which the subscriber tells the switches what number he wants.

The simplest form of

Figure 1



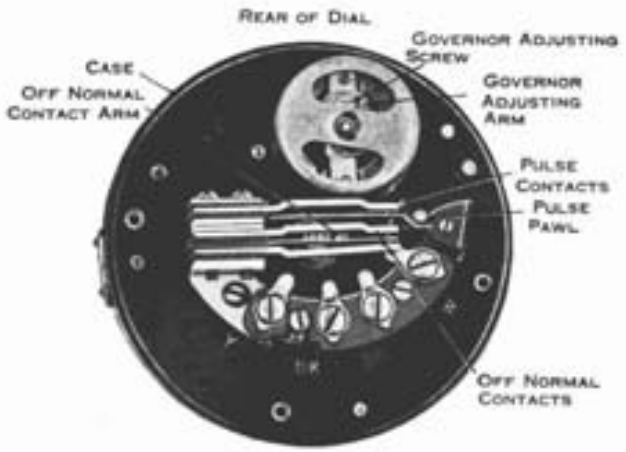


Figure 2

dial telephone (Figure Number 3) would be some sort of electromechanical switch electrically connected to the subscriber's line, the arm of which would, by means of a magnet, be moved one step each time the circuit of the subscriber's line was made and broken by the dial. This would enable the subscriber to connect his telephone to any one of several other telephones by a single rotation of his dial.

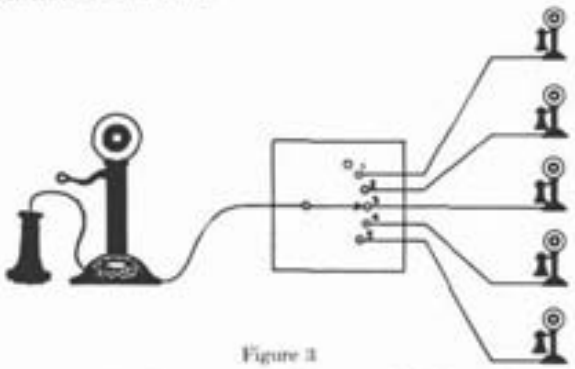


Figure 3

More telephones could be reached by the subscriber by arranging the switches as in Figure Number 4. Here the first rotation of the subscriber's dial moves the arm of the first switch while the second rotation of the dial moves the arm of the second switch. To insure that the second switch is moved 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 during the rapid

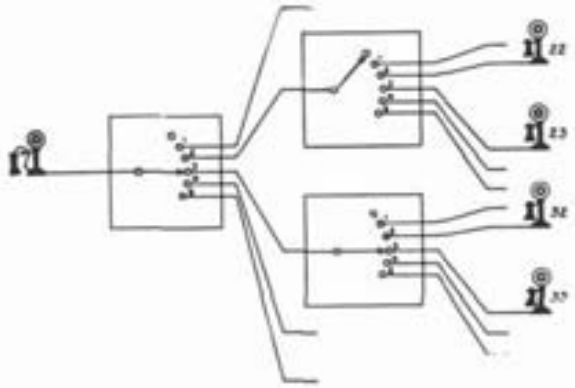


Figure 4

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 is a fundamental principle of dialing telephone systems.

The arrangement of switches as shown requires that one selector switch be provided directly connected to each subscriber's line. During the time that the subscriber is not using his telephone this switch is, of course, idle. In Figure Number 5 we see a complete telephone system on this principle but the number of switches has been reduced by introducing a switch known as a line finder. One of these switches is provided for each five subscribers' lines and is so arranged that it automatically moves to the terminal of the subscriber's line whose receiver has been taken off the hook to make a call. The use of this switch in the system shown is based on the idea that out of each five subscribers only one will be using his telephone at any one moment. It is possible, of course, to provide two of these switches for each five subscribers or any other number, depending upon the number of subscribers which it is found will be using their telephones at the same moment.

An additional feature is illustrated in Figure Number 5. It will be seen that there are two trunks between Office "A" and Office "B" and that these trunks are multiplied 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 the subscriber's dial 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 another characteristic feature of dial telephone systems of this type.

It should be observed that no attempt is made to make the action reversible; that is, an entirely separate set of apparatus must be provided for calls from Office "B" to Office "A." This is the usual arrangement in dial telephone systems of this type. A system based on the principles described above would be quite practical. There are other considerations, however, which influence the design of the apparatus.

The system described above operates on the "step-by-step" principle and is of the rotary type; that is, switch arms move in a series of steps and in the arc of a circle. The making and breaking of the subscriber's line circuit causes directly the movement of the switches which make the connection to the called line. This may be called "direct control." It follows also that the dialing of any digit causes the switch which is at that moment connected to the subscriber's line to make a corresponding number of steps; thus if 5 is dialed, the switch will make 5 steps, etc. This is described as "numerical selection."

A system operating upon these principles is in extensive use in many of the smaller cities of the United States and has proved to be well adapted to the conditions encountered in these cities.

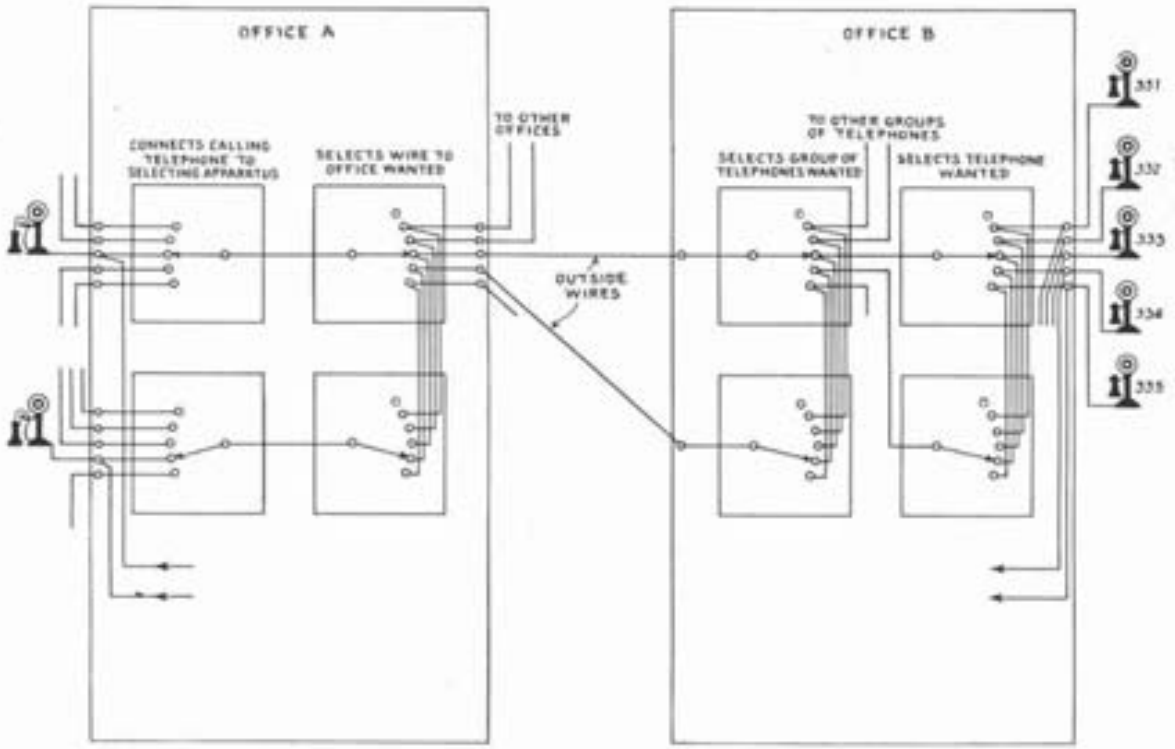


Figure 5

In the simple system illustrated above, two trunks are shown between Office "A" and Office "B" in the group over which the selector switch can hunt to find an idle trunk. In systems of this type the number of trunks in one group over which a selector can hunt is generally limited to ten by the mechanical limitations of the switch. Where more than ten trunks are required to some one place, they must be divided into two or more groups, each of which does not exceed ten. If all of the 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 the trunks be placed 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 there remained any trunk still idle. One group of twenty trunks will, in this way, handle more than twice as much traffic as two groups of ten trunks. Where a large number of trunks is required to each office, the advantages of apparatus so constructed that the selectors can hunt over large groups of trunks are apparent.

Principles of the Panel System

The panel type of apparatus is so constructed that the selector may hunt over a group of trunks as large as ninety but this group may also be divided into smaller groups, if desired, so that groups of 5, 10, 20, 30, etc., trunks may be obtained without waste.

When this arrangement is adopted, it is necessary to abandon direct control by the subscriber's dial, for if we wish a selector to choose the fourth group of trunks it might be necessary for it to jump ten trunks at the first step, 20 trunks at the second step and 40 trunks at the third step. This, of course, would be a very difficult matter to arrange. Furthermore, with a group of ninety trunks the time taken for the selector to find an idle trunk in this group, which might be the very last trunk, probably would be longer than the pause which the subscriber would make between the dialing of successive digits and therefore the subscriber might dial the second digit before the selector had completed the selection indicated by the first digit. Other reasons for the abandonment of 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 apparatus, to work over such large groups of trunks, is necessarily somewhat large and heavy, it is found more practicable 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 often is impracticable 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 makes and breaks the subscriber's line circuit nine times. It will be seen later that there are other reasons for doing away with numerical selection.

Having now abandoned direct control and numerical selection, it will be clear that 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 that the selectors do not move in unison with his dialing. Therefore it will be necessary to provide some apparatus 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 places. This apparatus is called the "sender."

Figure Number 6 shows diagrammatically the principles of the panel type dial system. This embodies the same fundamental ideas as the previous system, having a line finder switch and a series of selector switches, but the terminals over which the selector switches move have been arranged in vertical rows instead of in arcs and the switches are moved by motors instead of by magnets. No attempt is made to have the switches move in unison with the movements of the subscriber's dial. The dialing of the subscriber is registered in the sender and from that registration the movement of the switches is controlled after the subscriber has dialed.

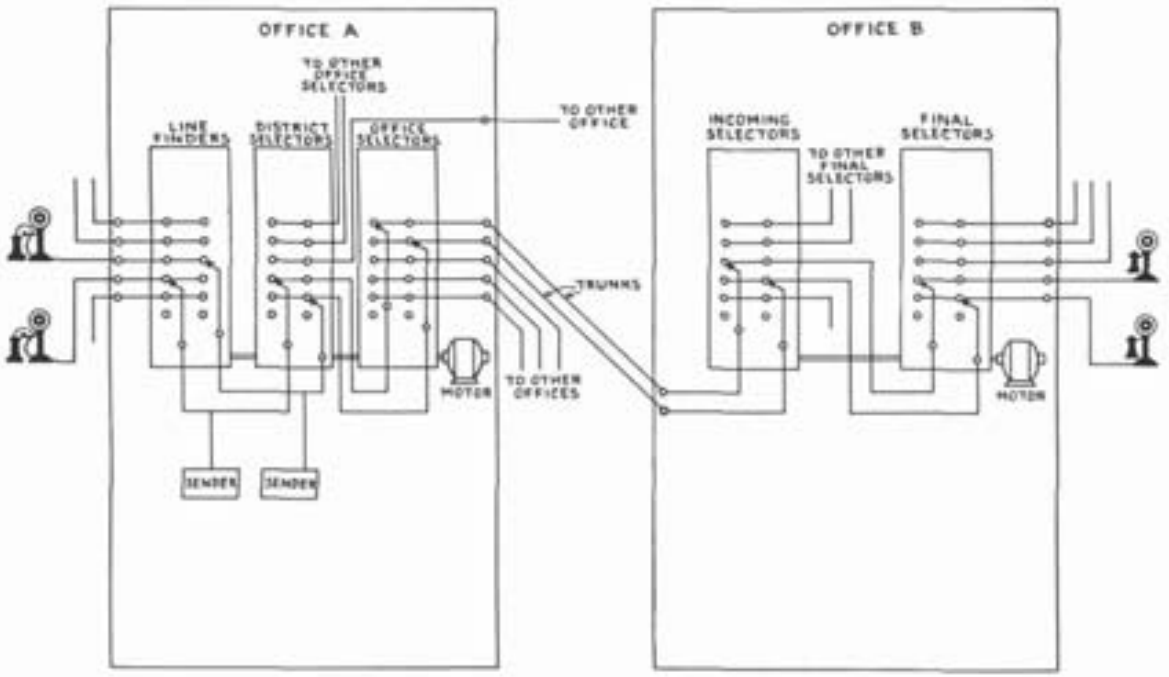


Figure 6

Figure 7

Construction of the Panel Type Selector

In order to understand fully the operation of the panel type dial system it is necessary to study the mechanical details of the various pieces of apparatus as actually constructed. The principal piece of apparatus which gives the system its name is the panel type selector, so called because the terminals over which the selector passes are arranged in a flat rectangular bank or panel. This is used throughout the system in various forms, differing in size, in detailed arrangement, in electrical connections, but all having the same general mechanical construction. We will begin by considering the general construction and describe later the detailed differences which distinguish the various selectors.

Figure Number 7 is a general view of selector frames in an office and Figure Number 8 is a closer view of a typical selector frame. It will be observed that all apparatus is mounted upon a structural iron framework securely bolted to the floor and to the ceiling. In Figure Number 8 there will be seen five banks of terminals mounted one above the other. Figure Number 9 shows one of these banks removed from the frame. It consists of flat strips of brass having projecting lugs, separated by strips of insulating material and clamped together by long bolts passing through holes in all of the strips. The lugs are so arranged that they project on both sides of the bank and are repeated thirty times on the front and thirty times on the rear of each strip. A set of three strips constitutes the terminals of one line or trunk and they are designated "tip," "ring" and "sleeve" terminals as in manual practice.

The terminals of the lines or trunks then appear in vertical rows, each row containing 100 lines or trunks in each bank and there are thirty such rows on the front and thirty on the rear, so that each line or trunk appears sixty times in each bank. Connections to the lines or trunks are made by wires soldered to lugs at one or both ends of the bank. In actual practice, in those selector frames where these terminals represent trunks, only 90 of the 100 possible trunks in each bank are used as trunks, the remaining 10 being required for other purposes.

The selectors consist of vertical brass tubes, one mounted opposite each vertical row of three terminals and arranged to slide up and down. Since there are 60 vertical rows, 60 selectors can be accommodated on each frame, 30 on each side. The selector tubes carry sets of spring fingers or "brushes" in front of each bank which may be made to rub on the terminals when the selector is driven up or down.

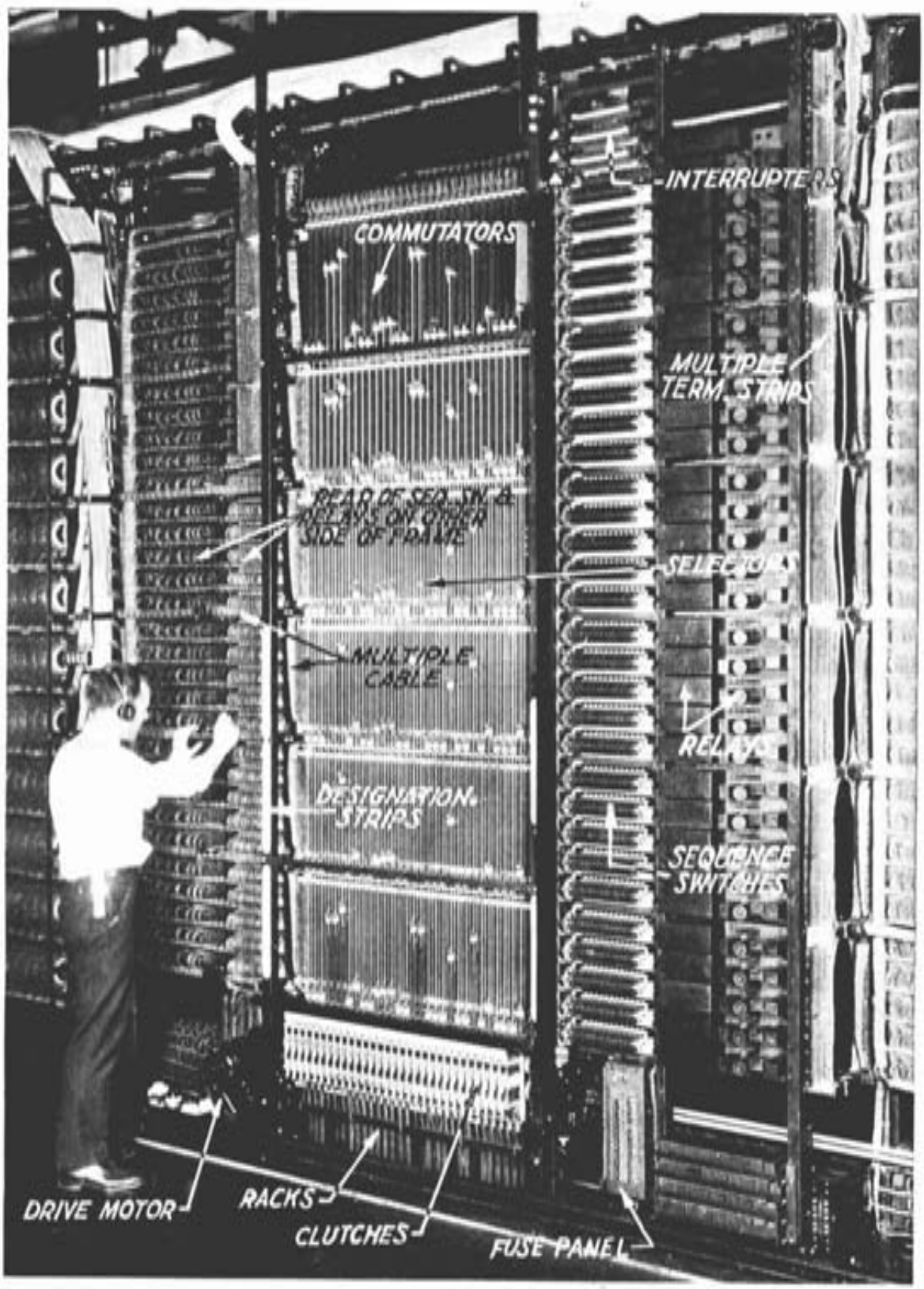


Figure 8
Panel Type Selector Frame

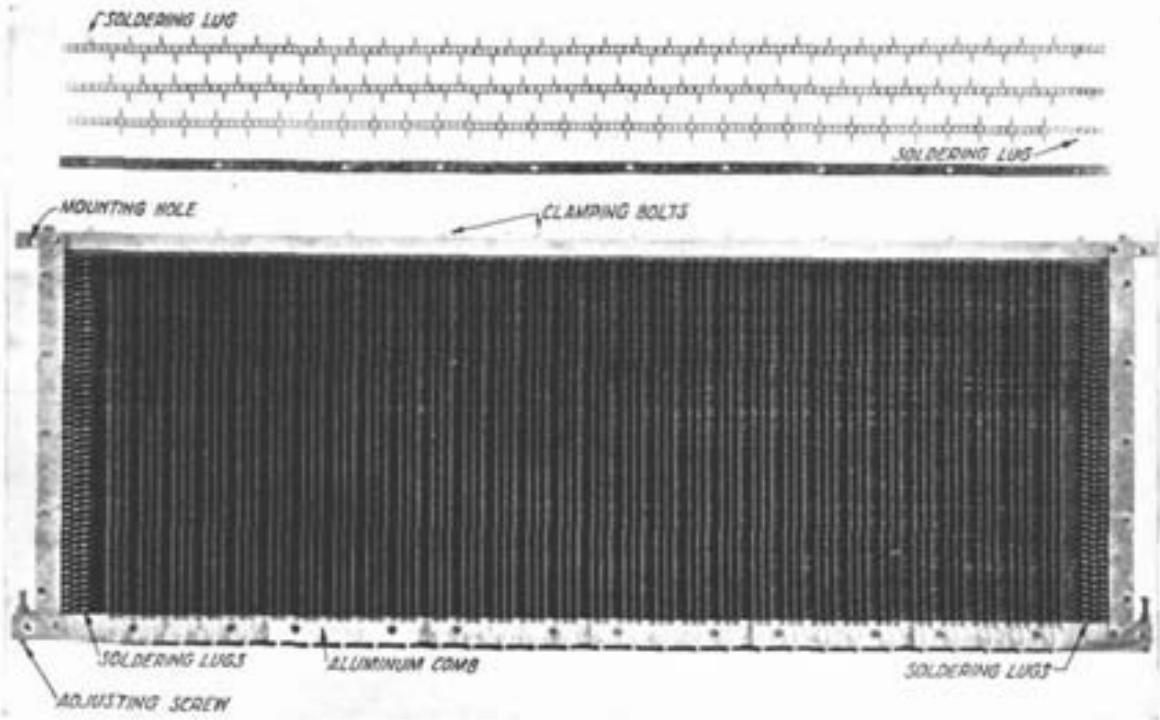


Figure 9

In the middle of the frame at the bottom are long rolls covered with cork composition which are constantly revolved by an electric motor through the medium of gears. The rolls, the electric motor and the gear boxes can be plainly seen in Figure Number 10, while Figure Number 11 shows the rolls with their gear boxes removed from the frame. The lower roll rotates in such a direction as to drive the selector upward and the upper roll in the opposite direction to drive the selector downward. Each selector tube is attached at its lower end to a flat strip of bronze called a "rack,"

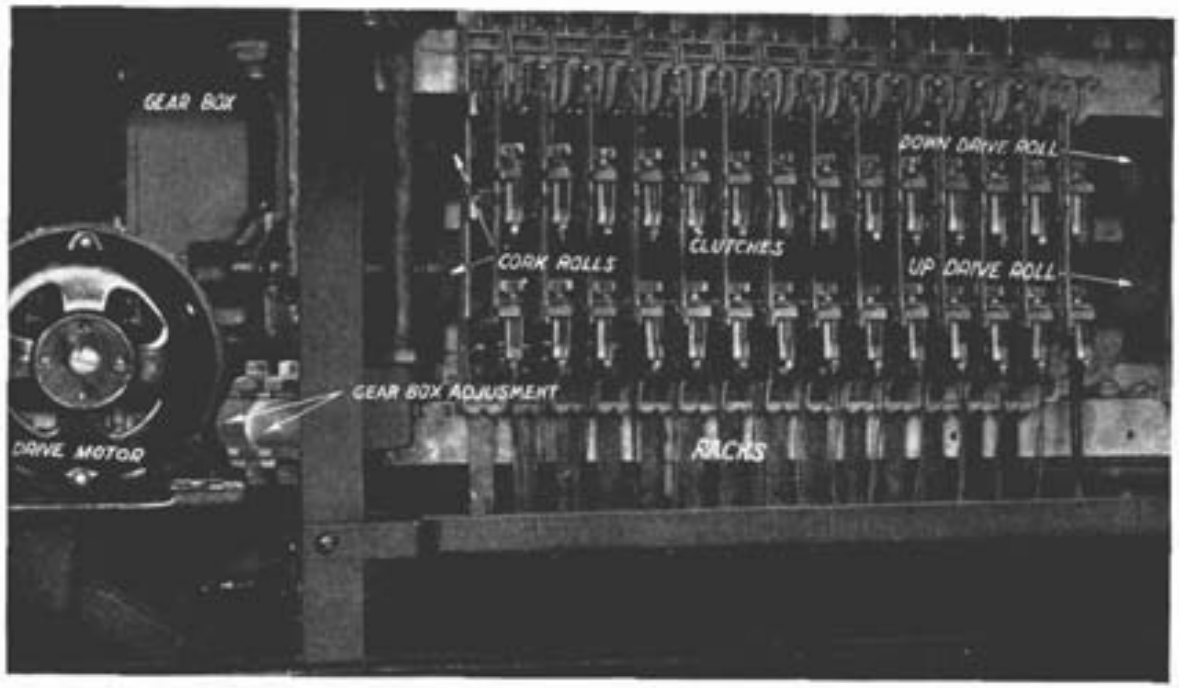


Figure 10

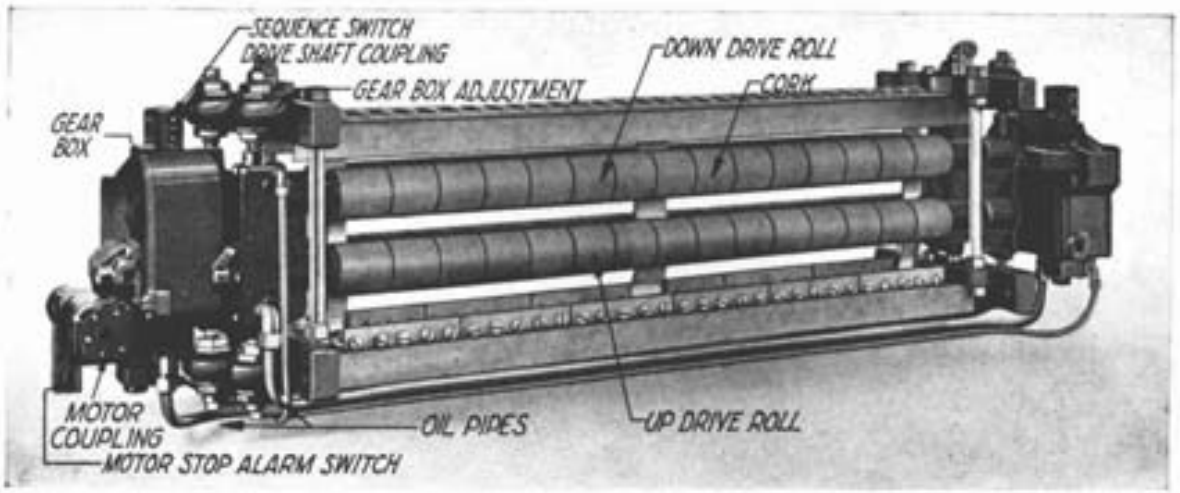


Figure 11

which normally stands just in front of the revolving rolls but not touching them. In front of each rack is an electromechanical device called a "clutch." The clutches are shown in position in Figure Number 12 and a separate clutch in Figure Number 13. When an electric current is passed through one of the magnets of the clutch a roller attached to its armature presses the rack against one of the revolving cork covered rolls which, by friction, moves the selector up or down. A spring pawl which can be seen just above the upper roller of the clutch in Figure Number 13 drops into notches punched in the rack and prevents the selector from falling when it has been raised. An arm on the armature of the down drive magnet of the clutch withdraws the pawl when the selector is driven downward. The rack, brushes, and upper part of the clutches are clearly shown in Figure Number 14.

Corresponding terminals of the five brushes on

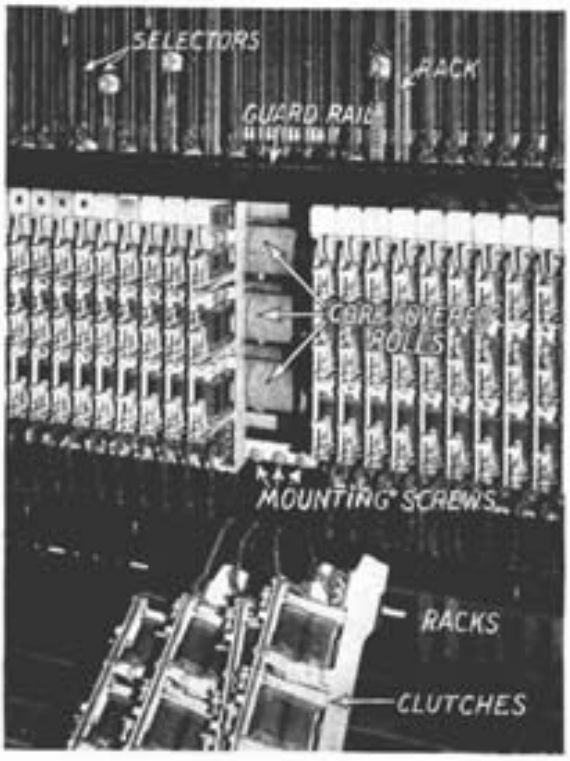


Figure 12

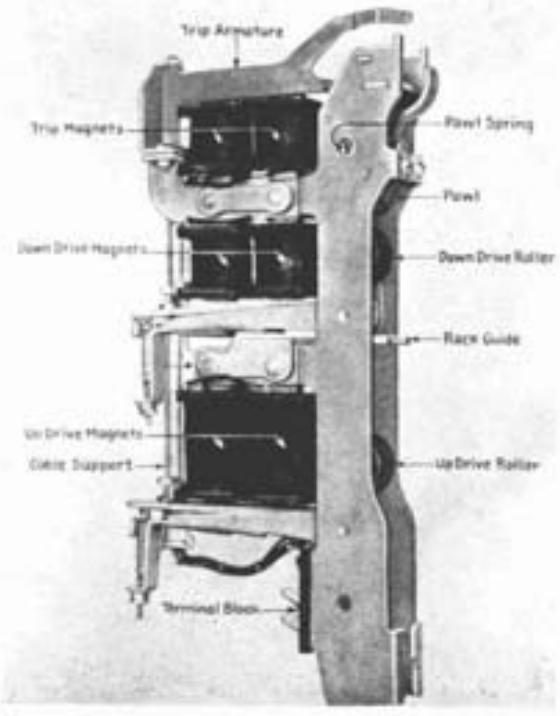


Figure 13

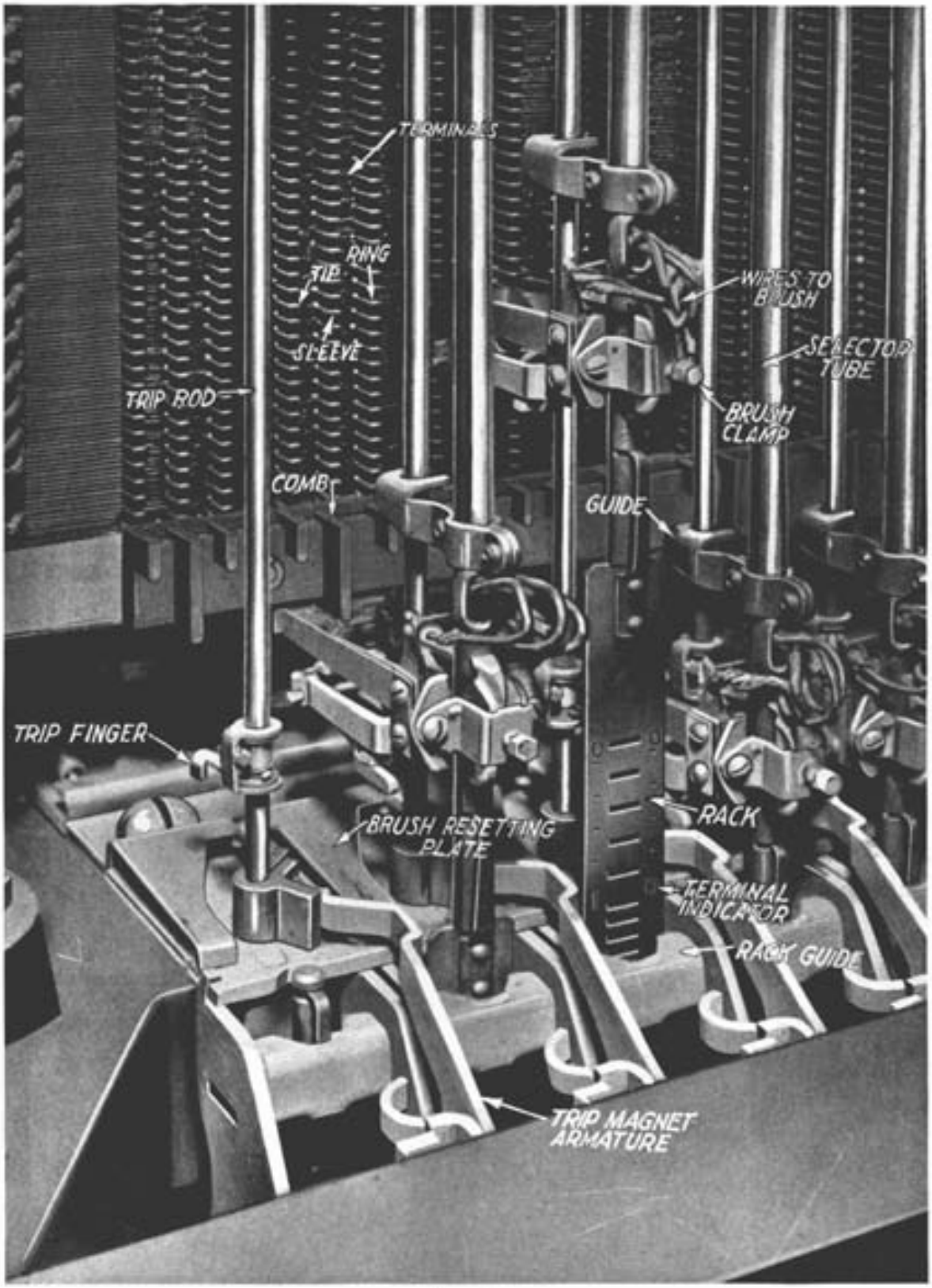


Figure 14
Panel Type Selecting Mechanism

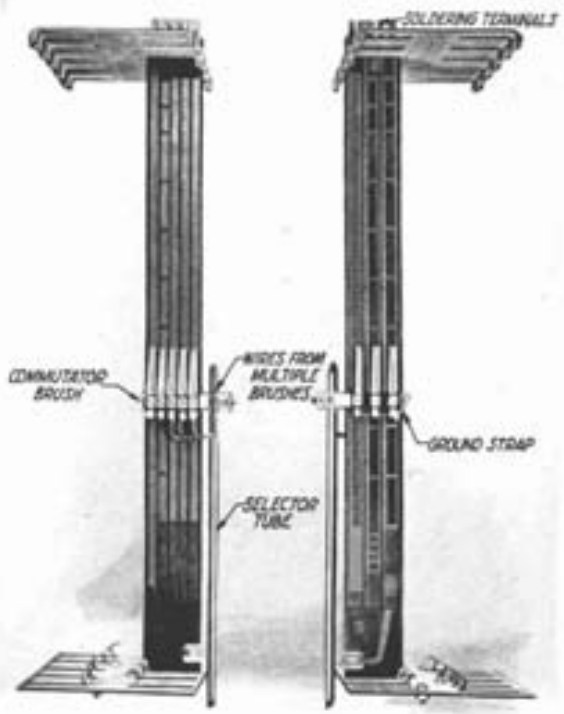


Figure 15

each selector tube are connected together by wires which pass inside the tube and come out at the top where they are connected to another brush of different construction mounted at the extreme top of the tube. This brush slides on a "commutator" which consists of brass bars molded in insulating material and serves to conduct current which enters the commutator to the moving selector brushes. The commutator and the commutator brush also control electrically the movement of the selector, as will be described later. The commutator and commutator brush are shown in Figure Number 15.

The selector brushes which are shown in detail in Figure Number 16 do not normally touch the terminals, their fingers being held apart by two little hard rubber rollers which are forced between them. When the selector rises, no contact is made with any of the terminals unless one of the brushes is closed or "tripped" by withdrawing the rubber rollers which hold the brush open. Between each selector tube and its terminals and encircled by the fingers of the brushes is a small vertical brass rod arranged to be partially rotated by a magnet at the top of the clutch (see Figure Number 14). This rod carries five spring mounted latches and is called the "trip rod." Either in the normal position or when fully rotated, the latches of the trip rod do not interfere with the movement of the selector, but if the selector is raised to a certain point and the trip rod then rotated, one of the latches will catch on a projection of its

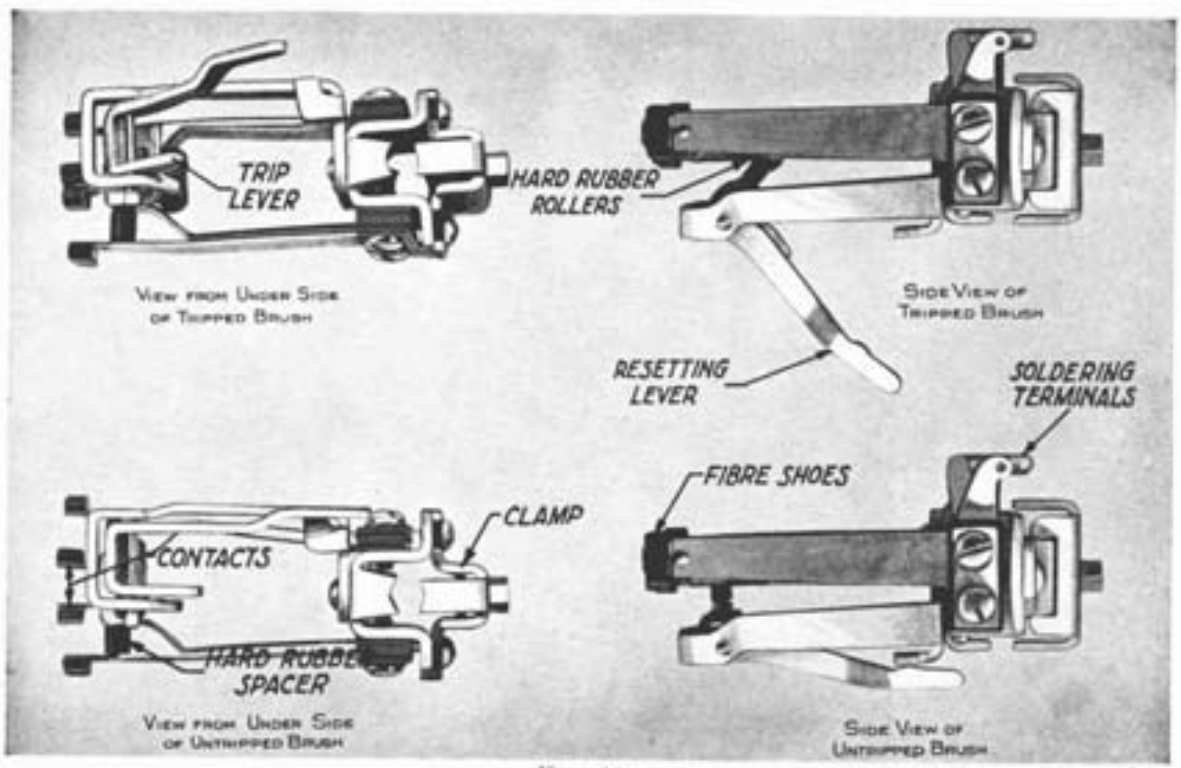


Figure 16

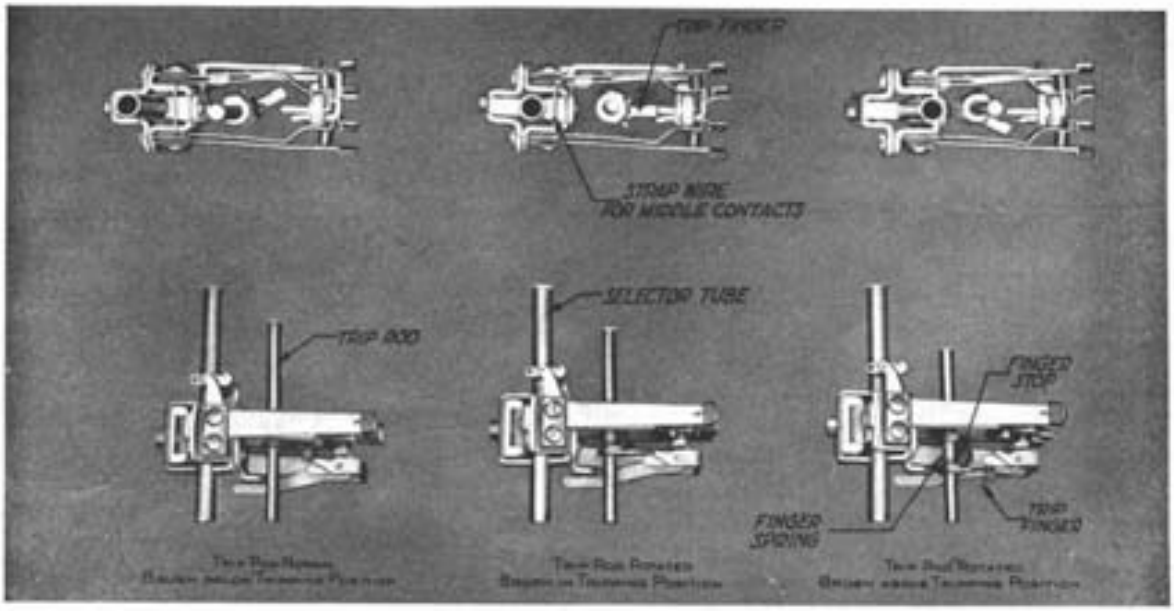


Figure 17

associated brush and be held there while the other latches continue to rotate with the trip rod. This projection is attached to the hard rubber rollers which hold the brush open and any further upward movement of the selector will now cause the hard rubber rollers to be withdrawn and the brush to close and make contact with the terminals of the bank. When the selector descends again a long trigger attached to the hard rubber rollers strikes the framework and restores the brush to its normally open position just as it reaches the lowest point of its travel. The various steps in tripping a brush are shown in Figure Number 17.

The brushes on the selector tube and the latches on the trip rod are placed equal distances apart but the latches are not the same distance apart as the brushes. There is, therefore, a certain position of the selector in which the first latch on the trip rod will, if the rod is turned, catch the projection on the first brush but in this position none of the other latches will catch the projections on the other brushes, being too high. Similarly, there is a certain position in which only the second brush will be caught, the latch for the first brush being too low and the latches for the other brushes being too high. This is shown diagrammatically in Figure Number 18. Thus by moving the selector up to a certain point before turning the trip rod, any one brush on that selector can be tripped but not more than one brush can be tripped at once. By this plan any terminal in any of the five banks can be reached by the selector although the total travel of the selector is only the height of one bank.

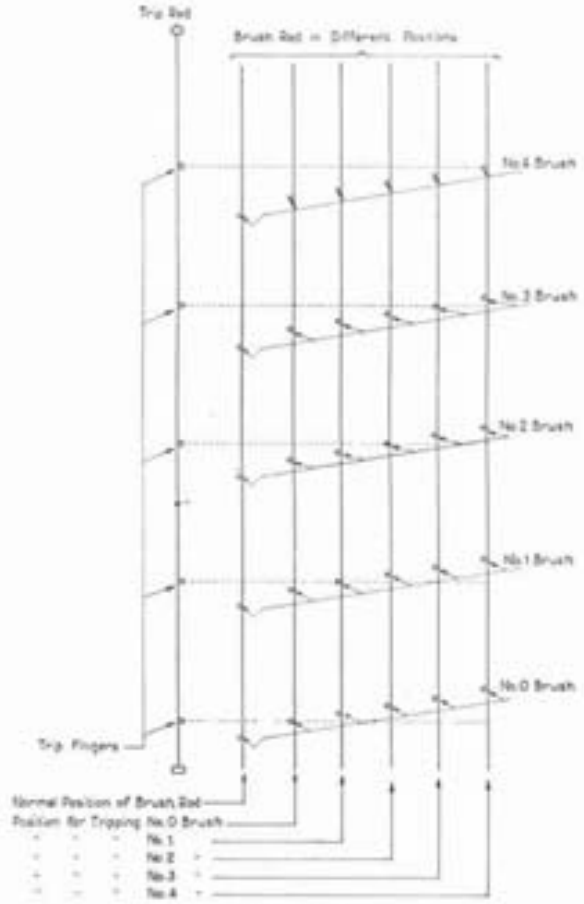


Figure 18

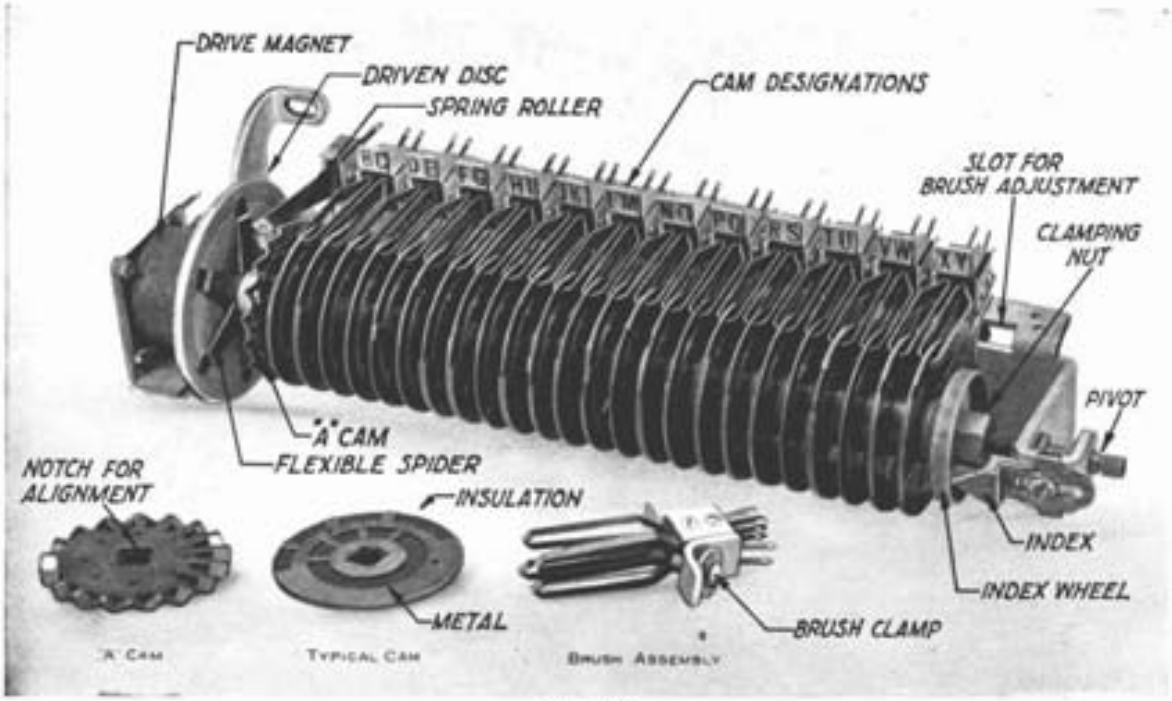


Figure 19

The Sequence Switch

The circuits which control the movements of panel type selectors are necessarily complicated and their operation requires the making and breaking of a large number of connections. Some of these connections are established or broken by means of relays. To reduce the number of relays required, a special form of switch called a "sequence switch" has been developed which, in general, performs the functions of a group of relays. Figure Number 19 shows one of these switches and Figure Number 20 a number of them mounted upon the framework. One of these switches is associated with each selector and the 30 switches associated with the 30 selectors on the front of the frame can be seen at the right of Figure Number 8. The 30 switches associated with the 30 selectors on the rear of the frame are mounted in a corresponding position at the right of the selectors on the opposite side of the frame. Switches of this type are also used for other purposes throughout the system.

The sequence switch is somewhat similar in principle to the controller of a street car. It consists of a number of discs or "cams," each composed of two plates of metal riveted one on each side of a disc of insulating material and all mounted on a square shaft which can be revolved. Four contact springs rest on each disc and a fluted cam with a spring roller at the end of the shaft serves to hold the shaft in any one of eighteen positions which are indicated by a numbered wheel at the opposite end of the shaft. The metal plates are cut with irregular notches so that in certain positions of the shaft certain contact springs rest on the metal of the plates and others on the insulating material, while in other positions different springs rest on the metal and the insulation, respectively. Turning the shaft therefore serves to make and break the connections between contact springs in various combinations. As one of these switches will accommodate as many as 24 cams, each of which has four contact springs, there may be 96 separate wires connected to the switch, which by turning the shaft can be connected or disconnected in 18 different arrangements and each arrangement is capable of an almost infinite number of variations by changing the shape and size of the notches in the metal plates. Contacts may be made or broken simultaneously or separated by exact time intervals, a thing which it is difficult to do by means of relays.

The functions of a sequence switch in controlling a selector are enumerated in Figure Number 21. Position Number 1 is the normal position of the switch when the selector is not in use. As soon as

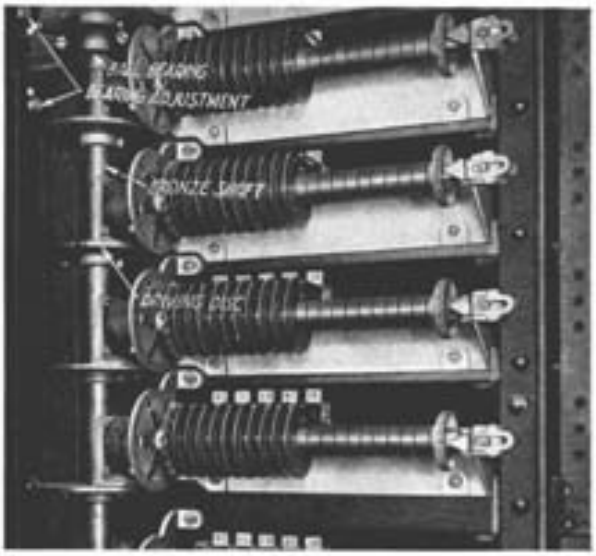


Figure 20

the selector has been chosen to be used in making a call, it is necessary to select an idle sender. This is not done by the sequence switch but it serves to make certain electrical connections for this purpose when it is turned to position Number 2. Until the idle sender has been found, nothing more can be done, so the sequence switch is turned to position Number 3, where the connections are arranged to wait for the sender. In the same way for each new operation to be performed the sequence switch is turned to a new position and in that position makes the proper electrical connections for that operation.

The sequence switch is turned by a friction drive mechanism at the end of its shaft. Next to the fluted cam is an iron disc mounted on a flexible bronze spider. With the sequence switch mounted on the framework, this disc stands close to but not touching a horizontal iron disc on a vertical brass shaft which is constantly revolved by the same motor which drives the cork covered rollers for the selector drive. Close to the first disc is an electromagnet. When current is applied to this magnet the flexibly mounted disc is drawn against the revolving disc and the sequence switch shaft is driven around by friction. The current on the magnet is maintained by a contact spring on the fluted cam which does not allow the switch to stop until it falls into an insulated notch in the fluted cam. It is only necessary, therefore, to put current on the magnet momentarily and the switch will revolve to the next position at which there is a notch in the fluted cam. If there is no notch in a position the switch will not stop in that position. Each time the switch stops it is necessary to apply current momentarily to the magnet to make it turn to the next position.

DISTRICT SEQUENCE SWITCH

Position	Corresponding Circuit Condition
1	Normal.
2	Selecting an idle sender.
3	Waiting for sender.
4	Selecting brush.
5	Waiting for sender.
6	Selecting group.
7	Waiting for relays.
8	Hunting idle trunk.
9	Waiting for sender.
10	Selection of brushes, groups, etc. beyond the district selector.
11	Waiting for sender.
12	Talking (non-loaded trunk).
13	Talking (medium-loaded trunk).
14	Waiting for operator to answer.
15	Talking to operator.
16	All trunks busy.
17	Operating message register.
18	Returning apparatus to normal.

Figure 21

Other Types of Apparatus

Figure Number 22 shows interrupters which are used for operating time measures, providing a busy signal, etc. A gear mounted at the top of the sequence switch driving shaft revolves a cam which moves back and forth a long bar, studs on which open and close a number of contacts. The lower interrupter in Figure Number 22 has a double reduction gear under the metal cover, so that it moves very slowly.

Another type of apparatus used in this system is the rotary switch shown in Figure Number 23. This switch has six rows of 22 terminals each, arranged in an arc, and a set of double armed brushes which wipe over the terminals. The brushes are rotated by means of a magnet which actuates a ratchet and pawl, the brushes making one step by each operation and release of the magnet. The armature of the magnet also operates a set of contacts and with these connected in series with the magnet winding, the magnet when it operates opens its own circuit and drives the brushes around continuously in a series of rapid steps so long as current is supplied. This switch without the above contacts is used for various purposes where it is required to make one step each time the circuit is made and broken, such as recording the pulses from the subscriber's dial or as a time measure, when it is operated by

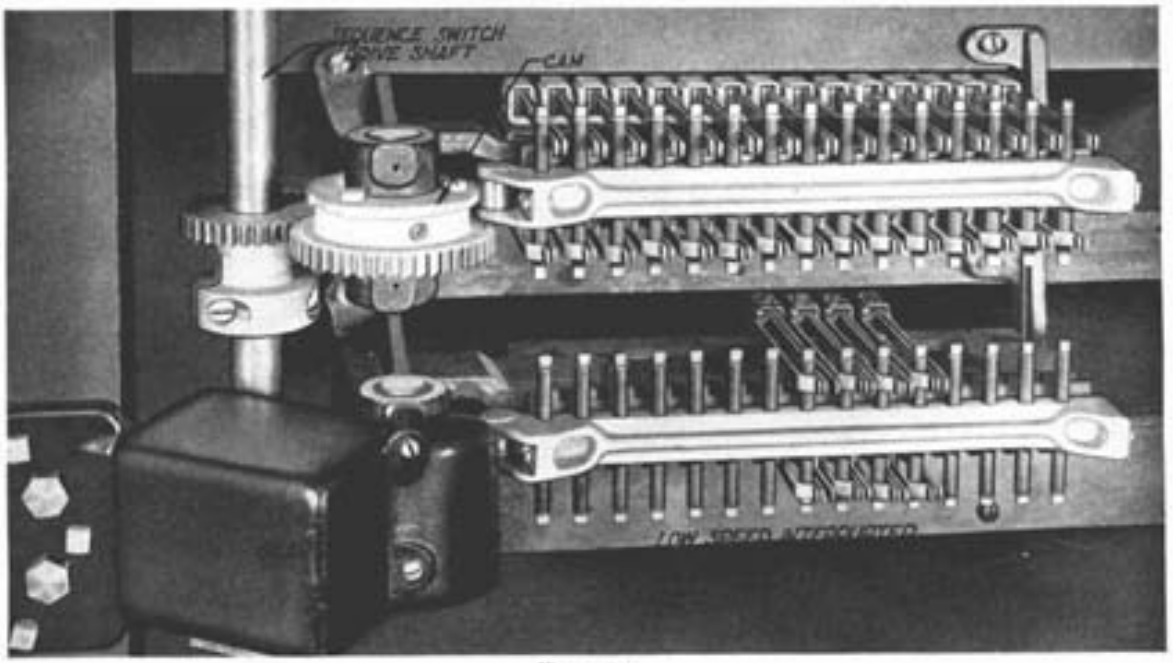


Figure 22

an interrupter which regularly opens and closes the circuit. With the contacts connected, it is used as a hunting selector, the current being applied continuously and being cut off by the switch itself when the brushes come in contact with the terminal for which the switch is hunting. Figure Number 24 shows a number of these switches mounted on a framework.

It should be observed that in all the above apparatus the contacts are made on vertical surfaces and are wiping. Such contacts free themselves from dust which would accumulate on horizontal surfaces and by the wiping action keep themselves clean and bright so that dust covers or dust-tight cases are not necessary.

Figure 23

Figure 24

Method of Operation

Figure Number 23 shows the general plan of a call from one dial subscriber to another. The rectangles represent the terminal banks of panel type selector frames and the vertical lines with arrowheads represent selectors. When the subscriber removes his receiver from the hook he permits current from the central office to flow through his line, operating a line relay, one of which is provided in each subscriber's line. The operation of this relay causes a line finder selector to start and to move upward until it finds the calling line. This connects the district selector associated with the line finder to the calling line. The district selector is the path by which the call must pass outward and it may be likened to the calling cord of a manual cord circuit, while the line finder performs the functions of the answering cord.

Each line finder selector is cabled permanently to a district selector. A third leg of the circuit extends to the sender selector, which is a rotary switch. Sender selectors are shown in Figure Number 24. As soon as a line finder starts to hunt for a calling line, the attached sender selector hunts for an idle sender. When both the line and the idle sender have been found, a tone called "dial tone" is sent to the subscriber as an indication that the apparatus is ready for him to dial. The subscriber then dials and the pulses of current from his dial are recorded in the sender, which then controls the movements of the other selectors in a manner which will be described later.

The purpose of the sender selector is, of course, to connect an idle sender to the subscriber's line when he wishes to make a call and to disconnect the sender as soon as it has completed its functions so that it may be used by another subscriber. The sender selector switch, having 22 sets of terminals, may be used to select an idle sender from a group of 22 senders. The panel type subscribers' links shown in Figure Number 26, perform the same functions but enable the sender to be chosen from

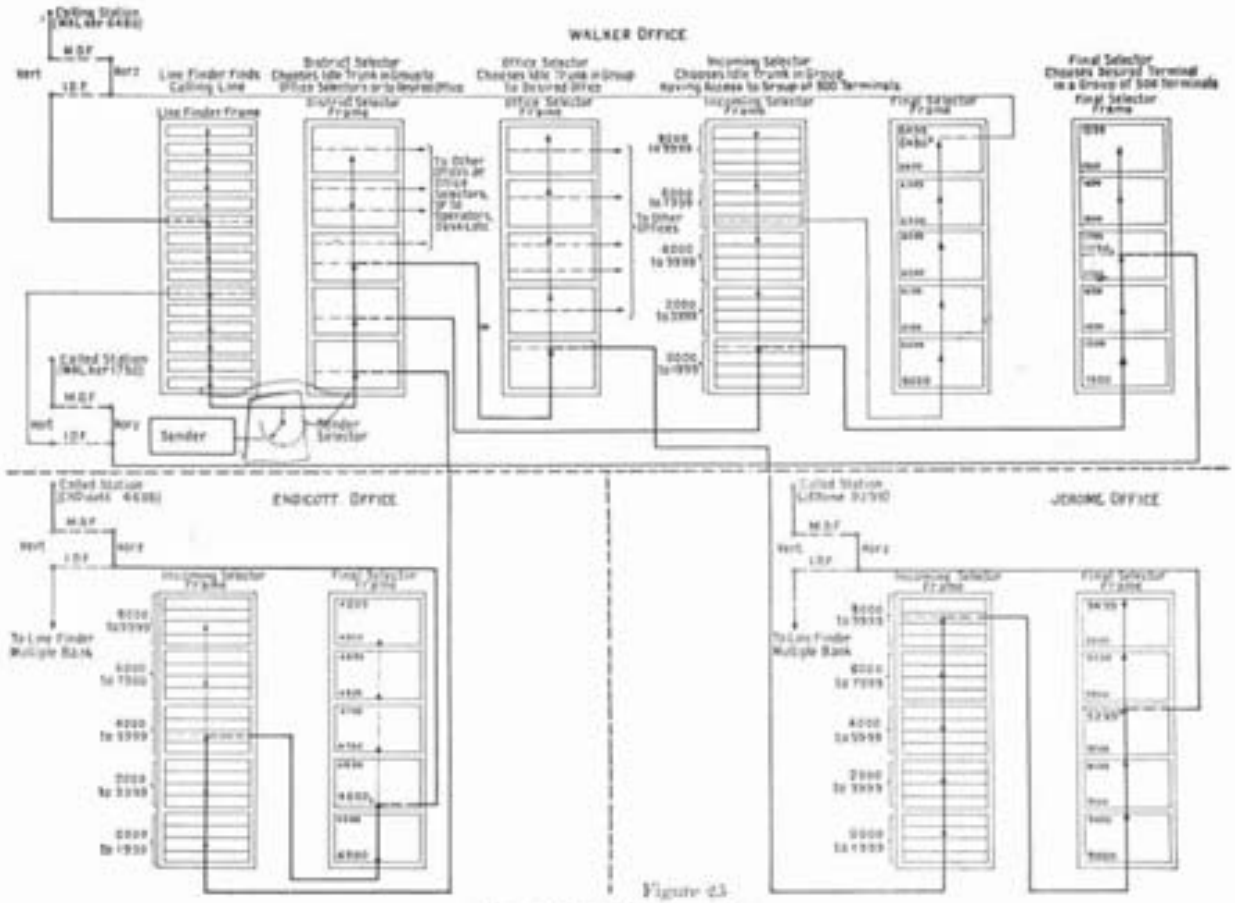


Figure 23

Plan of Direct Dial Connections

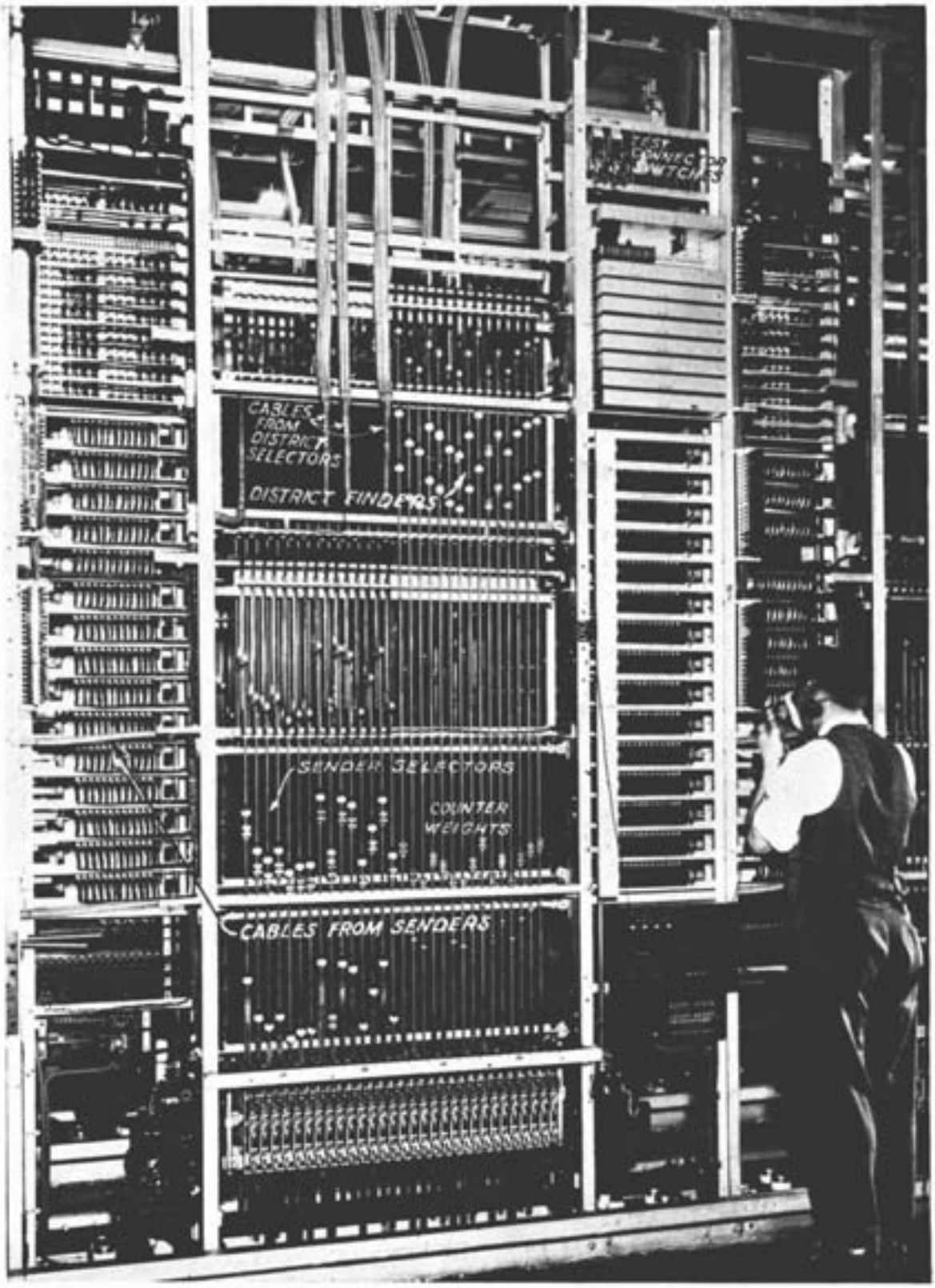


Figure 06
Subscriber's Panel Type Link Frame

a group of 100 senders. This type of equipment has superseded the sender selector since one group of 100 senders can handle more calls than 5 groups of 20 senders (or, as a matter of fact, 5 groups of 22 senders) for the same reasons that, as previously explained, one group of 20 trunks will carry more calls than 2 groups of 10 trunks, so that fewer senders are required in an office using panel type links than in a similar office using sender selectors.

Each panel type subscribers' link consists of 2 panel type selectors, a long "district finder" at the right in Figure Number 26 and a short "sender selector" in a corresponding position at the left. The district finder and the sender selector each have two brushes, those on the district finder working on the topmost bank and those on the sender selector on the two lower banks. These brushes are always tripped and are all used at the same time simply serving to make double the number of contacts that could be made by single brushes. The district finder finds the district selector to which the next subscriber that calls will be connected by the line finder, while the sender selector selects an idle sender when the call is received. The two, being connected together, serve as a link to connect the subscriber to the idle sender. Neither of these selectors returns to normal. At the completion of a connection, the district finder moves immediately to the terminals connected to the next idle district selector to be ready for another call. Since it cannot be determined in advance what senders will be idle when the next call comes in, the sender selector remains where it is, unless it is resting on one of the upper 20 terminals of the bank. In this case, it returns to normal, for the probability is too great that, starting from so high in the bank, it might not find an idle sender on its upward travel and would, therefore, cause a delay by returning to normal during the hunting period.

The district selector may connect the subscriber's line to a trunk to the distant office that he is calling. The 450 trunks which can be reached by a district selector are, however, not enough in large districts to provide sufficient trunks to all the offices which a subscriber may call. In this case, the district selector connects the subscriber's line to a trunk leading to an office selector which can reach trunks to the office called. Each group of office selectors can reach 450 trunks, so that by providing a number of groups of office selectors, trunks can be provided to any number of offices. The trunk to the distant office terminates there on an incoming selector. If the incoming selector selected the terminals of the subscriber called, only 500 subscribers could be reached, as only 500 lines can be connected to a panel type selector frame. Each office is arranged for 10,000 stations, so that 20 selector frames or groups of selectors are required to reach all the stations, each selector frame or group of selectors reaching a certain 500 stations. The incoming selector, then, is arranged to select a trunk to a final selector on one of these 20 frames and the final selector selects the station desired.

Not all calls will be for subscribers in distant offices. If a station in the calling subscriber's own office is called, the district selector may route the call directly to an incoming selector in the calling subscriber's own central office. On certain calls, such as toll calls, and calls for information, or if the subscriber wishes assistance, it will be necessary for him to be connected to an operator. This is accomplished by the district selector, which instead of choosing a trunk to an office selector selects a trunk leading to a jack in a switchboard where the call is answered by an operator. Calls of this character, calls for subscribers in manual central offices, and calls coming into the office from manual central offices will be described later.

Each of the various selectors mentioned above has certain peculiarities which adapt it to its particular functions. Figure Number 27 shows a frame of line finders. It will be seen that the line finder is a panel type selector but differs from the general type in having 15 small banks, each 20 sets of terminals high, thus accommodating 300 subscribers' lines. (A later design has 10 banks, each 40 sets of terminals high, taking care of 400 subscribers' lines.) In these banks four terminals are provided for each line instead of three as in other panel selectors. The object of the small banks is to reduce the travel of the selector and therefore to reduce the time required for the selector to reach the terminals of the calling line. This time is further reduced by dividing the bank in half and reversing the order of the terminals in half of the bank so that a line whose terminals appear near the top in the left-hand half of the bank appears near the bottom in the right-hand half. To find the calling line a selector is used which has the shorter distance to travel unless all such selectors are busy, when one of the other selectors will be used. Instead of a vertical trip rod for each selector, the line finder has a horizontal trip rod for each bank. The trip rod associated with the bank in which the calling subscriber's line appears will trip the corresponding brush of any selector which rises when the subscriber removes his rece'ver. The trip rods and the magnets which operate them can be seen at the right of Figure Number 28. The circuits are arranged to prevent two or more lines calling at the same moment from interfering with each

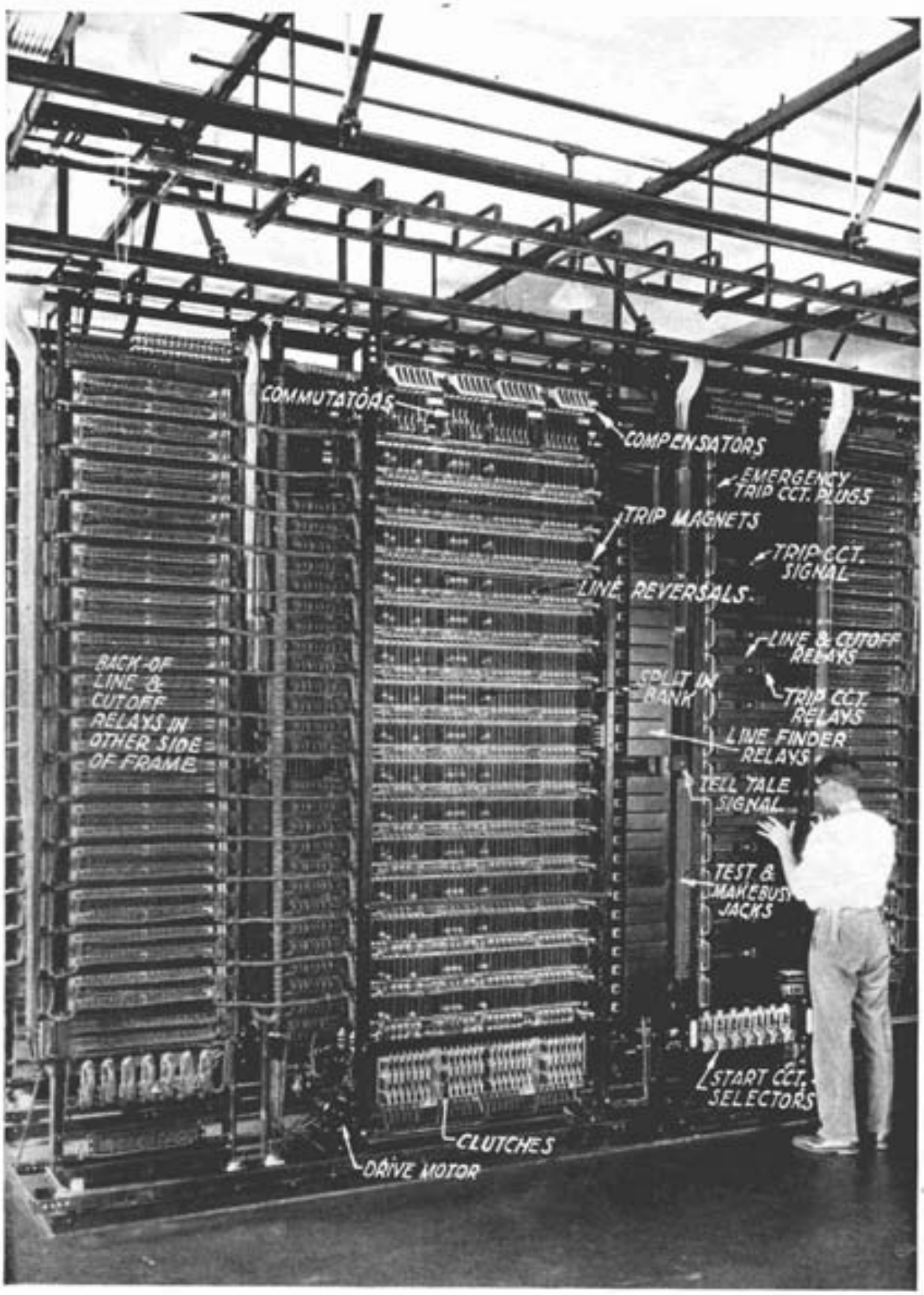


Figure 27
Line Finder Frame (300 point)

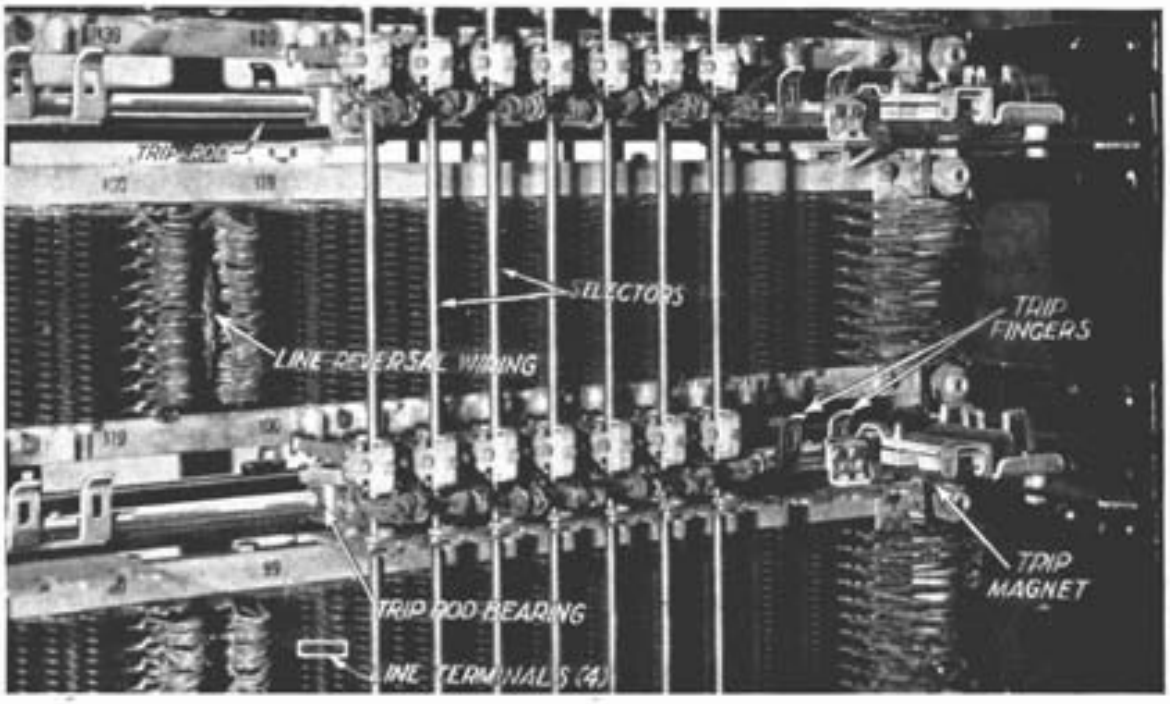


Figure 28

other and yet to insure that each line calling is attended to promptly.

District selectors are typical panel type selectors similar to those shown in Figure Number 8. In Figure Number 29 the large rectangles represent the five banks of terminals and the smaller rectangles represent ten trunks each, except at the top of each bank where there are two groups of five trunks each. Every eleventh terminal and an additional one between the two groups of five trunks at the top of the bank is arranged as an overflow terminal for use when the ten trunks below it are all busy. The trunks can be used in groups of any size from 10 to 90 in multiples of 10 and by using the groups at the top of the banks trunk groups of only 5 trunks can be obtained. When a trunk group larger than 10 is used the intermediate overflow terminals are made busy, so that the selector passes right over them. The size of the group to be used for any particular purpose depends, of course, on the volume of traffic to be handled. Figure Number 29 shows that trunks may be provided from the district selector frame to other offices, to groups of office selectors, to toll boards, to operators, etc. The district selector circuit is provided with a repeating coil through which is supplied the talking current for the calling subscriber.

The office selector is mechanically similar to the district selector and operates in the same manner.

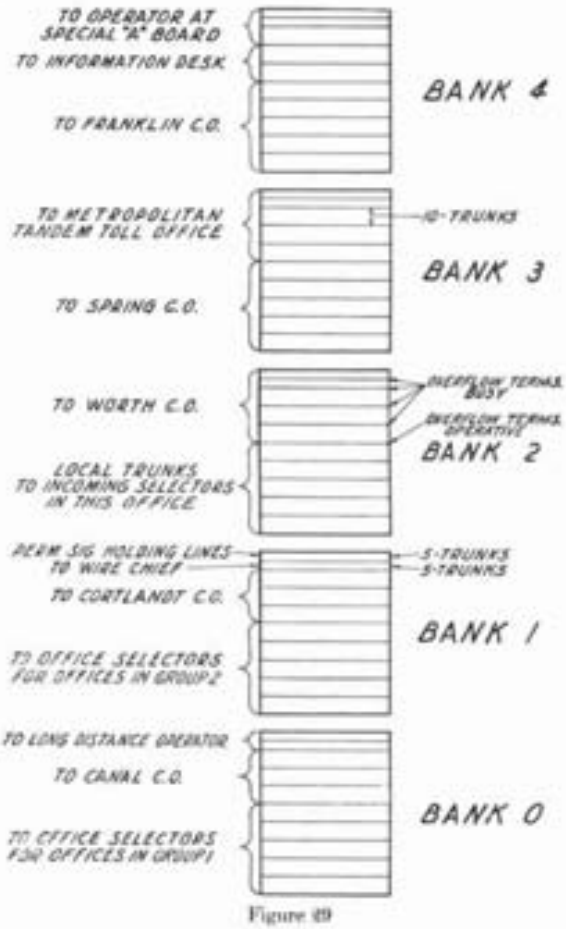


Figure 29

The circuit, however, is simpler and does not contain a repeating coil. From its terminal banks run trunks to distant central offices.

The trunks to the distant central offices terminate in those offices on incoming selectors. These are typical panel type selectors but each bank is divided into four groups of 24 trunks. Each of these groups gives access to certain 500 subscribers' terminals in the office, as shown in Figure Number 30. On all incoming frames, trunks in the same relative location lead to the same group of 500 subscribers' terminals and the numbering plan is the same in all offices.

The ringing current for ringing the called subscriber is applied at the incoming selector. In panel type offices each party, whether on a 2-party line or on a 4-party line, has his own number and his own set of terminals in the final frame for calls going out to that party, although for calls coming in from that line there is only one set of terminals in the line finder frame for all the parties on the line. In offices having direct lines and 2-party lines only, the ringing current is alternating current with the generator on the ring side of the circuit and ground on the tip side. On 2-party lines the bells of the two parties are connected from the ring and the tip sides of the line, respectively, to ground and the connections of the final terminals for that party whose bell is connected from the tip side of the

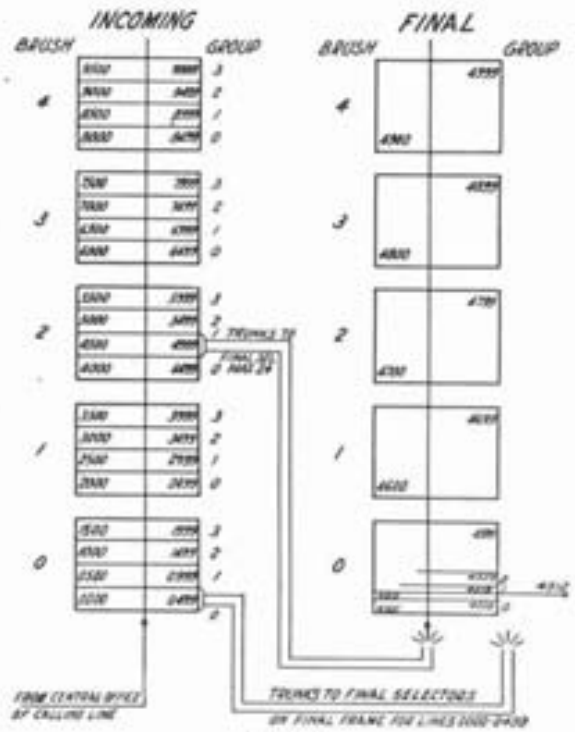


Figure 30

line are reversed, so that when he is called the generator current is sent out on the tip side of the line and ground on the ring side. In offices having 4-party lines with selective ringing, superimposed ringing current is provided. The generator cur-

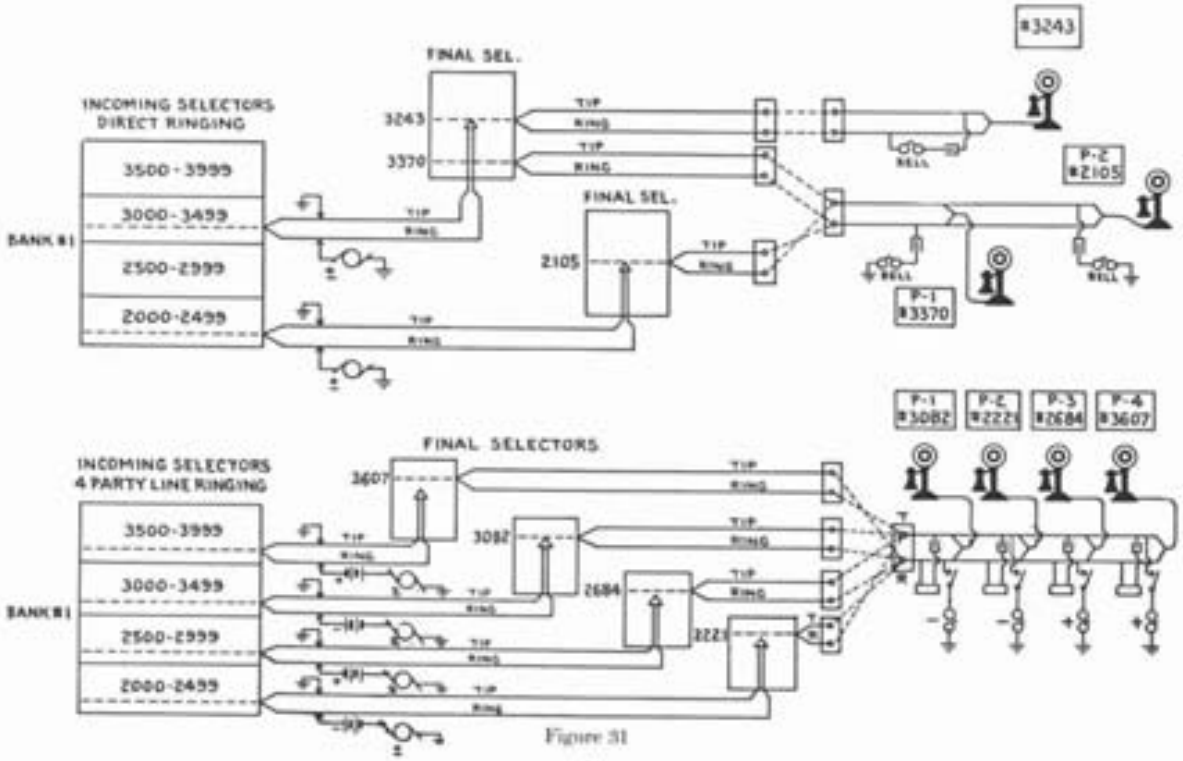


Figure 31

rent is always on the ring side of the circuit of the incoming selector and ground on the tip side, but there is a bar on the commutator which causes the superimposed direct current to be negative when the selector is stopped on any of the terminals of the first and third groups of trunks in each bank of the incoming selector frame and positive when the selector is stopped on any of the terminals of the second and fourth groups. The bells of two of the parties on the line are connected from the ring side to ground and biased to respond to positive and negative superimposed current respectively. The bells of the other two parties are connected from the tip side of the line to ground and biased also. Party Number 1 is rung by negative superimposed current on the ring side of the line and party Number 3 by positive superimposed current on the ring side of the line. Parties numbered 2 and 4 require negative superimposed current on the tip side and positive superimposed current on the tip side, respectively. For these latter parties the connections of the final terminals to the line are reversed. It will be necessary, then, that parties Number 1 and Number 2 have numbers which can be reached by the trunks in the first and third groups in any bank of the incoming frame, while parties Number 3 and Number 4 must have numbers that can be reached by the second or fourth groups. That is to say, any telephone which is party Number 1 or Number 2 on a 4-party line must have a number chosen from 0000–0499, 1000–1499, 2000–2499, etc., while any telephone which is party Number 3 or party Number 4 must have a number chosen from 0500–0999, 1500–1999, 2500–2999, etc. The numbers of the four parties on one line, however, bear no further relation to each other. Figure Number 31 shows this system of ringing.

The incoming selector circuit, like the district selector circuit, contains a repeating coil through which is fed the talking current for the called subscriber and the current for the trunk between the two offices.

The trunks from the incoming selector frame terminate on final selectors. These differ very little from the typical panel type selectors but each set of terminals in their banks represents not a trunk but a subscriber's station and as no overflow terminals are required, 500 subscribers' stations can be reached by each selector. District, office and incoming selectors are directed to the beginning of a group of trunks and then automatically hunt through that group for an idle trunk. Final selectors are directed to a certain group of 10 subscribers' stations and then must be directed to the particular station called. As the sets of terminals are only 1/8 of an inch apart, the final selector must move slowly when being directed to the particular station. For this reason, final selector frames are provided with a third cork covered roll which turns at about 1/4 the speed of the other rolls and drives the selector during the selection of the set of terminals representing the called subscriber's station. The final selector tests the line on which it stops and if it finds the line busy it returns to normal and sends back a busy signal. If a subscriber has a private switchboard with several consecutive lines, the final selector will stop on the terminals of the line the number of which was dialed, but if it finds that line busy, instead of returning the busy signal it

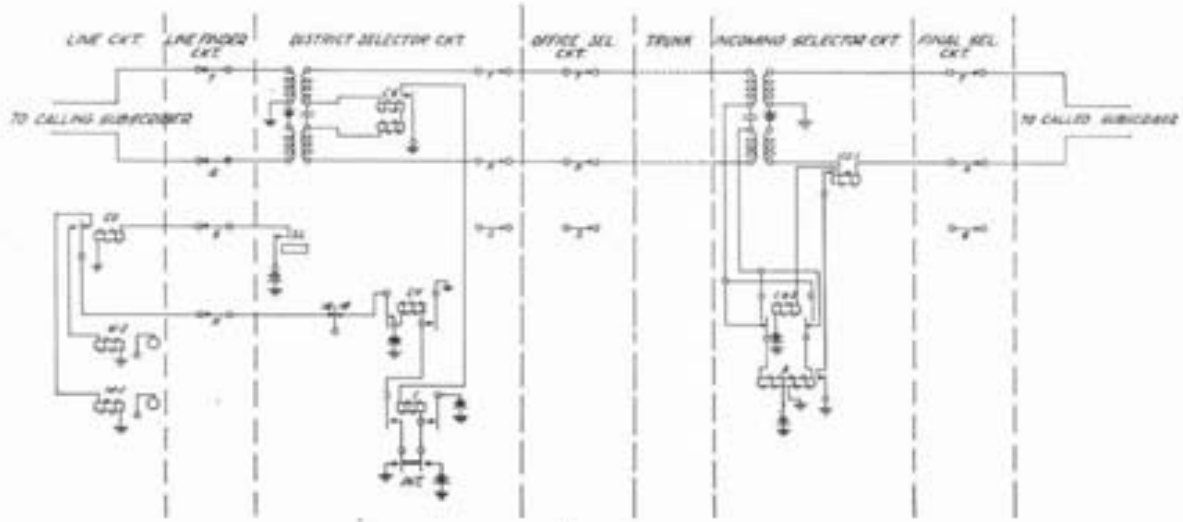


Figure 32

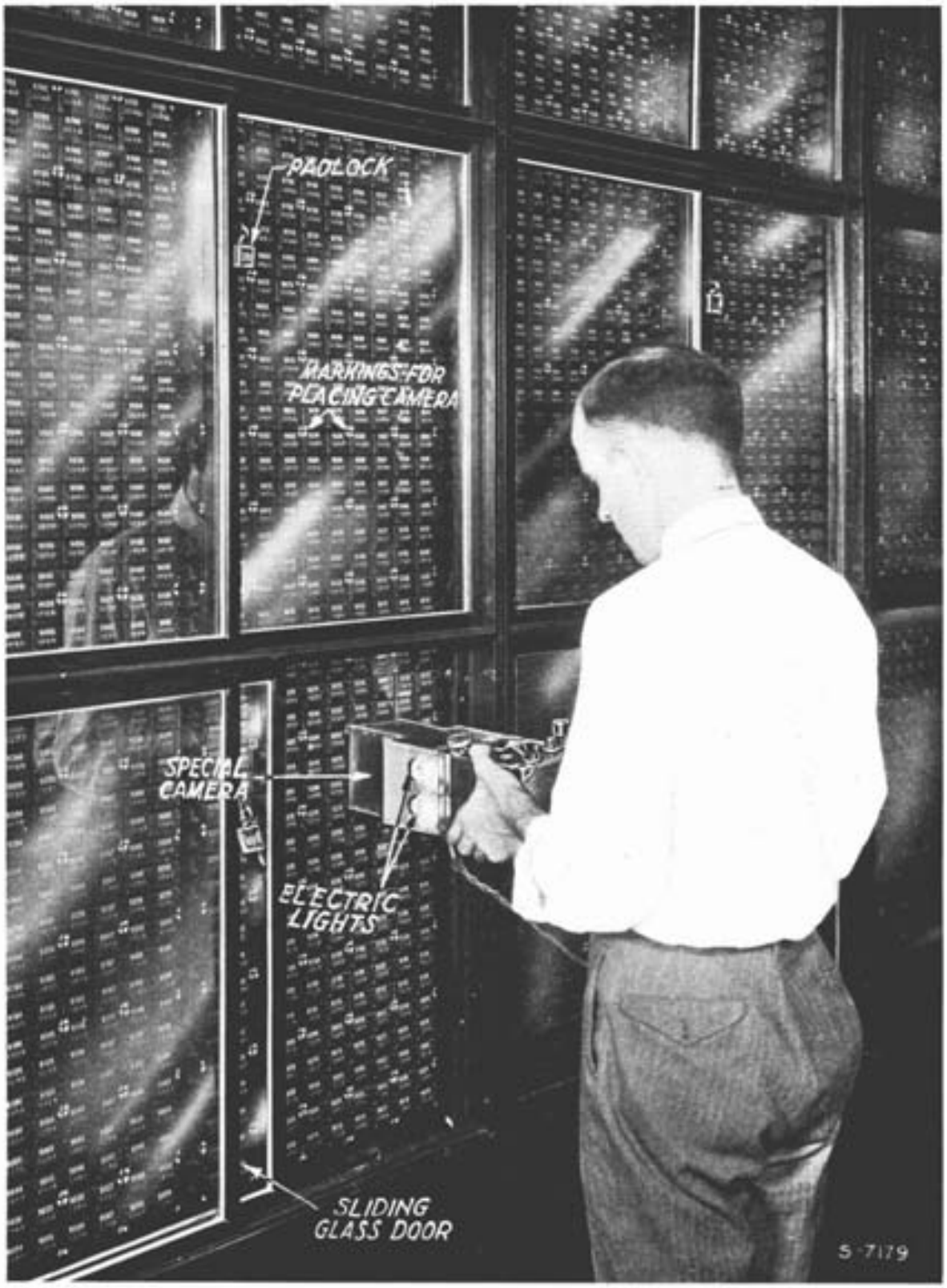


Figure 33
Photographing the Message Registers

will continue to the next line and not give a busy signal unless it finds all the consecutive lines of that subscriber busy. As soon as the selections on the final frame have been completed, the sender which has been controlling the movement of the selectors is released so that it may be used by another subscriber and if the line wanted is found idle, ringing current is applied at the incoming selector, as previously described. When the called party answers, the circuits are cut through for talking.

The release of the connection is under the control of the calling subscriber. When he hangs up his receiver, all of the apparatus involved in the call, with the exception of the final selector, returns to normal. After a predetermined interval the final selector also returns to normal. Should the called subscriber hang up his receiver, but the calling subscriber fail to do so, the apparatus will not be released but after a given interval the Maintenance Force will be advised of this condition by an alarm.

Message rate service is given with the panel type system and the message registers are operated automatically by the apparatus. The scheme of operation is shown in Figure Number 32. The answer of the called party causes the operation of relay "CS-1," which causes the relay "CS-2" to operate, relay "A" being, of course, operated as long as the connection is made. The operation of relay "CS-2" reverses the current in the trunk between the two offices. This causes the operation of relay "CS" which, being polarized, would not operate until the current was reversed. Relay "I" is now operated when the interrupter makes its right-hand contact. Relay "CH" is operated when the interrupter makes its left-hand contact, provided that relay "I" is still operated, which it can be only if the called subscriber still has his receiver off the hook. As the interrupter makes its left-hand contact approximately two seconds (in New York) after its right-hand contact, the called party must answer for at least two seconds for the call to be recorded. The "CH" relay being operated, the cam of the district selector sequence switch when it passes through position Number 16, which it will do after the completion of the conversation and the release of the apparatus, operates the message register.

The telephone of party Number 2 on a 2-party line is arranged to put ground on the line whenever his receiver is off the hook. This ground will cause the "SL" relay to be released, allowing the "CO" relay to release also and connecting the second message register to the "CH" relay when the call is made by this party. Message rate service is not given on 4-party lines.

The registers are mounted in a cabinet behind locked glass doors. Each month they are photographed with a special camera, as shown in Figure Number 33, and from this photographic record the charges to the subscriber are computed.

The Sender

In describing the method of making a connection a description of the operation of the most important feature of the panel type system has so far purposely been omitted so that this feature may be especially emphasized. It will be remembered that it was stated that in the panel type system, direct control of the selectors by the subscriber's dial and numerical selection have both been abandoned so that it is necessary to provide some mechanism which shall record the number as dialed by the calling subscriber, hold it, interpret it into terms of brush and group selection, and control the selectors in accordance with it. This mechanism as provided in the panel type system is known as the sender, and it and its associated apparatus constitute the most salient and distinctive features of this system. The sender with its associated mechanism of translator and pulse machine (or decoder) is the "brains" of the panel system and a thorough understanding of its functions and operation is essential.

Figure Number 34 shows a frame of subscribers' senders. The equipment for 5 senders is mounted on this frame. Each sender comprises the relays and other apparatus mounted in one of the metal cabinets and the 11 rotary switches and 6 sequence switches mounted to the right and left of the cabinet. A sender therefore is not a machine but an electrical circuit containing rotary switches, sequence switches, resistances, condensers, and relays.

The description of the operation of the sender will be divided into two parts: that due to the dialing of the office code, and that which results from the dialing of the called party's number. For the time being we will consider that the calling subscriber has dialed the office code and that it has served to obtain for him a connection to an incoming selector at the distant office in which is located the line of the subscriber with whom he desires to speak. The calling subscriber is now about to dial the number. Each panel type

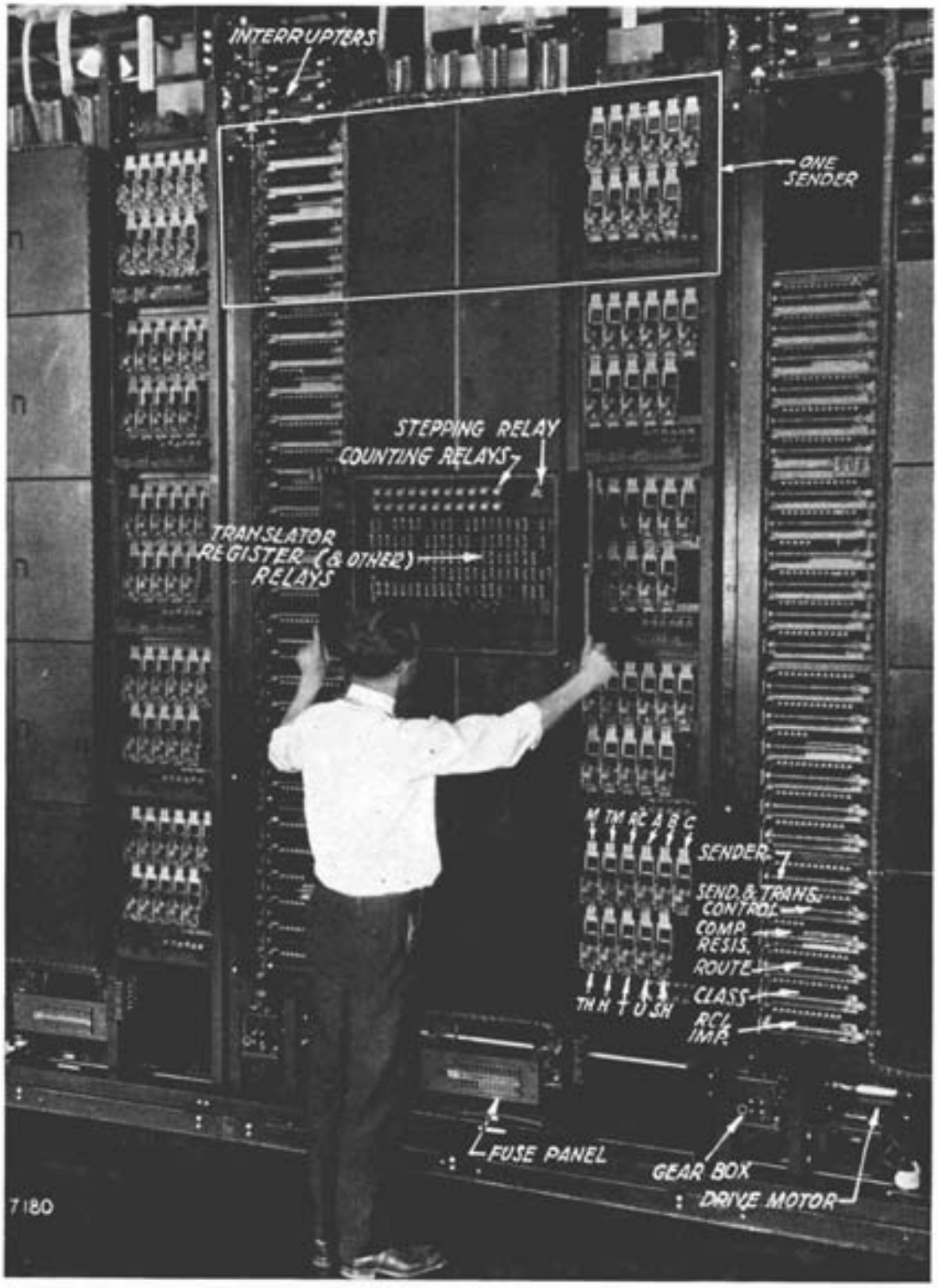


Figure 34
Subscriber's Sender Frame (3 Digit—Unit Type)

office is arranged for a maximum of 10,000 subscribers' stations so that each station will be given a number of 4 digits. It is always necessary to dial at least 4 digits. If the subscriber desired number 0353 but dialed 353 the sender would be unable to determine whether or not he intended to dial another digit. The digits dialed by the subscriber are recorded by rotary switches which make one step for each contact of the dial. Four of these register switches are used to record the number, one for the thousands digit, one for the hundreds, one for the tens, and one for the units. The transfer of the calling subscriber's line from one register to another is effected by a slow release relay, as previously mentioned, this relay, however, effecting the transfer by means of another rotary switch designated "register control." When the four registers have been set by the subscriber's dialing, they determine the movement of the incoming and final selectors to find the terminals of the called party.

The movement of the selectors is determined by what might be termed "reverse control." The selector, instead of being made to move a certain distance by the sender, is driven continuously upward and sends back pulses of current to the sender. These pulses are sent by the commutator of the selector and are counted by the counting relays of the sender. When a sufficient number of pulses has been sent back by the selector it is arrested. The number of pulses to be sent before the selector is stopped is determined by the number of counting relays included in the circuit and this is determined by the setting of the registers.

A complete description of the operation of the circuits of the panel type system is beyond the scope of this paper. No attempt will be made to trace any of the actual circuits and it must be understood that where a circuit is shown it is diagrammatic and contains only such portions as are necessary to demonstrate its operation when performing one particular function. Figure Number 35 is a simplified circuit showing one arc of one of the rotary register switches, some of the relays in the sender, and parts of the selector which is being controlled by the sender. The sender is shown controlling an incoming selector for the selection of the brush to be tripped. The dashed line separates the apparatus in the incoming selector from that in the sender. It should be noted that the sender is in the office of the calling subscriber, while the incoming selector is in the office of the called subscriber. When the contacts marked "B" are closed by the sequence switch the "L" relay is in an operated position (having been previously operated) and is held operated by the path through the stepping relay. The upward drive clutch of the selector also receives

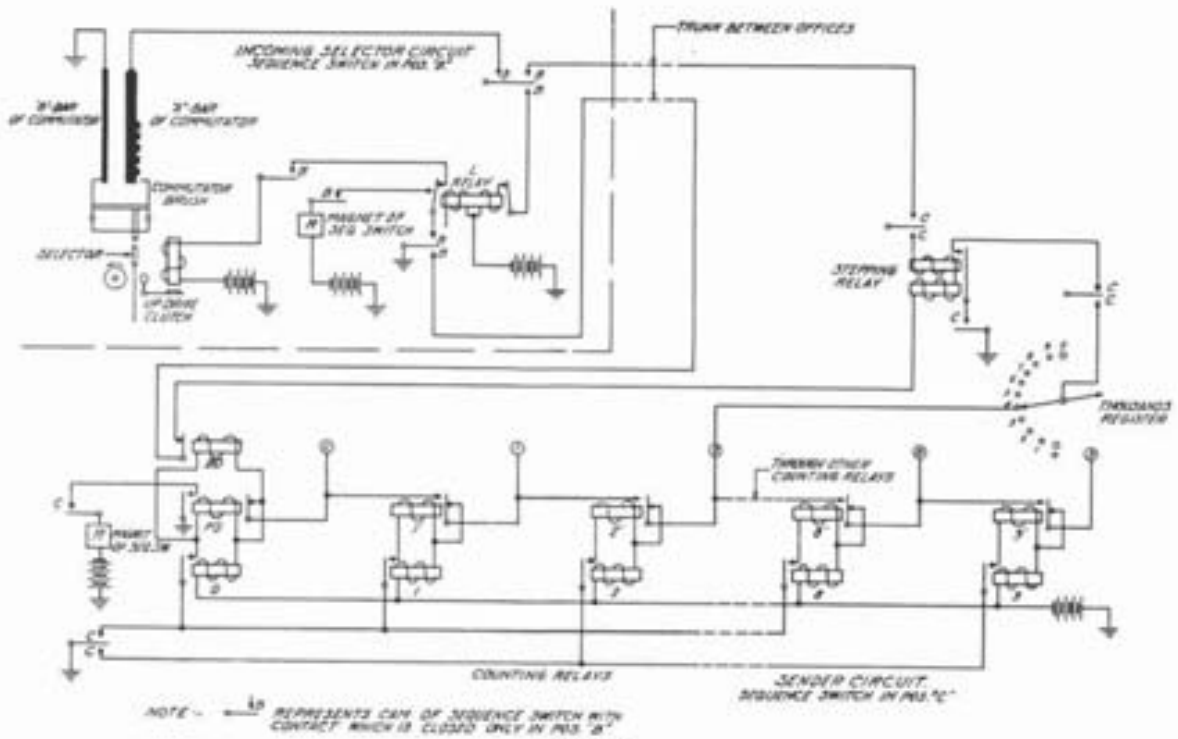


Figure 35

current through the contact of the "L" relay and therefore drives up the selector. It will be seen that every time the commutator brush passes over a metal segment in the commutator another path is formed for the current through the "L" relay, which shunts out the stepping relay. The "L" relay is held continuously operated, either by the path through the stepping relay or by that through the commutator, while the stepping relay is operated whenever the commutator brush rests on insulation and released whenever the commutator brush rests on metal. The first operation of the stepping relay operated counting relay Number 2. When the stepping relay released due to being shunted out by the commutator, it removed the shunt around relay Number 2', which operated and transferred the connection to counting relay Number 1. This operates when the stepping relay comes up again and relay Number 1' operates when the stepping relay releases again. The process is repeated each time the commutator brush passes over a metal segment and finally relays FO and BO are operated, cutting off the stepping relay altogether and causing the sequence switch of the sender (R designates the magnet of the sequence switch) to turn and release the counting relays which were held operated. The "L" relay is still held operated through the commutator but when the commutator brush passes off the metal segment, the "L" relay is released, cutting off the drive clutch and stopping the selector. This also causes the sequence switch of the incoming selector to turn, changing the connections of the selector for the next operation. This is the fundamental method by which the panel selectors are controlled for the selection of the brush to be tripped, for the group of trunks to be used, and, in the final selector, for the selection also of the terminals of the called party. The stepping relay is shown in Figure Number 36 and a counting relay in Figure Number 37.

We will suppose that the subscriber dialed number 4579. This means that brush Number 2 must be tripped on the incoming frame, since only

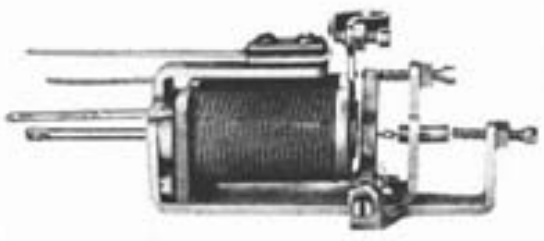
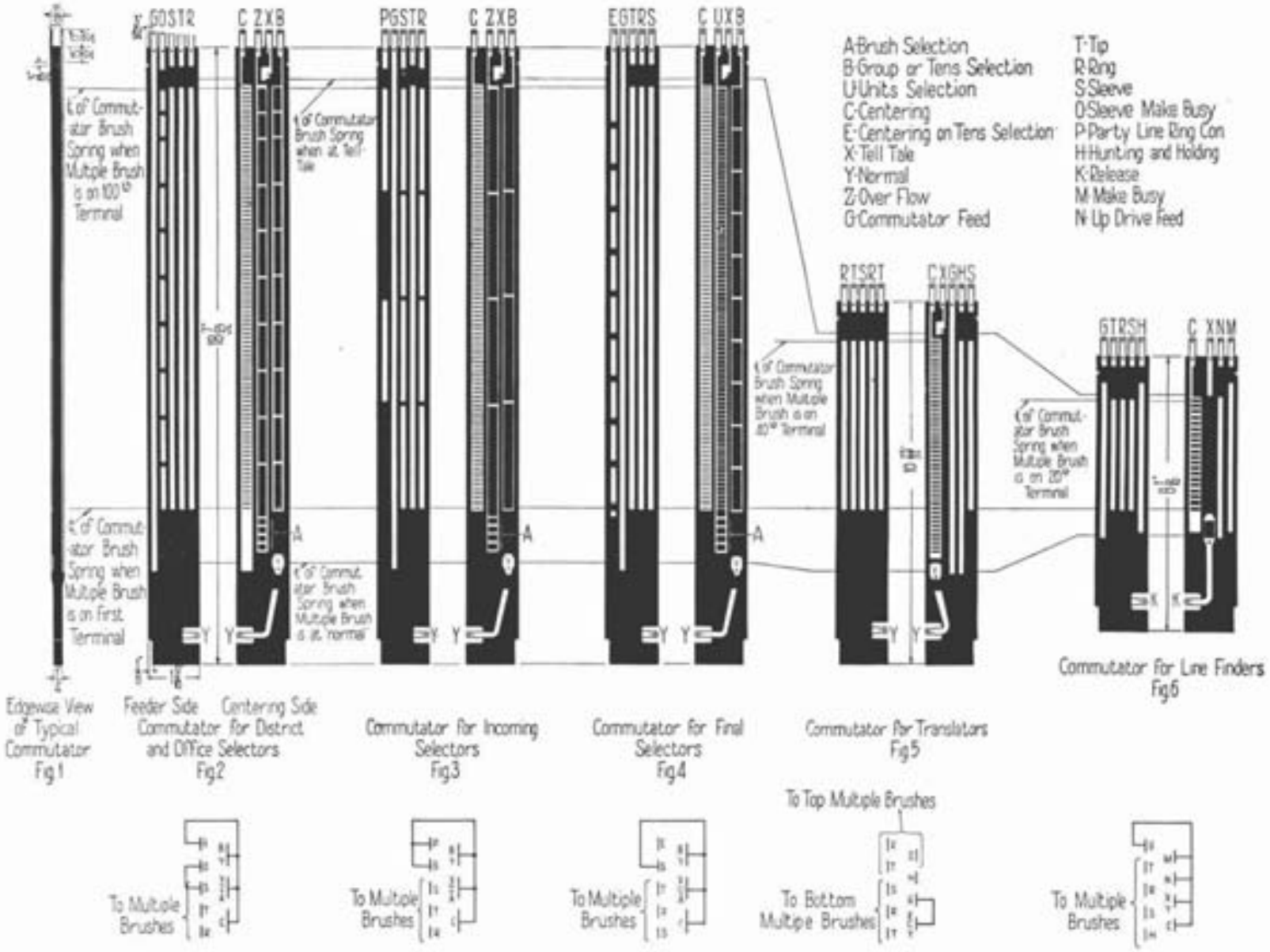


Figure 36

Figure 37

this brush has access to stations whose numbers begin with 4 (see Figure Number 30). To trip brush Number 2 the selector must rise until the commutator brush has passed over the third metal segment of the "A" commutator bar (see Figure Number 38). This is accomplished as just described. The selector being stopped, the sequence switch of the incoming selector causes the trip rod to rotate and the selector to start again. The upward movement of the selector trips the brush. Group Number 1 of trunks must be selected, since only this group leads to stations whose numbers begin 45. The setting of the thousands and hundreds registers together determine this, for had the number begun 55 it would have been necessary to trip the same brush but to select a different group of trunks. The selector is allowed to rise past the second metal segment of the "B" commutator bar and the brush will then be at the beginning of the second group of trunks. It will be seen that in these selections the function of the registers is to connect the proper number of counting relays into the circuit.

Mention has been made above of the "A" and "B" bars of the commutator. Figure Number 38 will make clear the arrangements of the various bars of the commutators and the functions which they perform. It will be seen that the commutators are different for different types of selectors but certain features are common to all types. The white parts represent metal and the black portion insulation. Each metal bar is designated by a letter opposite its terminal with the exception of the bars marked "A" which are in one piece with the "Z" bars. Each of the long bars on the "feeder" side is continuous but only the portions shown in white appear on the face of the commutator; where interrupted by black, the bar is bent below the surface of the insulation in which it is embedded. In the diagrams below the commutators, the short vertical lines represent spring contacts of the commutator brush which slide up and



Edgewise View of Typical Commutator Fig.1

Feeder Side Centering Side Commutator for District and Office Selectors Fig.2

Commutator for Incoming Selectors Fig.3

Commutator for Final Selectors Fig.4

Commutator for Translators Fig.5

Commutator for Line Finders Fig.6

COMMUTATOR BRUSH CONNECTIONS

Figure 38
Commutators

down on the bars whose letters appear opposite the vertical lines. These contacts are narrow enough not to touch the side portions of the A, B, C, and Z bars. Each commutator has a set of bars marked T, R, and S and the contacts of the commutator brush which slide on these bars are connected through wires inside the selector tube to contacts of the selector brushes which rub on the terminals of the selector banks. Each commutator also has a G bar which is connected to ground and simply serves to feed ground to other contacts of the commutator brush. The bars with which we are principally concerned at the present moment are the A, B and C bars. The portion

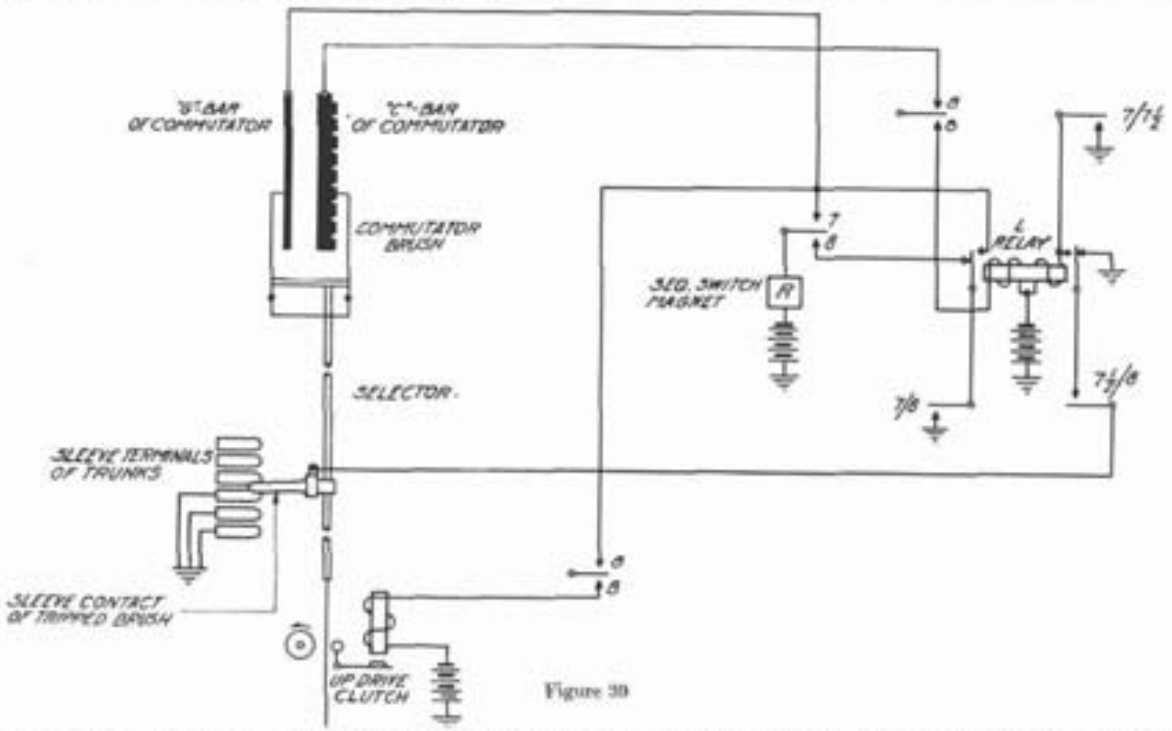


Figure 39

marked "A" controls the selection which chooses a brush to be tripped, each of the 5 metal segments being placed at the correct height to bring the selector in position for tripping one of the 5 selector brushes. The segments of the "B" bar are spaced apart the length of a group of trunks in the terminal bank. It will be noticed that they are different for the district and office selectors from those for the incoming selectors, for the trunks in the district and office selectors are divided into groups of 10 and in the incoming selectors into groups of 24 as previously described. The "C" bar is used for centering the brushes when trunk hunting and will be referred to later.

The selector now being at the beginning of a group of trunks it automatically hunts through that group, and through the succeeding groups, if the intermediate overflow terminals are made busy, for an idle trunk. The connections for this performance are arranged as shown in Figure Number 39. The "L" relay is operated and the up-drive clutch is receiving current through the contact of the "L" relay so that the selector is going up. The sleeve terminals of busy trunks will have ground on them. So long, then, as the sleeve contact of the selector brush is touching the sleeve terminal of a busy trunk, the "L" relay will be held operated by the ground on the sleeve terminal. As soon, however, as the selector brush passes off the terminals of the last busy trunk there will be no ground there to hold operated the "L" relay. But should the "L" relay release at this moment the current would be cut off from the clutch and the selector would drop back onto the terminals of the last busy trunk. This is prevented by the fact that the "L" relay is obtaining ground through the commutator brush which is touching one of the metal segments of the "C" commutator bar. Not until the commutator brushes pass off the metal segment does the "L" relay release, cutting off the clutch and stopping the selector. By this time, however, the selector is opposite the terminal of the idle trunk and the pawl in the clutch has fallen into a notch in the rack so that the selector is prevented from dropping

down. Thus it will be seen that in trunk hunting the condition of the sleeve terminal of the trunk determines whether or not the selector will stop on that trunk and the metal segments of the commutator merely serve to assure that the selector will be raised high enough so that the pawl in the clutch will surely fall into the notch in the rack and the selector be held on the idle trunk and not be allowed to slip back onto the trunk below. Should the selector find all the trunks in the group busy it will pass over them all and onto the overflow terminals and the "Z" segment of the commutator. This will give a busy signal to the calling subscriber.

The Office Code

Let us now consider the office code. The subscriber is instructed to dial the first letters of the name of the office. In some cities this will be the first two letters, in others the first three letters, and in still others, the first two letters and a number. It will be seen that dialing letters is the same as dialing three figures, for the letters appear in the same holes as the figures, and, of course, the dial cannot transmit a letter but merely makes and breaks the circuit a certain number of times. Thus, dialing "PEN" for Pennsylvania Central Office is the same thing as dialing 736 (see Figure Number 40). The first letters of a name are used, since it is easier to remember the name and four figures than to keep in mind the seven figures that otherwise would be required. With this arrangement we cannot have two offices in the same area whose names begin with the same three letters in the same order, nor can we have two offices whose names begin, not even with the same three letters, but with three letters which correspond to the same three numbers in the same order. Thus if we have an office named Canal, the number code for that office is 226, and we cannot have offices named Cambridge, Bampton, Banks, Abner, Aborn, Acme, or Acorn, for all these would have the same number code and would be the same thing when dialed.

Figure 40

It will be observed that no letters appear in the hole with the figure 1, so that the digit 1 never forms a part of the office code. There are two reasons for this. This figure is used for the second and third digits of certain official codes, such as codes for Long Distance, Repair Clerk and Commercial Office. Furthermore, if 1 formed the first digit of some office codes an accidental jog of the switchhook before the subscriber starts to dial would have the same effect as dialing this digit. In any code, the first digit dialed is never a 1 and the sender is so arranged that the dialing of 1, or, what amounts to the same thing, jogging the switchhook before beginning to dial, does not interfere with the operation of the apparatus. It is hardly possible that the subscriber could, by jogging the switchhook, dial any other number, since he could not imitate in that way the rapid and uniform pulses of the dial. Jogging the switchhook three times would therefore be received by the sender as a series of three 1's rather than as a 3 and would not affect the subsequent dialing.

The digit 0 is reserved for dialing the operator so that 8 holes are left into which to put letters. This makes it necessary to eliminate two letters from the alphabet and "Q" and "Z" have been omitted. Since all of the three letters in the same hole will be the same digit, the number of different combinations available is 512 where three letters are used for the office code. Not all of these combinations are actually available, however, where the offices are given names, since for some of the combinations such as WWW, WWX, WWY, WXW, WXX, WXY, WYW, WYX, WYY, XWW, XWX, XWY, XXW, XXX, XXY, XYW, XYX, XYY, YWW, YWX, YWY, YXW, YXX, YXY, YYW, YYX, and YYY which represent all the possible arrangements of the code 999, it is hard to find a suitable name, in the English language at least.

Only in the larger cities is the number of offices to be dialed by the subscribers so great as to require the use of 3 digit codes. By dialing the first two letters of the office names 64 codes may be obtained.

On the other hand, in a very large Metropolitan Area such as New York, a sufficient number of

suitable names cannot be found for the large number of offices included in the dialing area. This difficulty is overcome by instructing the subscriber to dial the first two letters of the office name followed by a single digit number. Several offices may then be given the same name with distinctive numbers, such as: Canal-2, Canal-3, Canal-4, etc., the codes for which would be CA2, CA3, CA4, etc.

The subscriber then dials the first three letters of the name of the office which he desires (or two letters and a number) and these set three register switches known as "A," "B," and "C" registers to positions corresponding to the number of pulses produced by the dial for each letter. The combination of these positions must determine a number of questions in regard to the call which the subscriber is making. These are as follows:

1. The class of the call; whether it is to reach a dial line, a line in a manual office, or an operator.
2. Whether the call is covered by the regular telephone charges or should be sent to an operator in order that a toll charge may be made.
3. What district brush should be tripped.
4. What group of trunks on the district frame is to be selected.
5. Whether or not an office selector is required in order to reach the proper trunk.
6. What office brush is to be tripped (if an office selection is to be made).
7. What group of trunks on the office frame is to be selected (if an office selection is to be made).
8. What compensating resistance should be introduced into the circuit during the control of the selectors to compensate for the resistance of the circuit over which the selection is to be made.
9. Whether the call should be routed to a special operator such as long distance or toll.
10. Whether a delay should be introduced for the recording of a number above 9999 or for a party letter of a manual party line
11. What type of connection is necessary during talking.

The Translator

It is the function of the translator to settle these questions. Each sender is connected permanently to its own translator selectors. The translator for 3 digit codes which is shown in Figure Number 41 consists of a panel type selecting mechanism having 10 banks of 40 terminals each and a hunting bank of 57 terminals. In the hunting bank the terminals are in a single vertical row before each selector instead of in three rows as in the other banks. Furthermore, each vertical row in the hunting bank is wired separately and not connected to the adjacent row. Adjacent brushes of the translator are connected together and they trip in pairs so that there are six leads connected by the brushes, whenever the translator selector rests upon a set of terminals. The hunting bank serves to locate the translator selector upon the proper set of terminals and its terminals are connected to the registers of the sender. As will be seen from Figure Number 42, the set of terminals on which the translator will stop is determined by the combination of the setting of the registers which record the letters which the subscriber dials. The first two letters determine the translator brushes which will be tripped and the group of eight sets of translator terminals which will be selected. As soon as the third letter has been dialed by the subscriber the translator selector moves up to the determined set of terminals. Each working office code has its own particular set of terminals. When the translator selector brushes rest on any set of six terminals in the translator banks there are six leads connected through the translator selector brushes to six sets of translator register relays in the sender, each set consisting of six or less relays.

These relays by the fact of their being operated or not operated in various combinations determine the number of counting relays that will be introduced into each selection performed by the district and office selectors on this call and also set to certain positions sequence switches which make the proper circuit connections for the different classes of calls, insert the proper compensating

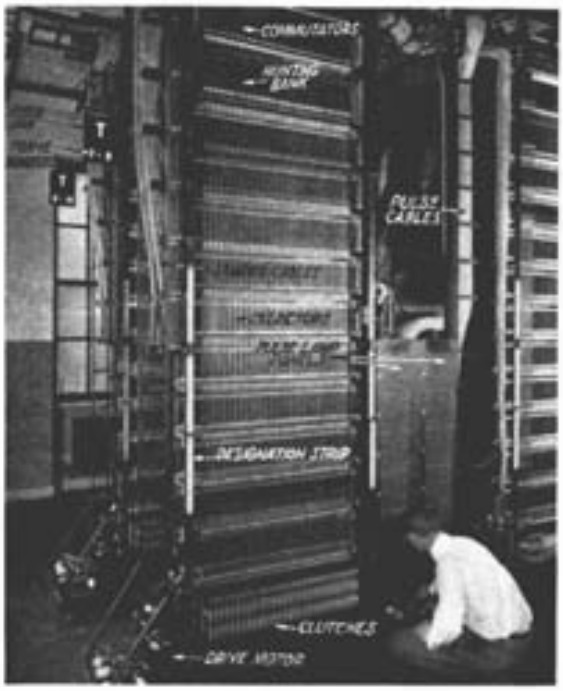


Figure 41

resistances, etc. Each terminal in the translator banks is constantly fed with a series of pulses from the pulse machine and no two sets of six

terminals in the translator have the same combination of pulses. Thus each working office code is represented by six terminals in the translator with its own peculiar combination of pulses. A translator frame will care for 200 office codes. In each office two sets of translator frames are provided and each sender is connected to two translator selectors, each caring for a different 200 codes. Which of these two translators the sender uses is determined by the first letter of the office code which the subscriber dials. Since there are 512 possible codes and translators are provided for only 400, there are a number of sets of terminals in the translator frames which are assigned to two or more codes each, only one of the codes in each case being used by the subscriber. Figure Number 43 shows the arrangement of the codes on the translator terminals.

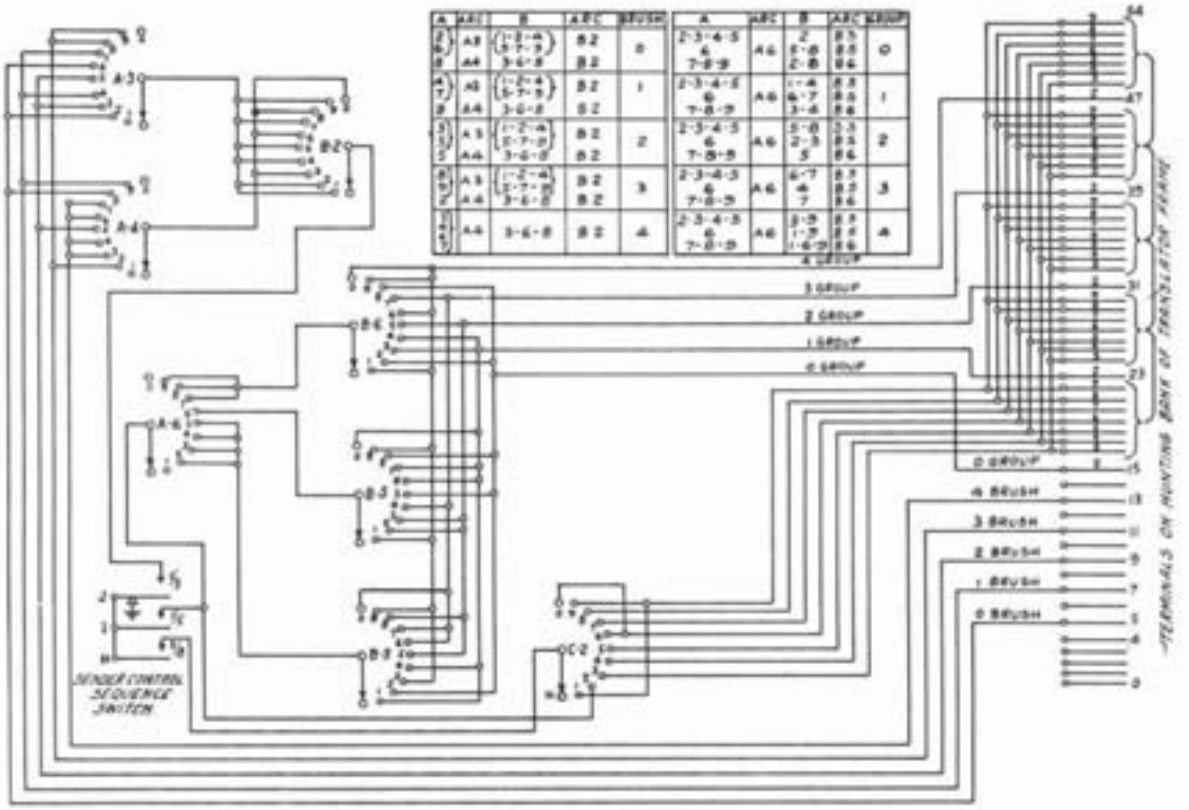
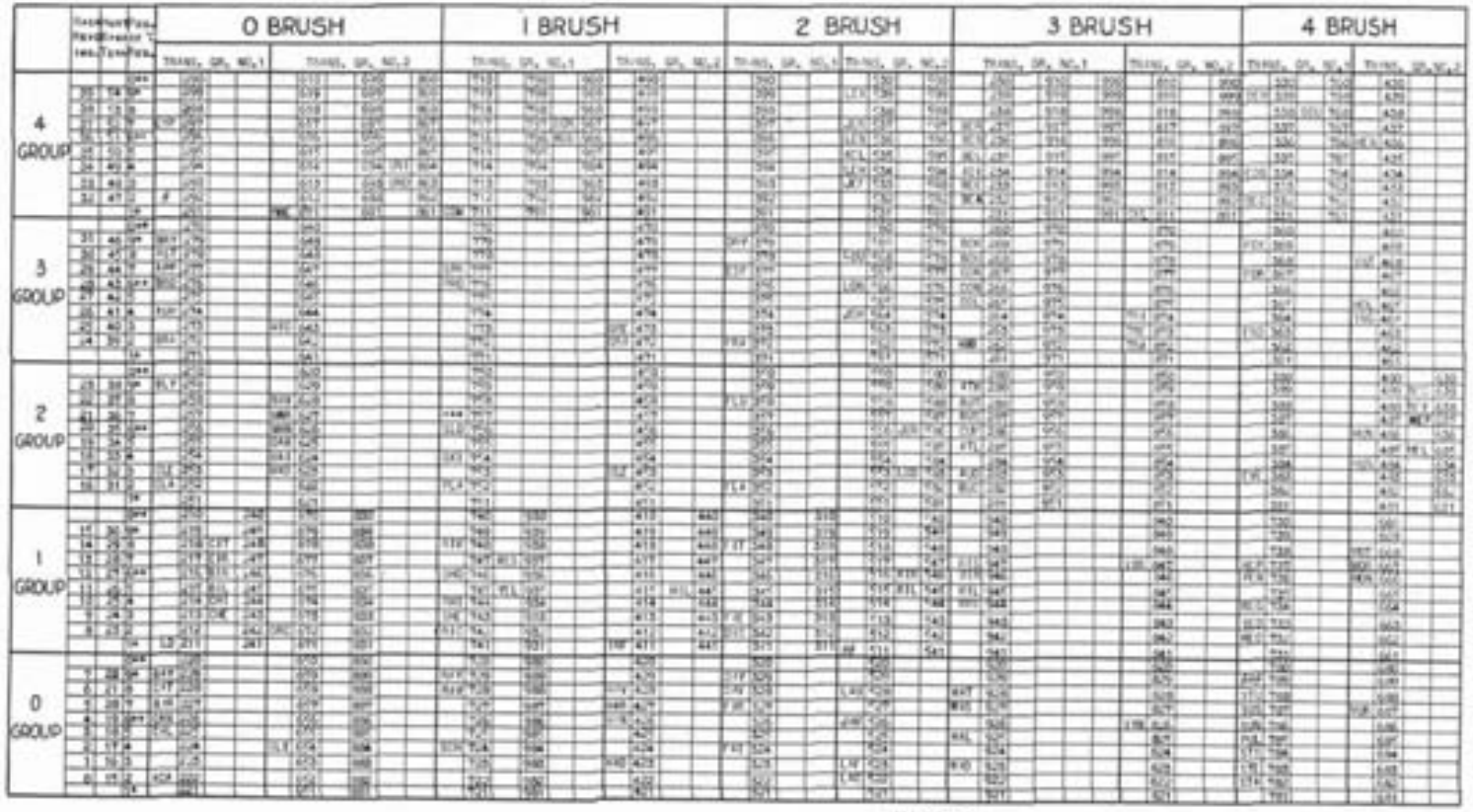
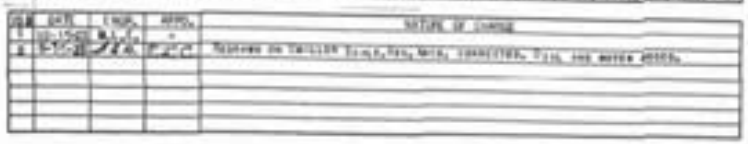


Figure 42

The Pulse Machine

The pulses are furnished by the pulse machine shown in Figure Number 44. It consists of a series of drums which are constantly revolved by a motor. Each of these drums is divided into six segments which may be connected either to battery or to ground. A complete set consists of 40 "sending" drums, each of which has a different arrangement of battery and ground on its segments as shown in Figure Number 45; six "receiving" drums, each of which has battery on only one segment; and one "timing" drum which has battery on all segments. From the 40 sending drums are chosen six which are connected to the six terminals in the translator frame which represent an office code. The same sending drum will be connected to many terminals in the translator, but no set of six terminals representing an office code will be connected to the same drums as another set representing another office code unless all the conditions of a call made with the former code are the same as those for the latter code. The six receiving drums are connected directly to the senders and are used for all office codes. The timing drum is connected to counting relay Number 6 in each sender and when in use operates a pair of counting relays at each contact. When it has made seven contacts the





- NOTES -

1. = EXAMPLE OF USE OF CHART. TO FIND THE BRUSH, GROUP AND TERMINAL FOR PENNSYLVANIA, "PEN OR 736" WOULD BE DIALED, 7 ON THE "M" REGISTER WOULD BE FOLLOWED TO 3 ON THE "H" REGISTER. THE BRUSH WILL BE FOUND TO BE 4 AND THE GROUP 1, THE TERMINAL BEING TWO LESS THAN THE THIRD DIGIT DIALED.

2. = TRANSLATOR GROUP G1 INCLUDES ALL OFFICE CODES THE FIRST DIGIT OF WHICH IS 2, 3, 7 OR 9.

3. = TRANSLATOR GROUP G2 INCLUDES ALL OFFICE CODES THE FIRST DIGIT OF WHICH IS 4, 5, 6 OR 8.

4. = OFFICIAL CODES FOR INFORMATION, 836, WILL REQUIRE THAT G1 BE DIALED ON THE "C" REGISTER, = EXAMPLE = INFORMATION WILL BE 411.

5. = * 1 AND 9 ON THE THIRD DIGIT ON "C" REGISTER ARE BRIDGED SO THAT 0 TERMINAL IS SELECTED.

6. = ** 2 AND 6 ON THE THIRD DIGIT ON "C" REGISTER ARE BRIDGED SO THAT 5 TERMINAL IS SELECTED.

7. = 0 AND 6 ARE BRIDGED ON THE SECOND DIGIT ON "B" REGISTER SO THAT 6 IS SELECTED.

8. *** 917 = DISTRICT SELECTOR TEST WITHOUT OPERATING DIAL.

9. # 250 = DISTRICT SELECTOR TEST WITH OPERATING DIAL.

10. ## 511 = WIRE CHIEF.

11. ### 789 = TROUBLE DESK OR PERMANENT SIGNAL TEST.

Figure 43

NEW YORK CITY AREA
3 DIGIT TRANSLATOR -
CHART

connections of the pulse machine drums through the translator to the register relays of the sender will be broken. Thus during one revolution of the pulse machine drums certain of them will be connected to the register relays of the sender. Seven contacts of the timing drum are required to insure a complete revolution.

During this one revolution each of the six sending drums which are connected through the translator brushes closes the leads to its associated register relays as many times as it has live segments. During the same time each of the six receiving drums makes contact once, since they each have only one live segment. If the live segments of a receiving drum and those of a sending drum make contact at the same moment, the particular register relay which is connected to the receiving drum, in the particular set which is connected to the sending drum, will be operated and locked. (The locking circuits are not shown in Figure Number 46.) Thus certain register relays will be locked up in a combination peculiar to the office code dialed. The object of this scheme is merely to make it possible to produce easily a large number of combinations and to change them with facility. The connections between the translator terminals and the drums of the pulse machine are made on a cross connection frame so as to be readily changed. The arrangement of the translator, pulse machine, and register relays is shown diagrammatically in Figure Number 46.

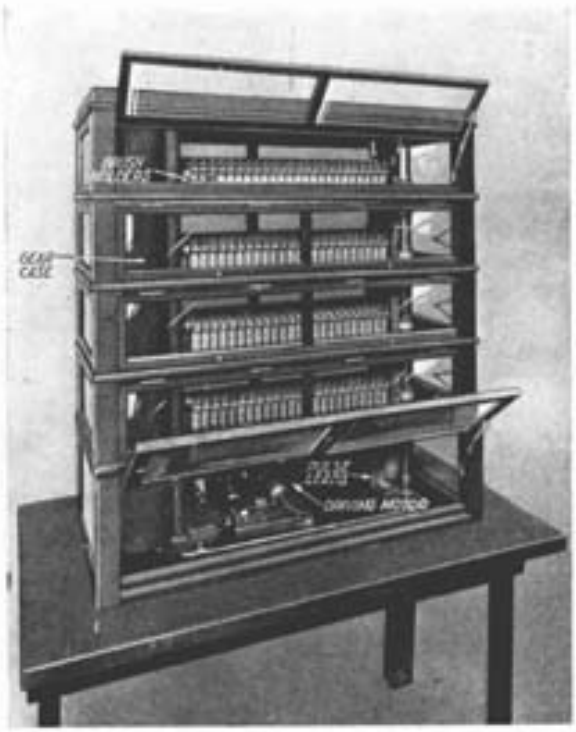


Figure 44

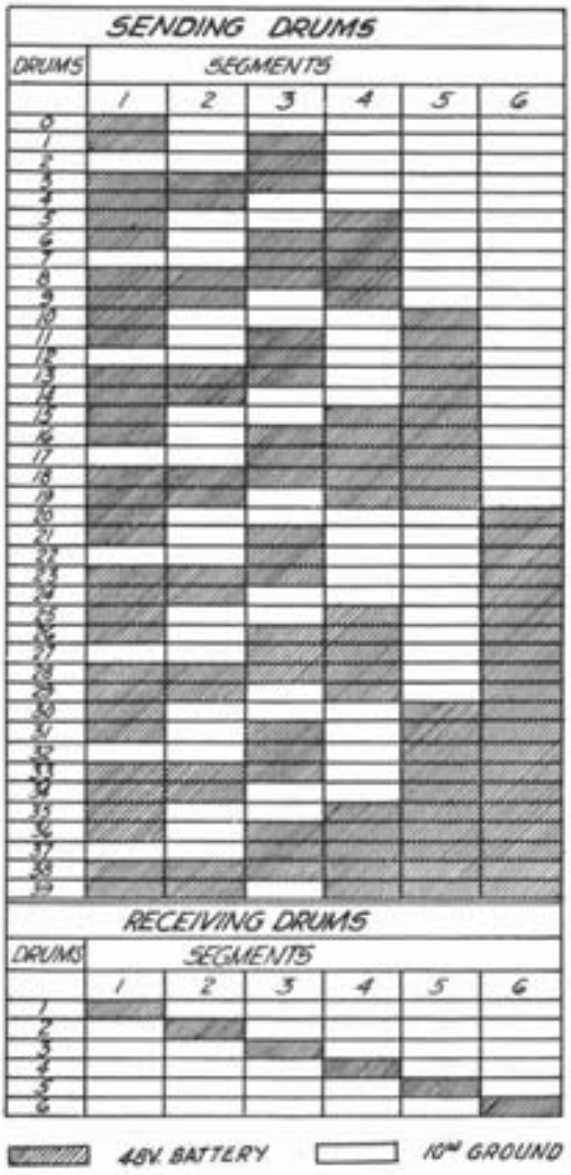


Figure 45

Thus the dialing of the office code sets the office code registers; their setting directs the translator to the proper set of terminals; these terminals are so connected to the pulse machine drums that a certain combination of register relays will be operated, and it is that combination which determines the course the call will take.

Where 2 digit codes are used, rotary switches are provided in each sender which act as translators and will care for 44 codes. With this simpler form of translator, no pulse machine is required.

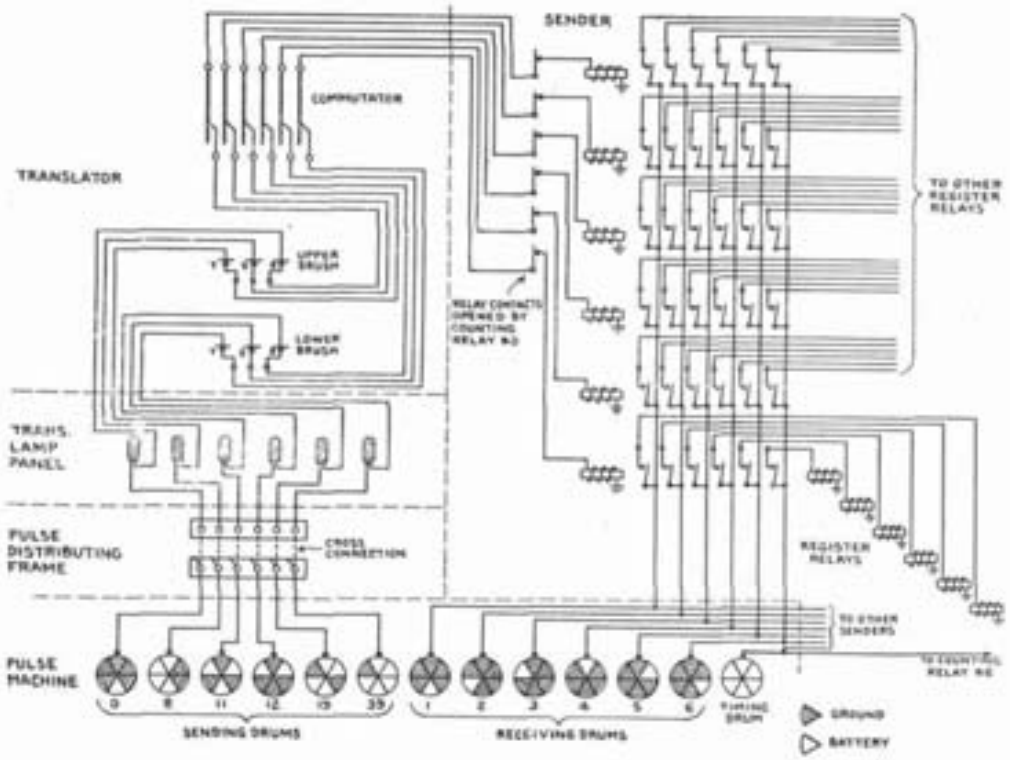


Figure 46

The Decoder

A second system for accomplishing the work of the translator and pulse machine has been devised that effects an economy in space and cost. In this system, the sender is somewhat simplified, the rotary switches being omitted and replaced by relays which record the numbers dialed by the subscribers. Senders of this type are shown in Figure Number 47.

To record on relays the numbers dialed, a set of counting relays is employed to count the number of pulses from each rotation of the dial. Each number as counted is recorded on recording relays which are operated in combinations representing the number of pulses received and the counting relays then released to count the pulses from the next rotation of the dial.

When the three numbers representing the central office called have been recorded in the sender, the sender circuit is connected to an idle decoder by multi-contact relays in the decoder-connector which is shown at the right in Figure Number 47. Figure Number 48 shows a multi-contact relay. The decoder-connector, three of which are mounted on a frame, serves 10 senders and can connect a sender to any one of 6 or less decoders.

The office code, which is recorded on relays in the sender, is then transferred to similar relays in the decoder, which by their operation select and operate a single "route" relay, one of which is provided for each path which a call originating in this office may take. The route relay controls transmitting relays which in turn control the setting of the sender registering relays in a combination peculiar to the particular route relay chosen. This latter operation is similar to the registration of pulses from a pulse machine and is for the same purpose. The office code which is dialed by the subscriber determines the route relay which will be operated; the route relay operated determines the combination of registering relays which will be operated; the registering relays operated determine the brushes which will be tripped on the various selectors handling this call and the groups of terminals to which they will be directed and therefore the course which the call will be made to take.

The decoder is capable of receiving and translating in this manner 800 different 3-digit codes and directing calls over 285 different routes. By the addition of one supplemental bay to the de-

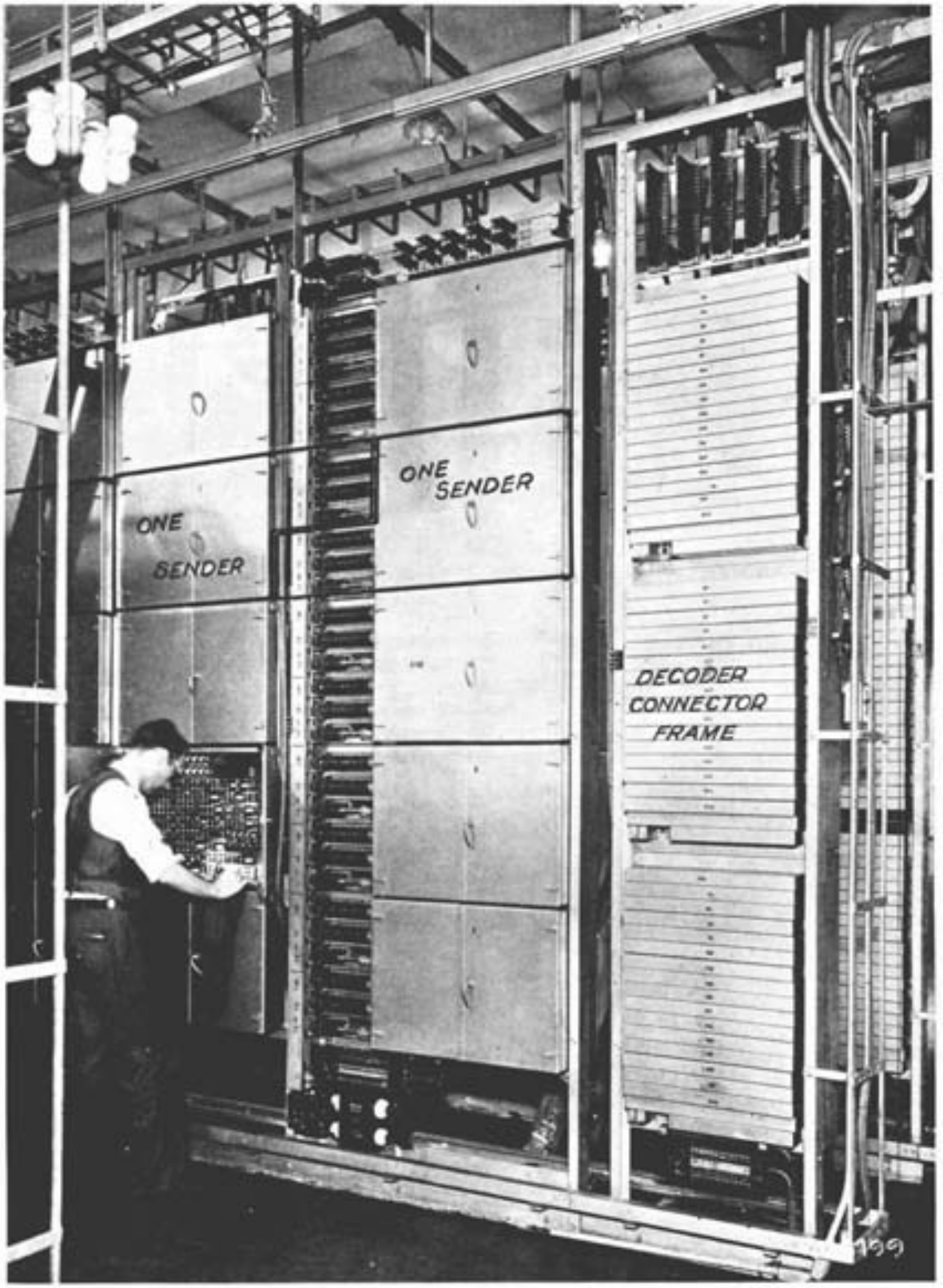


Figure 47
Subscriber's Sender Frame (Decoder Type) and Decoder Connector Frame

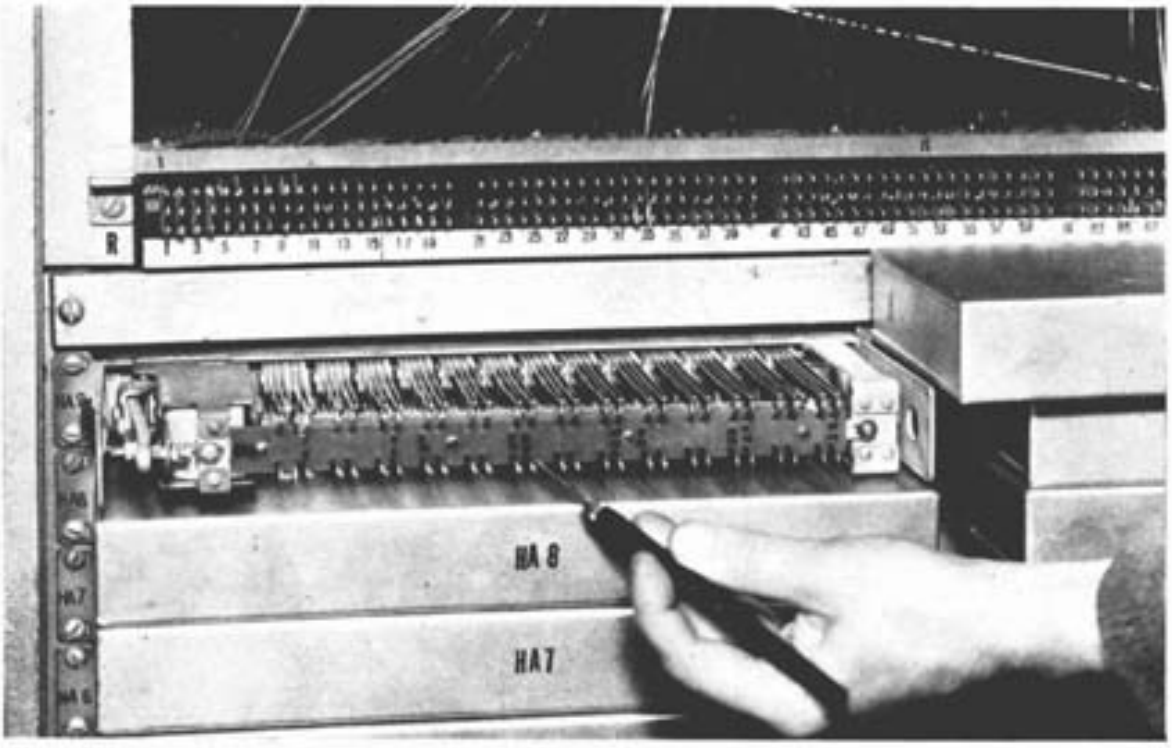


Figure 48
Multi-Contact Relay

coder frame, the number of routes may be increased to 585 and by using 2 supplemental bays, to 885.

If a sender is connected to a decoder for the translation of an office code but due to some trouble the sender fails to receive the necessary information within a few seconds, it will be automatically connected to another decoder. Should a second failure occur, the subscriber will be connected to the sender monitor as described later.

Since the operation of the decoder occupies only about 1/3 of a second on each call, its movements cannot be closely observed and since it contains only relays there is no mechanism the position or action of which might indicate the cause of a fault. Our unaided senses of sight, hearing and touch are quite useless in the detection of trouble in equipment of this character. A "trouble indicator" as shown in Figure Number 50 is therefore provided. A decoder which has failed to function when connected to a sender, will be automatically connected to the trouble indicator where it will record its number, the number of the sender to which it was connected, the number of the decoder-connector, and the point at which its operation failed. By means of lamps, this record is made visible to the maintenance forces.

Associated with the trouble indicator is a decoder test frame by means of which the operation of one decoder may be compared with the operation of another. If both decoders operate in the same manner, they must both be operating correctly or they must both contain exactly the same fault. The probability of the latter occurrence is extremely remote. If, however, they differ one of them must be faulty. Each may then be tested individually, if necessary, to determine the cause of the trouble. A decoder test frame is shown in Figure Number 50.

Figure 49
Decoder Frame

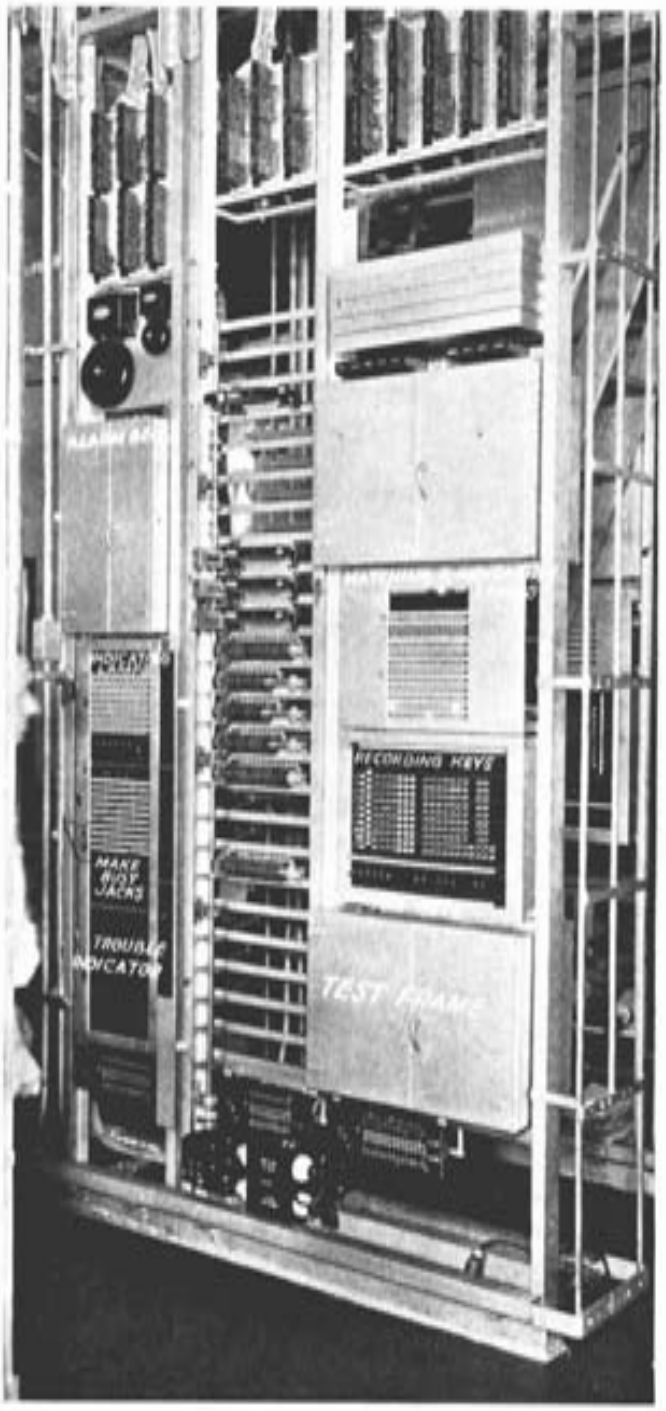


Figure 50
Decoder Trouble Indicator and Test Frame

Figure 51

The Call Indicator

Figure Number 51 is a portion of a New York City telephone directory. It will be seen that no distinction is made between lines in manual central offices and those in dial central offices, for at the time this directory was issued Academy was a dial central office and Vanderbilt a manual office. So far as the subscriber is concerned, there is no difference in the two types of call. If the office code which the subscriber dials is that of a manual central office the sender will receive from the pulse machine, pulses which will cause it to select a trunk to that office in the usual manner but to function beyond that point in a different manner from its procedure in the case of calls to dial central offices.

The trunk to the manual central office terminates there at a position of the "B" board which is fitted with a device known as a "call indicator." A "B" board with call indicators is shown in Figure Number 52 and a close view of a call indicator in Figure Number 53. It consists of a glass plate beneath which lamps and stencils are arranged so as to display a series of numbers when the lamps are lighted, different numbers being displayed by lighting the proper lamps. The plan of operation for the call indicator is shown in Figure Number 54. The trunks appear as single ended cords with lamps and keys as on a regular manual "B" board. When one of the trunks on a call indicator position has been selected by the mechanical apparatus in a dial central office it is indicated by the lighting of the assignment lamp associated with the trunk. The operator then presses the display key which serves to associate the call indicator with that trunk and to cause the sender in the dial central office to send out a series of pulses which lights certain lamps in the call indicator and so display the number desired. The operator then makes con-

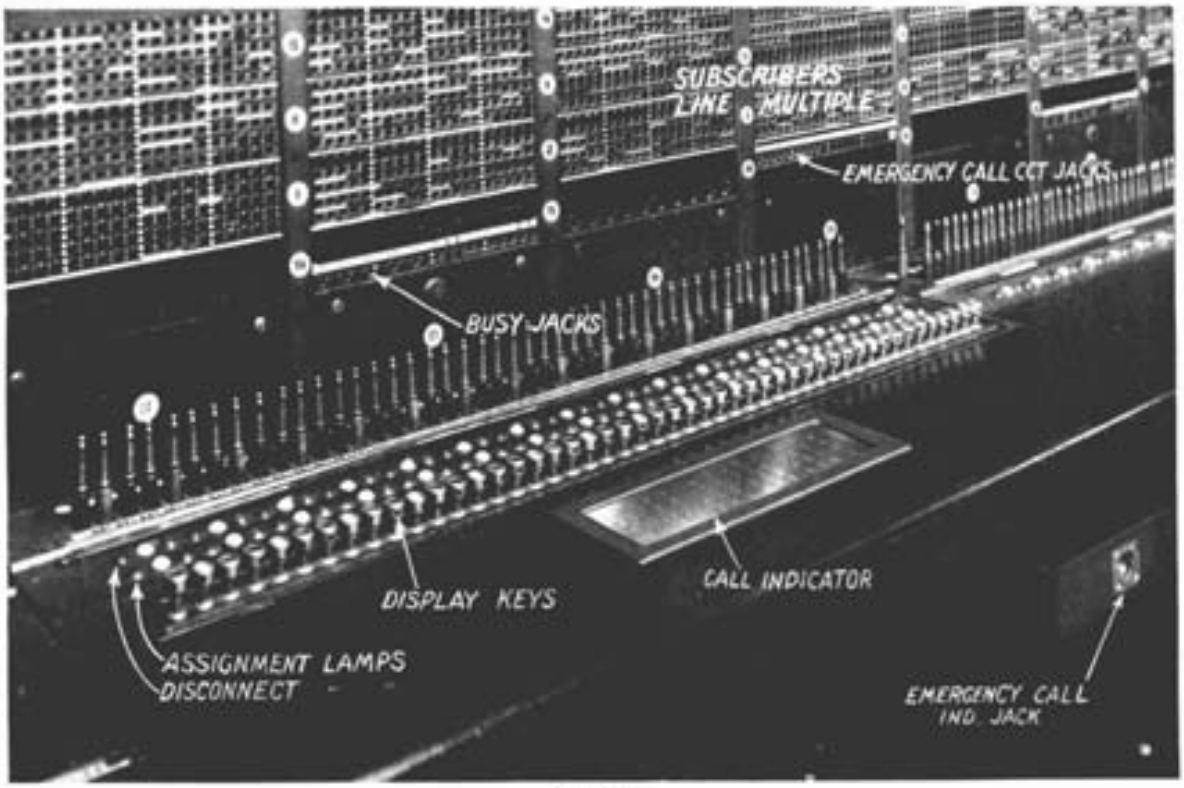


Figure 52

Figure 53
The Call Indicator

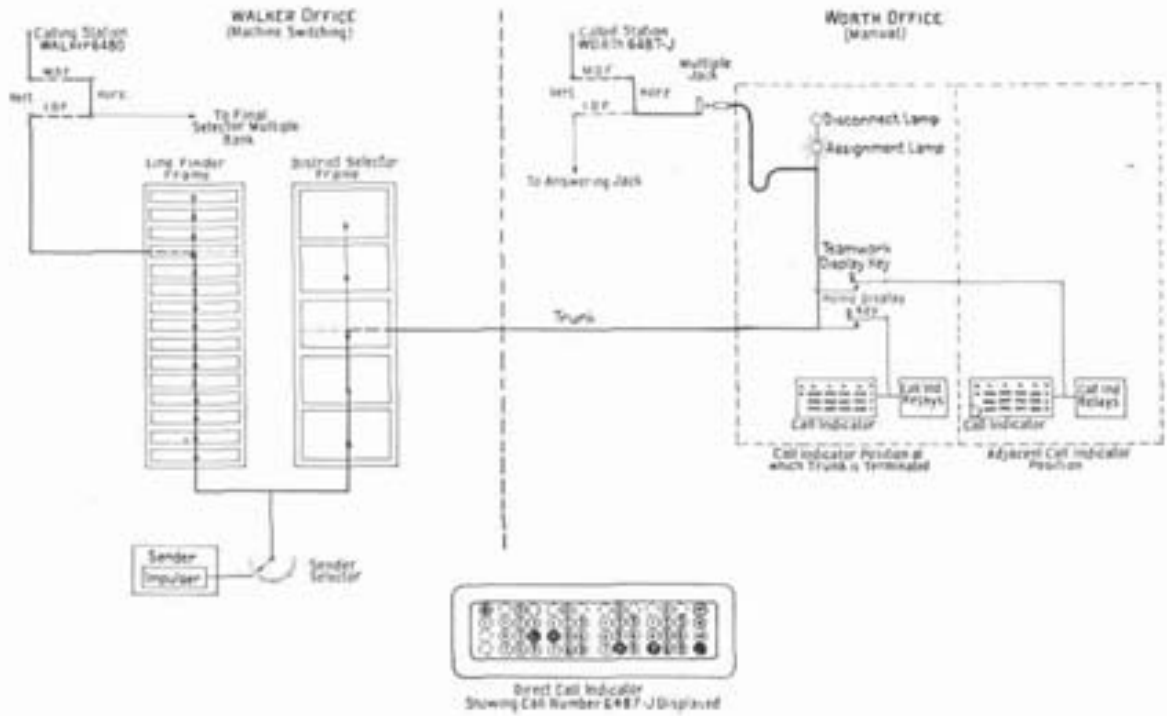


Figure 54

nection to that line by inserting the plug of the cord into the jack of the line in the usual way. This causes the call indicator to be disconnected and the lamps extinguished ready for another call. The pressure of the "home" display key causes the number to be displayed on the call indicator of the position at which the trunk terminates. The trunks may also be provided with "teamwork" display keys which, when pressed, cause the number to appear on the call indicator of the adjacent position, enabling the operators to assist one another in the handling of the calls.

Manual central offices will accommodate 10,500 lines and four party stations in manual offices are designated by the letters "J," "M," "R," and "W." For certain stations, therefore, it is necessary to dial five digits or four digits and a letter. An extra register is provided in the sender for this purpose and on calls to offices where there are stations requiring five digits or four digits and a party letter, a delay will be introduced to allow the fifth digit or the party letter to be dialed. That is, if there are four party lines in the office called, the sender will receive pulses from the pulse machine which will cause it to wait for four seconds after the dialing of the fourth digit to receive the party letter. If no party letter is dialed at the expiration of that time, the sender will proceed, it being assumed that there is no party letter. For offices having lines with numbers above 9999, the delay will be introduced only if the first two digits dialed are 1 and 0, since the only numbers of five digits are between 10,000 and 10,499.

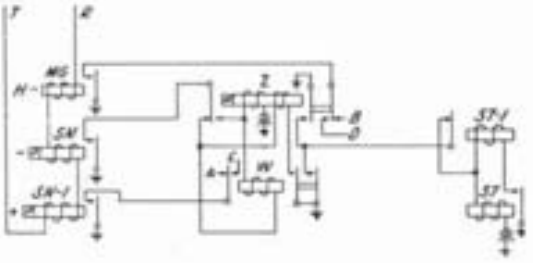
The pulses from the sender to the call indicator are sent out by a sequence switch in the sender, which makes one revolution in the course of which it transmits a series of positive and negative pulses over the trunk to the manual central office. Four pulses are allowed for each digit to be displayed in the call indicator. The sender cancels some of the positive pulses and strengthens some of the negative pulses as determined by the registers of the sender which recorded the various digits so that for each digit a particular code of

STATIONS						DIGITS						
STA.	LAMP RELAYS OPERATED	PULSES REQUIRED				THOU-SANDS	HUNDS TENS UNITS	LAMP RELAYS OPERATED	PULSES REQUIRED			
0	NONE		—		—	0	0	NONE		—		—
1	A	+	—		—	2	1	A	+	—		—
W	B		R		—	4	2	B		R		—
J	C		—	+	—	6	3	AB	+	R		—
R	AB	+	R		—	8	4	C		—	+	—
M	D		—		R	1	5	D		—		R
						3	6	AD	+	—		R
						5	7	BD		R		R
						7	8	ABD	+	R		R
						9	9	CD		—	+	R

Figure 55

pulses is sent. Figure Number 55 shows this code. These pulses are received by relays at the call indicator position and these relays control other relays, four of which, designated A, B, C, and D, are provided for each digit to be displayed. The operation of these latter relays determines which lamps will be lighted and therefore what number will appear in the call indicator as indicated in Figure Number 55.

The three relays which receive the pulses from the sender are shown in Figure Number 56. The SN and SN-1 relays are polarized so that the SN responds only to positive pulses (battery on the ring side of the trunk) and the SN-1 to negative pulses (battery on the tip side of the trunk). The MG relay is marginal and responds only to heavy pulses. Negative pulses operate the SN relay which controls the W and Z relays which introduce the A, B, C, and D relays successively, while heavy negative pulses also operate the MG relay which controls the B and D relays. Positive pulses operate the SN-1 relay which controls the A and C relays. The ST and ST-1 relays act as counting relays to introduce a new set of A, B, C and D relays for displaying the next digit. The



IF 1ST PULSE IS +	SN-1 OPERATES	OPERATES A RELAY
1ST — PULSE	SN "	" W
		" ST
IF HEAVY PULSE	MG "	" B RELAY
ON RELEASE OF SN	Z "	
IF NEXT PULSE IS +	SN-1 "	" C "
NEXT — PULSE	SN "	RELEASES W
IF HEAVY PULSE	MG "	OPERATES D RELAY
ON RELEASE OF SN	Z RELEASES	" ST-1

Figure 56

operation of the circuit is explained in the figure.

A later design of "automatic display" call indicator operates in a similar manner but it is not necessary for the operator to press a key in order to have the called number appear. The numbers appear automatically as fast as the calls come in or as fast as the operator can make the connections.

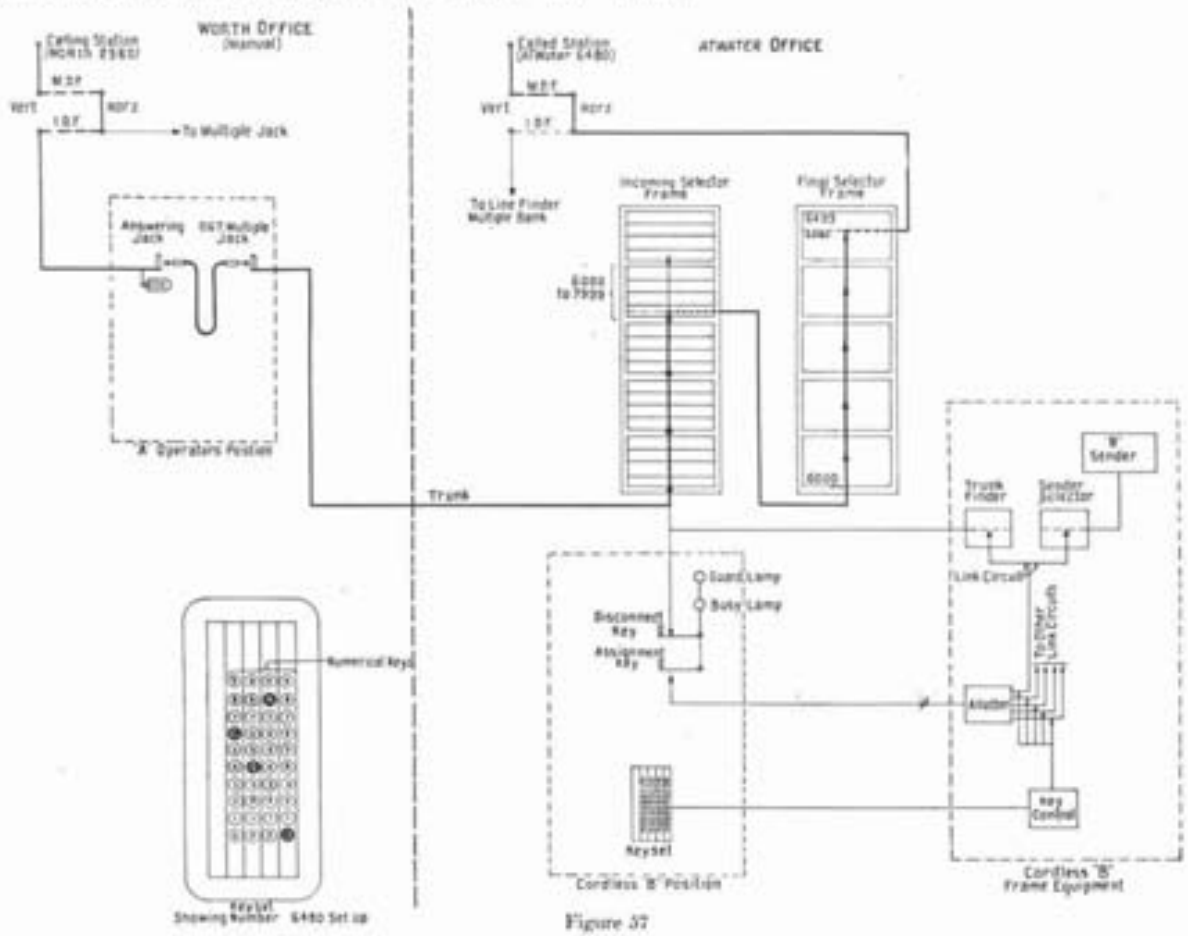


Figure 57

The Panel Type "B" Switchboard

The reverse of the call just described is equally simple from the standpoint of the subscriber. A subscriber in a manual central office gives to his operator the number he requires without knowing whether the line which he is calling is or is not in a dial central office. The operator in a manual central office also makes no distinction between calls to manual central offices and calls to dial central offices. In each case she merely selects a trunk to the "B" board of the required central office and upon hearing a tone which indicates that the "B" operator has responded, passes the number to her verbally. The plan of operation for a panel type office is shown in Figure Number 57. The "B" operator is seated at a special form of "B" switchboard, shown in Figure Number 58. On the upright part of the board is a double row of lamps and keys representing 60 trunks, and on the lower part 4 rows of key buttons marked with the numbers 0 to 9. Each trunk has an assignment key, a disconnect key, a guard lamp, and a busy lamp, and is connected directly to an incoming selector in the office. When the "B" operator presses the assignment key of the trunk, she causes two small panel type selectors mounted on a single frame to rise. One selector finds the trunk whose assignment key has been pressed, the other finds an idle sender of special type provided especially for the use of the "B" operators and associates it and the numerical keys on the lower keyboard in front of the operator with the trunk. The operator records the number desired on the numbered keys which lock down. This sets certain relays in the sender which control the movement of the incoming selector, which is permanently connected to the trunk and of a final selector, and so makes connection to the line desired. The keys release as soon as the number has been recorded and are ready to be used for another call. The sender is released as soon as it has completed its functions. Each "B" operator has 5 sender selector and trunk finder circuits (provision is made for 6 if required), so that she can handle calls in rapid succession, and any sender of a large group common to the office may be used. A frame on which may be mounted the trunk finders and sender selectors for 3 "B" positions and 6 of the special senders is shown in Figure Number 59.

Figure 58

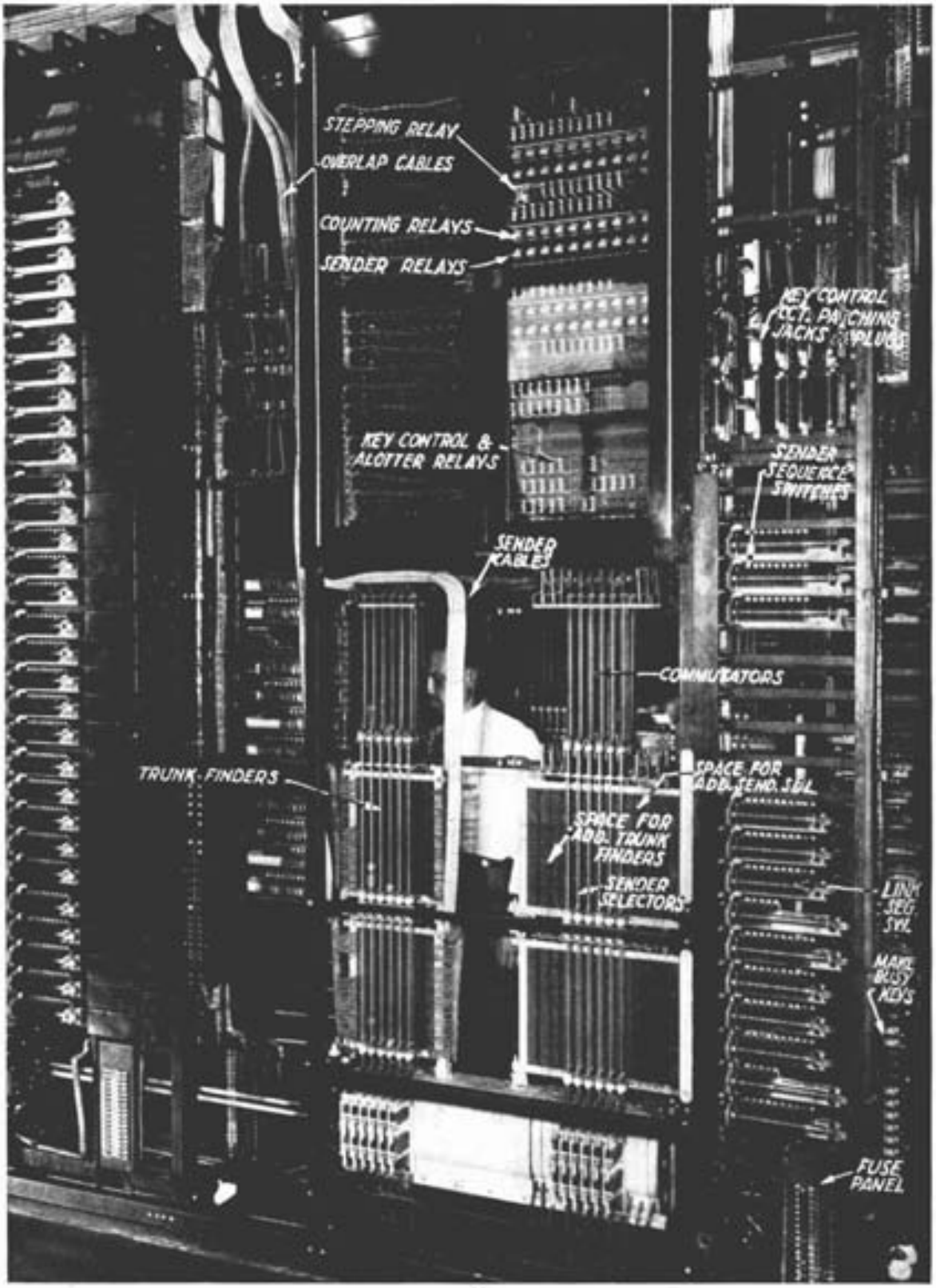


Figure 30
"B" Operator's Sender and Link Frame

At the "key-listening" type of "B" switchboard just described, each operator serves certain definite trunks. There may be moments when the trunks served by one operator are very busy while those of another operator are not. With the "call distributing" type shown in Figure Number 60 the load is always evenly distributed since the calls as they come in are connected to idle operators in rotation. Furthermore, it is not necessary for the operator to press keys to connect her equipment to the trunks and to disconnect the trunks at the termination of the conversations, these functions being performed automatically in the call distributing type. The operator has only, therefore, to record the numbers given to her on the recording keyset, in this case consisting of only 10 keys which are pressed in succession and which do not lock down.

If all operators are busy, incoming calls will wait until operators become disengaged. The number of such waiting calls is indicated by the "calls-waiting-meter" at the head of the switchboard and an alarm will call attention to the fact that 4 or more calls are waiting. By operating the calls waiting change key, the alarm may be made to function only if 7 or more calls are waiting.

Figure 60

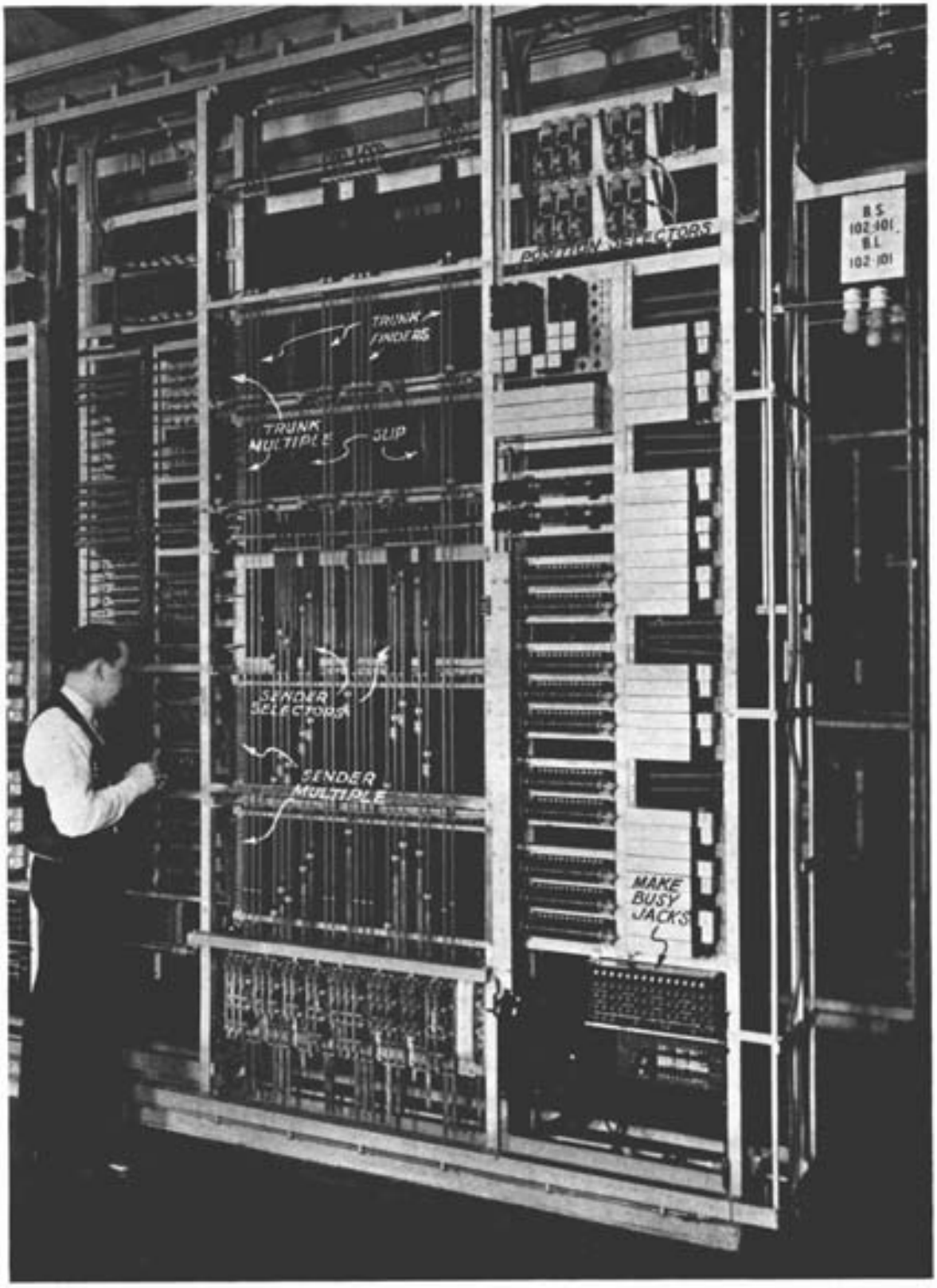


Figure 61
Call-Distributing "B" Link Frame

Figure 62

The Panel Type "A" Switchboard

An "A" switchboard with operators is required in a dial central office for several purposes. If a subscriber requires assistance, or in case of emergency, it is important that there should be an operator always within reach. Operators are also required to make out tickets for the charges on toll calls and to take care of calls to lines which are out of service or whose numbers have recently been changed. A panel type semi-mechanical "A" board is shown in Figure Number 62, and Figure Number 63 shows a closer view of the equipment of a combination position for handling all classes of calls. The manner of handling the various calls is as follows:

1. Assistance Calls.

   The subscriber dials zero. The sender directs the district selector to a special group of trunks leading to a jack and lamp in front of the operator and no further selections are made. The operator answers the call with a cord and gives the subscriber the necessary instructions.

2. Toll Calls.

   The subscriber dials zero and is connected to the operator as above. Should he dial the code of a central office which appears in his directory but for a call to which a toll charge is made, the sender will receive from the pulse machine such pulses as will cause it to direct the district selector to a trunk leading to the operator. The operator answers with one of the single ended

cords shown at the right in Figure Number 63. The other end of this cord terminates in a district selector on a special operator's district frame. A link circuit consisting of a cord finder and a sender selector, which in this case are rotary switches, connects to the cord a special operator's sender and the numbered keys shown in Figure Number 63 in front of the cords. A frame with link circuits and senders is shown in Figure Number 64. The operator records the number desired on the above keys, pressing first a "route" key, which directs the operator's district selector to a group of trunks leading to another office where the movements of selectors are controlled in the usual way, or to a tandem board where the office code and the

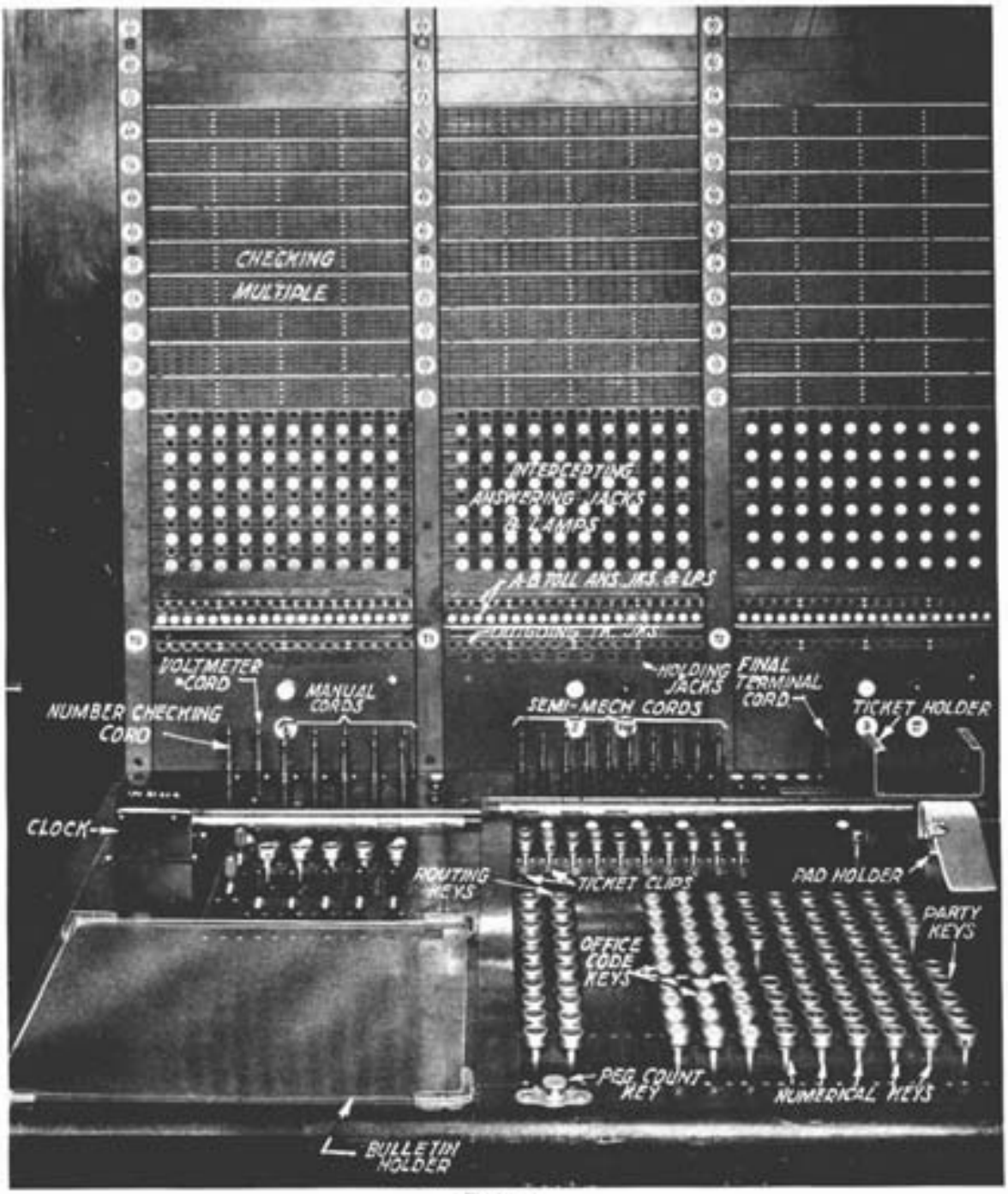


Figure 63
Semi-Mechanical "A" Switchboard—Combination Position

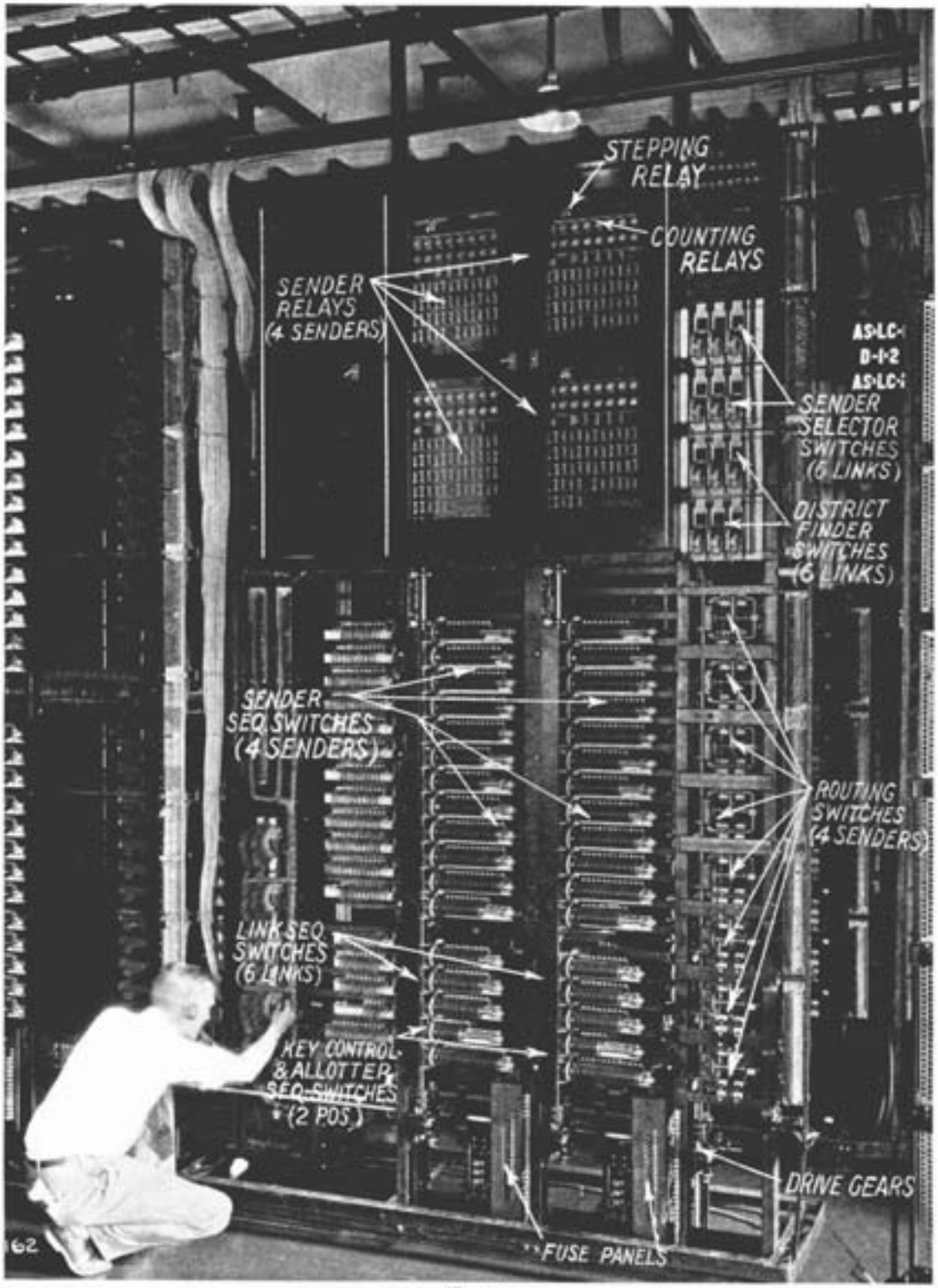


Figure 64
"A" Operator's Sender and Link Frame
(Non-Unit Type)

number are displayed on a call indicator. Figure Number 65 is a plan of the operation of such a call to another panel type central office.

3. Vacant Code Calls.
   If a subscriber dials by mistake an office code which is not assigned to any working office in his area, the sender will receive pulses from the pulse machine which will cause it to direct the district selector to a special group of trunks on which a tone will indicate to the subscriber that he has made an error.

4. Intercepted Calls.
   All subscribers' line terminals not in use are connected together in groups and each group connected to a jack and lamp at the "A" board. Lines temporarily out of service or on which service is denied are also connected to similar jacks. Anyone calling one of these lines will therefore be answered by an operator who will use one of the double ended cord circuits shown at the left of Figure Number 63. With these cords the operator may complete calls to other lines in the central office by way of the "B" board.

When handling a toll call the operator writes a ticket and the subscriber is charged for the call in accordance with this ticket. As all subscribers in the office use the same jacks when calling the operator, it is necessary for the operator to ask the subscriber his number in order to know to whom to charge the call. To guard against the possibility of the subscriber giving the wrong number and so causing the call to be charged to someone else, each subscriber's line is connected to a brass pin in a "checking multiple" installed in the face of the board above the answering jacks. If while the operator is talking to the subscriber she touches the pin connected to his line with the tip of a plug on a special checking cord, one of which is installed in each operator's position, she will hear a distinctive tone and she will not hear this tone when she touches any other pin in the checking multiple. The operator may thus verify the correctness of the number given by the subscriber.

The cord circuits of the "A" board are so arranged that the answer of the operator does not operate the subscriber's message register.

If the offices to which calls from the panel type A switchboard go are not provided with mechanical equipment or call indicators, it may be more economical and desirable to handle toll calls manually. In this case, an A switchboard is provided in the dial office exactly similar to that used in manual offices except that each position is equipped with a dial so that the operators may use the dial equipment to complete local calls, if necessary, and checking multiple is provided. Such a switchboard is shown in Figure Number 66.

Figure Number 67 is a view of an operating room showing both A and B switchboards.

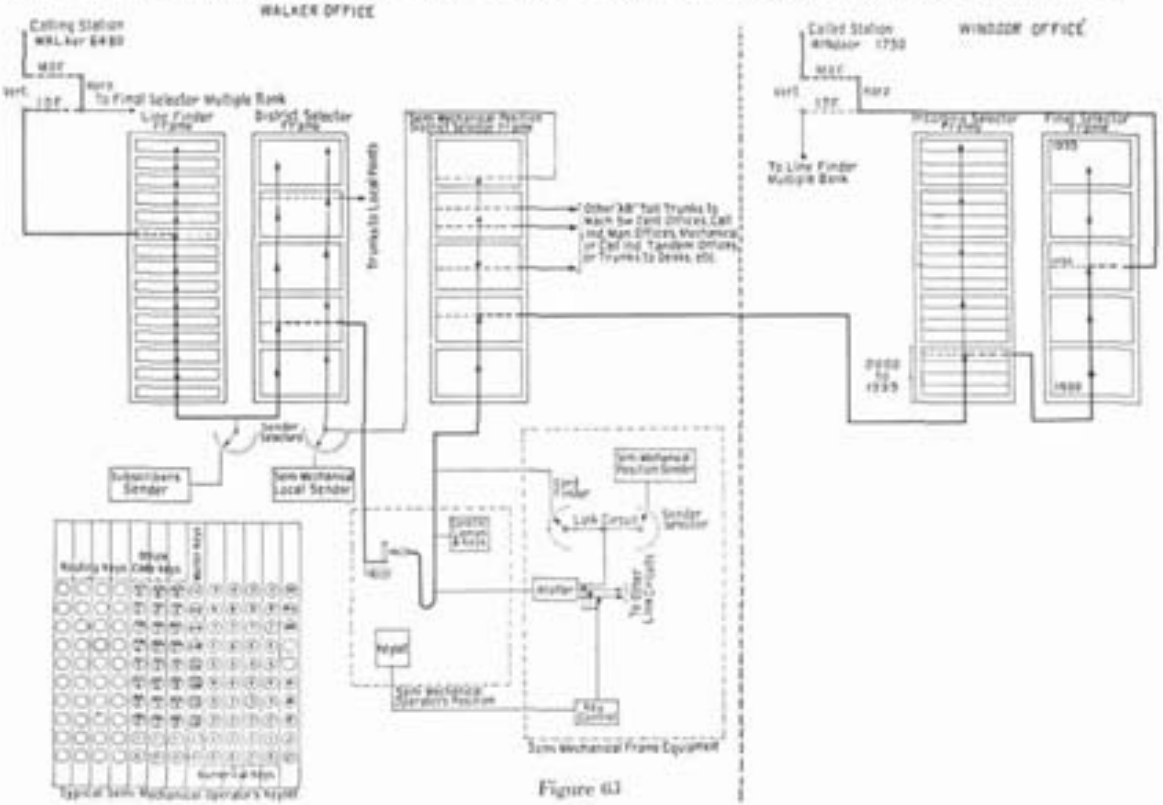


Figure 63

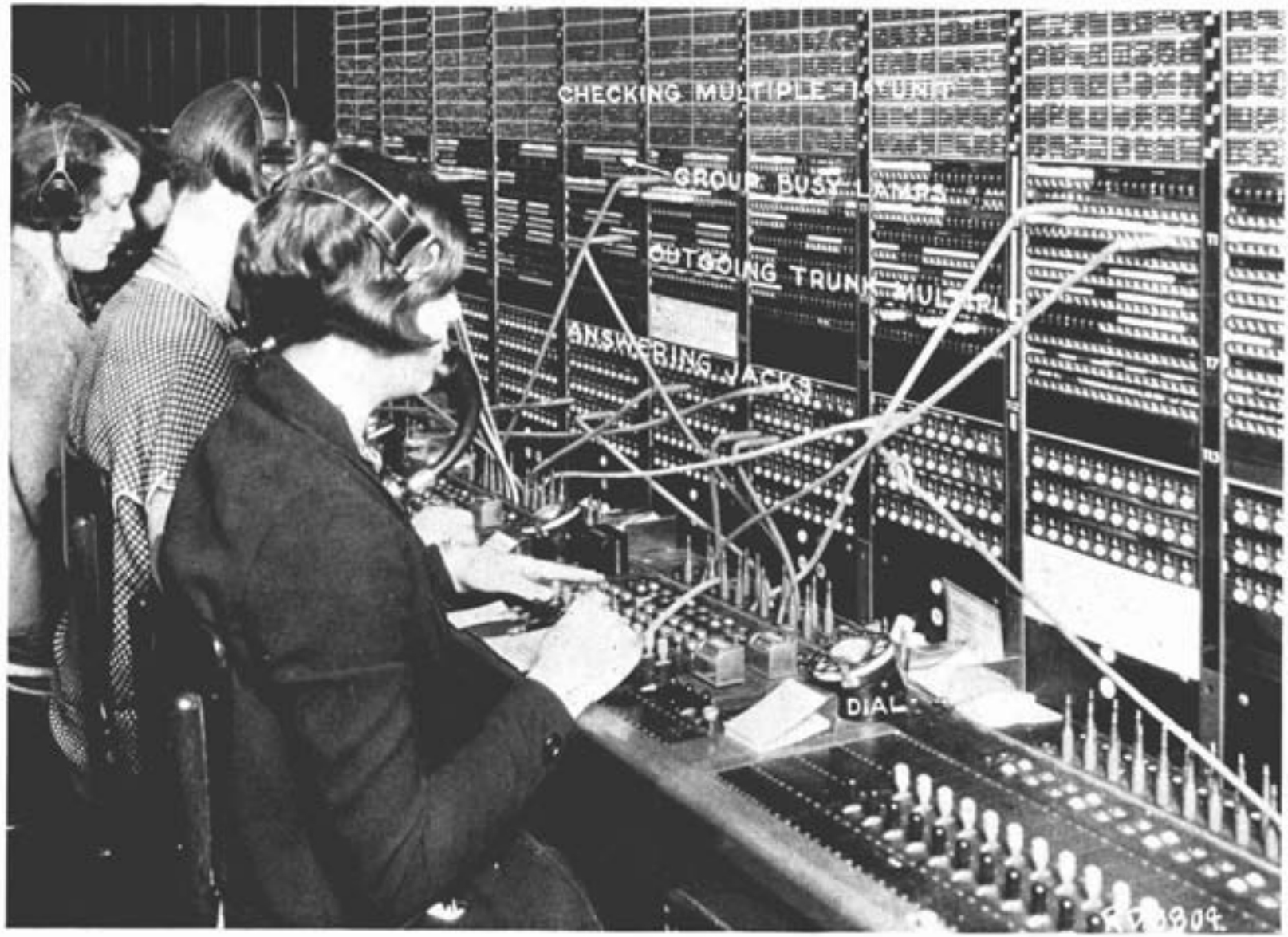


Figure 66
Dialing "A" Board

Figure 67
Operating Room

Figure 68

The Sender Monitor

In manual telephone systems any irregularity in the progress of a call is at once made apparent to the operator by the condition of the supervisory lamps. On dial calls there is no operator to keep watch or "monitor" so that other means must be provided to take care of the subscriber should trouble arise in the course of the operation.

Each sender circuit is provided with a time measure which consists of a rotary switch operated by an interrupter. As soon as the sender has been connected to a subscriber's line, this time measure starts to count time and if at the end of a certain time (33 seconds to 1 minute in New York— the subscriber has not dialed, a lamp, one of which is connected to each sender, is lighted. This lamp appears at a switchboard in front of an operator called the "sender monitor." Such a switchboard is shown in Figure Number 68. The two girls seated at the left are the sender monitors. The time measure continues to operate during all of the time that the sender is in use. Should the subscriber fail to dial all of the number, or should the sender fail to complete its proper functions in a given time, the lamp will light. Associated with each sender lamp are jacks, by means of which the sender monitor can enter the talking circuit and talk to the subscriber. She may also, by means of these jacks, release the sender from the connection or make it busy if it is causing the trouble, so that it may be kept out of use until it can be repaired. Should a subscriber remove his receiver from the hook and fail to dial, or should the receiver be accidentally removed or any of those conditions be present which in a manual office would cause a permanent line signal, the sender connected to the line will, after a certain interval, automatically cause a call to be made to a special line known as a "permanent signal holding line" which terminates in jacks and lamps at the sender monitor's position. In this way the operator is advised of the condition and can take the necessary steps to have it corrected while the sender is released so that it may be used by other subscribers.

All vital parts of the apparatus, such as driving motors, fuses, etc., are provided with alarms so that any failure which would affect operation is at once announced to the maintenance forces. These alarms are grouped on panels known as "floor alarm boards," one of which is provided on each floor. Pilots at the sender monitor's position also call the attention of the sender monitors to the failure, and aisle pilots, located near the ceiling at the end of each aisle between the rows of frames of mechanical apparatus, indicate the location of the fault, so that it may be quickly found by the maintenance men.

Testing

The right-hand part of the switchboard in Figure Number 68 is the outgoing trunk test board. Here appears a multiple of all trunks going out of the office. A complete equipment of keys for making calls, a dial, a voltmeter, etc., are provided so that the testmen are able to make complete tests on all of these trunks and check not only their condition but the operation of the apparatus to which they are connected in distant central offices.

Equipment similar to that used in manual offices is provided for testing subscribers' lines and, in addition, an automatic apparatus to assist repairmen in adjusting the speed of subscribers' dials. This consists of a pendulum device mounted on the wall of the central office. A repairman at a subscriber's station, wishing to adjust the dial, dials a special code, which connects the subscriber's instrument to the dial tester. He then dials zero and the dial tester indicates to him by means of tones whether the dial is moving too fast or too slow.

To give the best type of service to the subscribers and to maintain the equipment at its best efficiency it is not considered sufficient to care for troubles in the mechanical apparatus as they occur in actual use, but in each office equipment is provided for routine testing of the apparatus at stated intervals, even though no faults have appeared in service. A test frame is provided for each type of selector and each type of sender in the office. Figure Number 70 shows a frame for testing incoming selectors and Figure Number 71 portable and permanent types of equipment for testing subscribers' senders. The test frames are automatic in operation. When in use a test frame connects itself to each of the selectors or senders which it is designed to test and simulates calls passing through that selector or sender under the limiting conditions for proper operation. If the selector or sender responds properly, the number of tests is registered and the next selector or sender taken in turn. Should a selector or sender fail, however, the operation is arrested while the test frame sounds an alarm and indicates by means of lighted lamps at what point in the operation the failure occurred. The test frames when making routine tests will not, of course, interfere with selectors or senders which are in use by subscribers.

For making tests on particular selectors while observing their operation a portable test set such as is shown in Figure Number 69 is used.

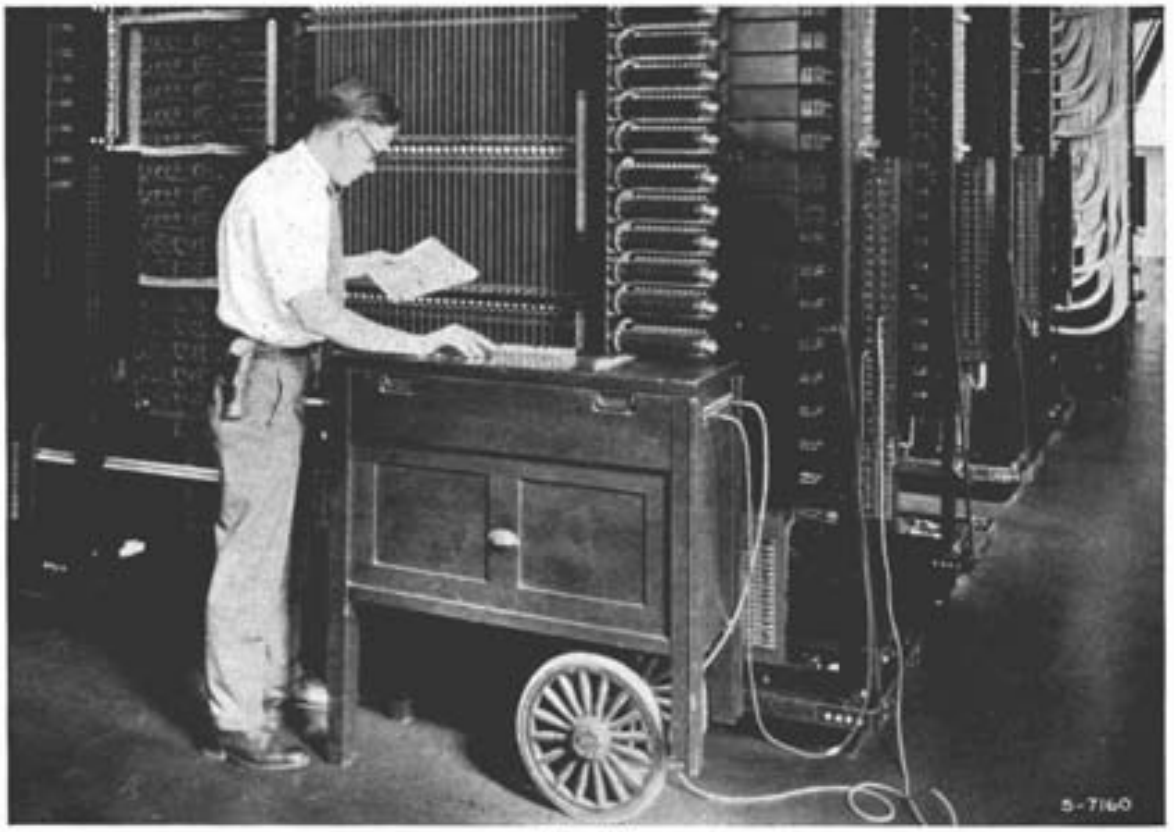


Figure 69

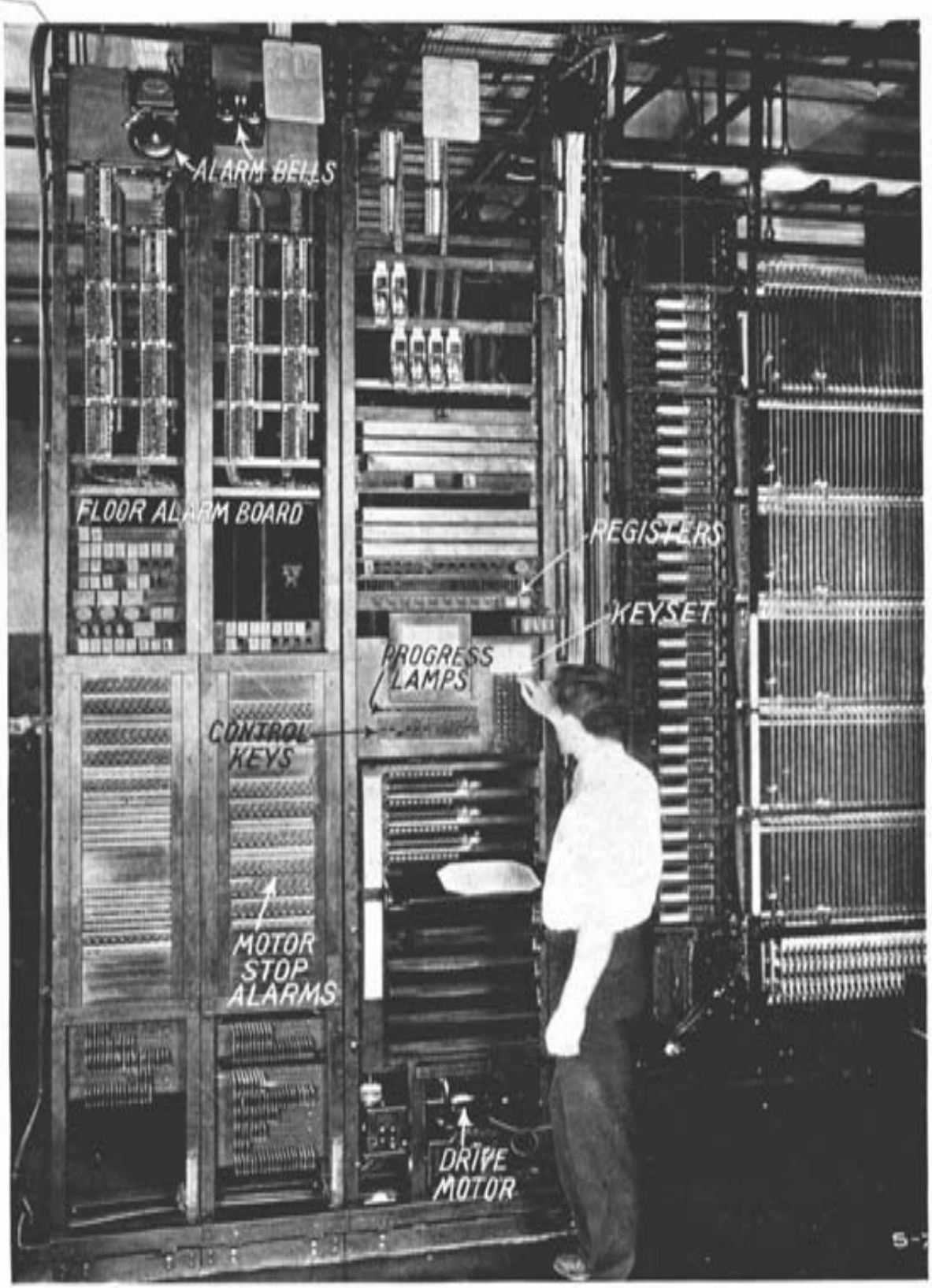


Figure 70
Incoming Selector Routine Test Frame and Floor Alarm Board

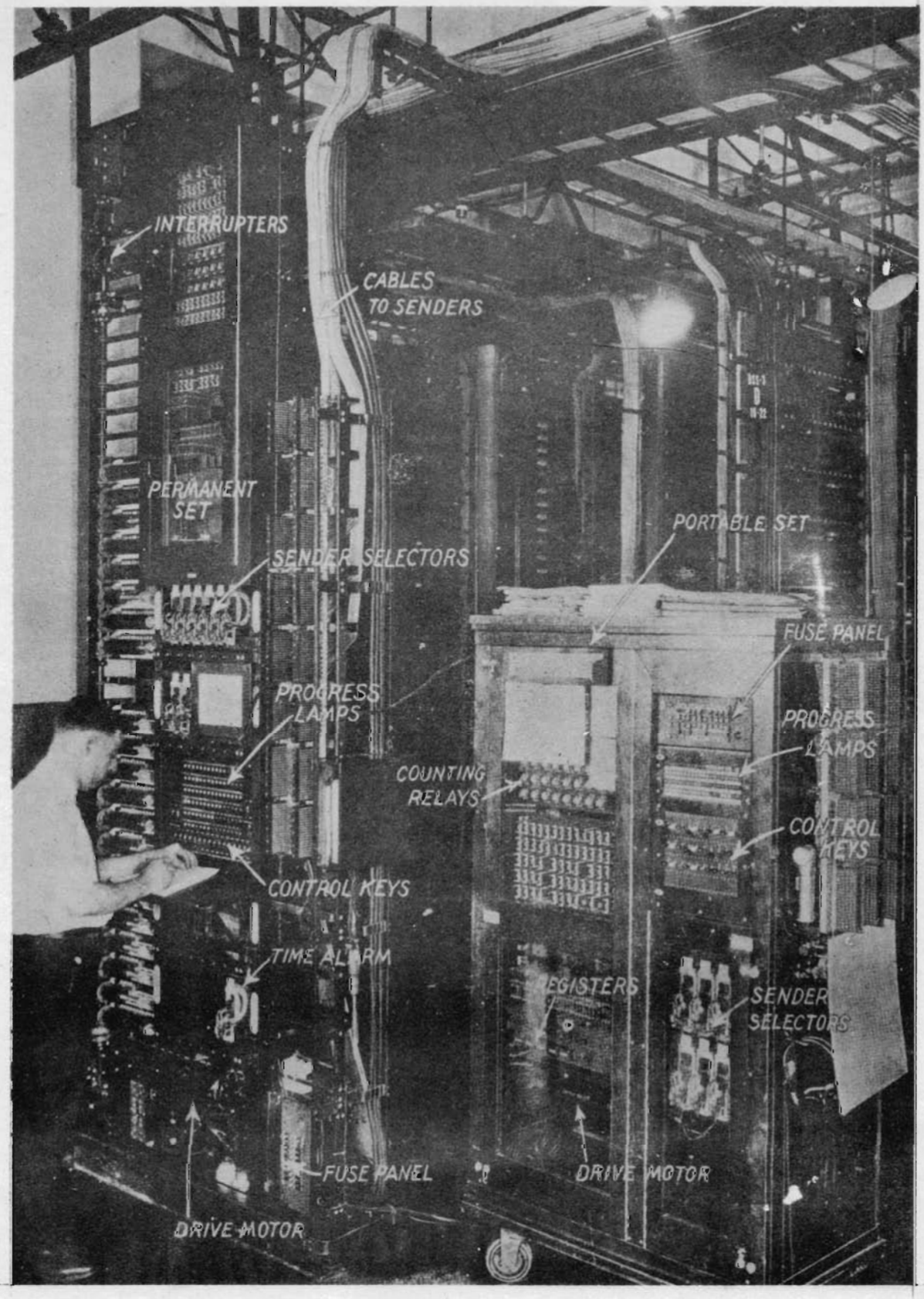


Figure 71
Permanent and Portable Subscriber's Sender Routine Test Sets