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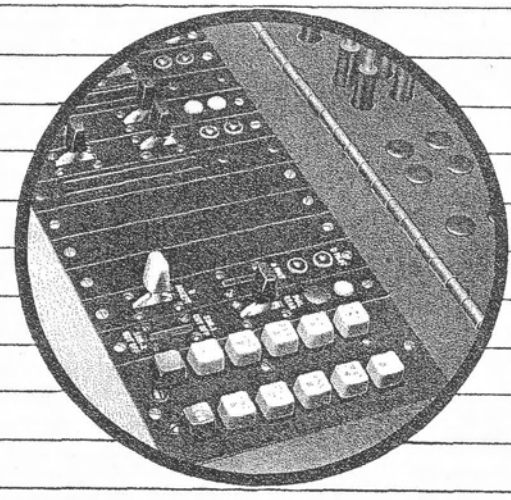
MANUAL SWITCHBOARDS

STROWGER AUTOMATIC TELEPHONE SYSTEMS



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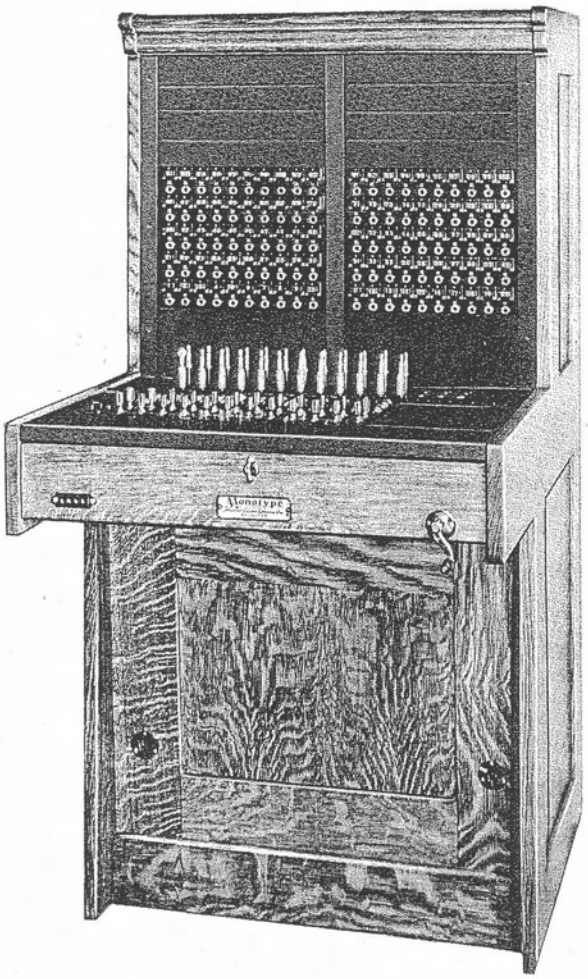

Figure 1b. Magneto Switchboard

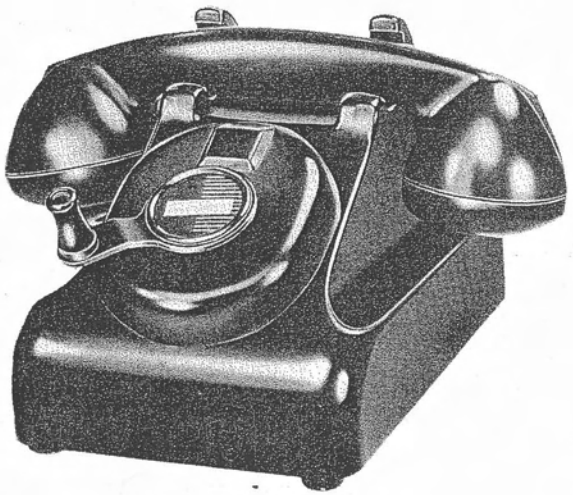

Figure 1a. Modern Magneto Telephone

MANUAL SWITCHBOARDS

1. EARLY HISTORY AND DEVELOPMENT OF TELEPHONY

Since the development of the first practical telephone model in 1876, the field of telephony has been expanding to compensate for ever-increasing usage.

The first telephone receiver was essentially a permanent magnet with a coil of wire wrapped about it and a metallic diaphragm held at a small distance from the end of the magnet by a casing. A varying electric current in the coil induced a varying magnetic field about the magnet. This varying field caused corresponding vibrations in the diaphragm as it was attracted by the field. The vibrating diaphragm then produced sound waves corresponding to those imposed on the transmitter at the other end of the line.

The transmitter was similar to the receiver in construction, except for detail. As sound waves struck the transmitter diaphragm, it vibrated, causing the magnetic field surrounding the permanent magnet to vary in intensity. This variation in the field induced a current in the coil which was transmitted along the line to a receiver. There was no outside source of power in the circuit.

This newly developed telephone was first used for connections between two stations at a short distance. Gradually more than two telephones were connected in series along one line until the optimum number (approximately 20) was reached. Numerous individual lines were then established, each with its own separate system of telephones. It soon became apparent that some method must be devised for switching one such telephone line into another. A telegraph switching system had already been developed, and consequently this method was adopted for telephone switching, first, in joint telegraph-telephone switching centers, and then in telephone switching centers alone.

It also became evident that a signaling device had to be developed to signal from telephone to telephone, telephone to switchboard, and switchboard to telephone. The earliest means of signaling the switchboard employed telegraph apparatus or a combination of telegraph apparatus and bells. Later, signaling was accomplished by a battery and hand-operated circuit interrupter at the calling station which rung an electric bell at the called station. By 1878, the forerunner of the magneto was developed. A crude form of this hand-operated generator was used at the calling station to ring bells at the called station. Coded ringing was then employed to signal the operator at the switching center or any party on a line.

The telegraph switching systems, designed for the long and infrequent connections of telegraphy, soon proved too clumsy for the relatively short and frequent connections of telephony. A switchboard that provided supervision for prompt handling of calls was needed, as well as one that was compact enough to accommodate the steadily increasing number of lines.

The first improvement was the association of a spring connected drop with each line. This drop literally "dropped" when a party on the line signaled for service. Connections were then made to the calling and called lines by two flexible insulated cords with plugs on each end and an intermediate connecting bar. One plug of a cord was inserted into the jack of the calling line, mechanically restoring the drop, while the other plug was joined to the connecting bar. The call was completed in the same manner by inserting one plug into the connecting bar and the other into the jack of the called line. The operator's connections for talking and listening were also made through the connecting bar. Clearing out signals indicating the end of the call were given by means of a telegraph relay associated with a drop on each connecting bar.

Shortly, though, the connecting bar and the two pairs of plugs were incorporated into one cord circuit comprised of two plugs and a connecting cord. Ringing-listening key connections were provided for this new cord circuit and a permanent clearing out drop was associated with each pair of plugs. This form of switchboard was considered the standard switchboard for many years.

As demand for telephone service in outlying areas developed, transmission distance had to increase. Since the power output of the transmitter was insufficient for use over long lines, the design of the transmitter was changed radically in 1878. A carbon contact resistance

was introduced into the transmitter, and a source of direct current was included at each station. The vibrations of the sound waves varied the resistance offered by the carbon contact to the flow of direct current and caused corresponding variations in the strength of the current. The telephone induction coil was also added to the circuit. This coil, acting as a step-up transformer, separated the transmitter circuit from the line circuit. These changes increased transmission voltage so that longer lines could be established.

Transmission distance also was extended by substituting copper wire for iron wire in telephone lines. Just as telegraph switching systems were tried in telephony, galvanized iron wire was first adopted for transmission lines because of its previous use in telegraphy. Iron wire soon outlived its usefulness, though. It strongly resisted current flow, and transmission from any one phone to another was limited, at best, to about 20 miles. Copper wire was known to be a much better conductor of electric currents than iron wire, but because of high cost and lack of tensile strength, it was impractical for outside connections. However, as telephone service became more widespread and transmission lines increased in length, the cost of copper wire became less important, and by 1883, a method was devised for strengthening copper wire by hard-drawing. One long line of this new copper wire was put into service, and proved so successful that copper wire soon became the standard for long line transmission.

Transmission distance and quality were given an extra boost with the introduction in 1899 of the bridging telephone. Up to this time bell windings were connected in series with transmission lines. These high resistance bell windings opposed the talking current and noticeably cut down transmission distance and quality of reproduction. In the bridging telephone, the bell winding was connected across the line wire and "bridged" the talking circuit of the telephone. Then, the resistance of the bell winding prevented most current from passing through it, and directed the major portion through the low-resistance receiver.

Quality of transmission was again improved with the use of a fully metallic circuit. Due to the extra expense of fully metallic circuits, ground returns had been utilized on telephone systems. These were relatively noisy because of local electrical disturbances, but as power lines were strung and electric railroads and street cars were established, earth returns became impractical. At first telephone companies tried to improve service by grounding all lines on a single line return, but this did not prevent one line from interfering with another. It was finally agreed that the only efficient method was to establish fully metallic two-line circuits with a common ground at the central office. This was gradually adopted in all areas except relatively isolated rural locations.

With these early advances in the field of telephony, a lasting foundation was laid for efficient telephone service to all parts of the country.

2. Development of Manual Switching Systems

Changes made in telephone switching systems characterize the development of the telephone industry after its infant stage. Refinements continued to be made in long distance transmission, such as the addition of repeating, hybrid, and loading coils, transposition of lines at predetermined intervals, and the development of phantom circuits and coaxial cable, etc., along with the improvements in telephone receivers and transmitters. But these developments would have been futile without parallel development of extensive, efficient switching systems to connect telephones in all parts of the country.

Telephone switching systems have developed along two lines: manual switching and automatic switching. Since World War I, automatic switching systems have superseded manual systems as the standard of the telephone industry. While it is true that the first Strowger Automatic Telephone System was installed in 1892, widespread use of automatic switching was not feasible until 1905 because of limited mechanical development, cost, and quality of service. For all practical purposes, then, manual switching was the sole method of operation during the first thirty years of rapid growth in the telephone industry, from 1880 to 1910.

As was the case for most developments in telephony, increased usage made improved switching systems a necessity. The first major improvement was the development of the common battery switchboard. With this switchboard transmission battery was supplied to all lines from a common source at the central office. Simultaneously, the multiple switchboard came into use, with limited application at first in magneto systems, and then with complete success in common battery installations. The multiple switchboard brought every subscriber's line within the reach of several operators, allowing a greater number of calls to be handled through one office.

Following closely on the heels of the multiple switchboard, came the universal board with the universal cord circuit. This board permitted common battery and magneto telephone lines to terminate at one switchboard and provided adequate supervision for both.

As the number of trunk lines increased, A-B switchboards were introduced. These switchboards were designed to handle only one phase of a call, the incoming portion at the A-board, the outgoing at the B-board, with all subscriber lines terminating at both positions. Outgrowths of the B-board were the tandem and toll boards. The tandem board handled trunks to frequently used outlying areas which were too numerous for the B-board, yet could not be accurately classified as long distance trunks. The toll board was the terminating point for trunks to distant cities and towns for completion of long distance calls.

During this same period of rapid growth, demands of subscribers for special services also increased. The Private Branch Exchange was developed, and special desks were designed for handling information calls, repair service, and testing.

Though it would seem that the advent of the automatic switching system would bring to an end the era of manual switchboards, a smaller yet more important field of development was actually being opened and is at the present time reaching its peak. The main objective of the telephone industry today is Direct Distance Dialing to and from all parts of the nation. The ease and convenience with which toll calls will be completed will lead, in all probability, to greater use of telephone services. With increased usage, toll rate and route, information, and repair calls along with toll testing and person-to-person toll calls (which of necessity must remain under the control of operators) must be handled by the most efficient methods. These services will require the latest in manually controlled switchboards which will operate in conjunction with all automatic equipment. And until this conversion to nation-wide dialing is complete (which will still require several years), switchboards of all types must be provided which will tie into both the automatic installations and the manual equipment still in existance.

3. The Magneto Switchboard

Although magneto telephone systems are now obsolete, the magneto switchboard of 1880 was the first successful application of switching equipment to telephone systems. It guaranteed the expansion of local service into the network we use today, and the arrangement of its parts proved so functional that it was retained in later switchboards. Thus, even if magneto telephone systems were extinct -- and indeed they are not -- a knowledge of their purpose, construction and operation would be important.

3.1 The magneto telephone. The magneto switchboard received its name from the telephone to which it was allied. Characteristically, a magneto telephone had a set of storage batteries which supplied transmission current, a receiver, a transmitter, an induction coil, a magneto generator which produced ringing current when cranked, and a bell which rang when generator current crossed its winding. A modern magneto telephone is shown in figure 1-a.

3.2 Arrangement of a magneto switchboard. A magneto switchboard is shown in figure 1-b. On this switchboard, the line outlets or jacks, and their associated drops occupy much of the vertical face. At the back of the horizontal shelf are twelve pairs of plugs, which are the ends of twelve connecting cord circuits. To connect two telephone lines the operator inserts the back plug of a given pair into the jack of the calling line, and the front plug into the jack of the called line.

In front of each pair of plugs on the horizontal shelf is a pair of clearing out signals that notify the operator of the termination of a call. In front of the signals is a pair of keys which switch the operator's telephone circuit in and out of the corresponding cord circuit and ring the telephones when connections have been made. Each vertical row of one cord circuit (two plugs), two clearing out signals, and two keys is sufficient (with the operator's telephone) to connect and supervise a call between any two telephones.

At the far left of the switchboard (aligned with the name Monotype) are jacks into which the operator plugs her headset. The handle at the far right works a hand generator in case the automatic ringing generator does not operate.

3.2.1 Jacks and drops. A single switchboard jack and drop are shown in figure 2. Each jack consists of a spring arrangement on which the two wires of a telephone line terminate in contacts called "tip" and "sleeve." Each drop is a hinged piece of metal held in a vertical

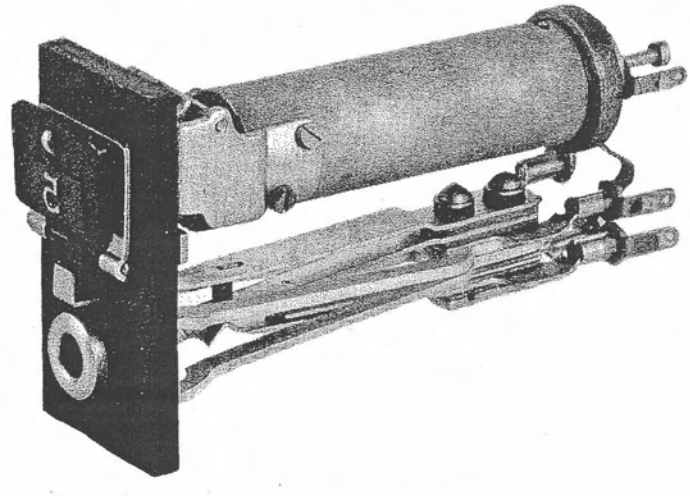

Figure 2. Magneto Switchboard Jack and Drop

position by an armature catch attached to a relay. When this relay is magnetized, it attracts the armature catch, which releases or "drops" the hinged piece of metal.

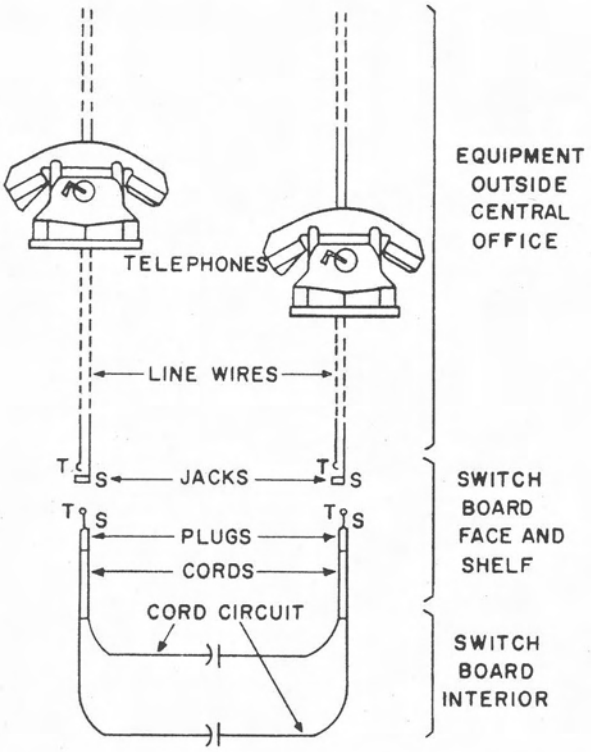

Figure 3. Schematic Magneto Telephone Connection

3.2.2 Plugs, cords, and cord circuits. Figure 3 is a schematic presentation of one set of plugs, cords and the corresponding cord circuit, with two telephone line jacks into which the plugs are inserted to establish a connection. A two-conductor plug is shown in figure 4. The two wires of the cord circuit terminate on the tip and sleeve of two such plugs.

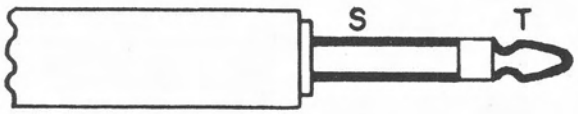

Figure 4. Two-Conductor Plug

When each plug of a set is inserted into a jack, the two corresponding telephone lines are connected. When the two telephone handsets are removed from their cradles, they are connected for voice transmission as follows: from the calling telephone, through the "tip" line wire, "tip" jack spring, plug tip cord, capacitor, plug sleeve, "sleeve" jack spring, "sleeve" line wire, to the called telephone, and back from the called telephone to the calling telephone in the same manner, to complete the circuit.

3.2.3 Keys and clearing-out signals. The switchboard keys and clearing-out signals are shown in figure 5 assembled on a single plate. The front key, when pushed back, is in the listening-talking position, its contacts bridging the operator's headset across the corresponding cord circuit. When pulled forward this key closes the circuit to a ringing generator, sending ringing current out to the called telephone line. The back key is the ring-back key. When pulled forward, it rings the calling telephone line (for completion of a delayed toll call, etc.).

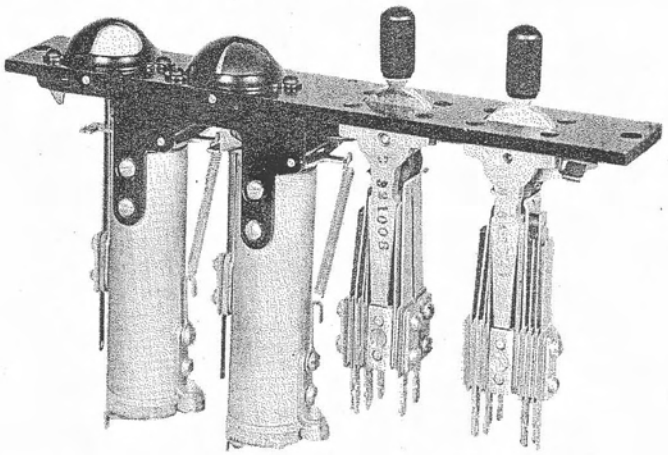

Figure 5. Magneto Switchboard Keys and Signals

The clearing-out signals are visual indicators linked to each cord circuit which notify the operator when one or both parties to a telephone call have hung up or wish further attention. They are hemispherical shutters, half black and half white, shielded by transparent dust covers. Normally, the black portion of the shutter is in view; ringing-off current from either telephone rotates the white half up. Both signals are mechanically linked to the talking key, so that when this key is operated, the signals restore.

3.2.4 Operator's headset and ringing generator. The operator's headset is a telephone designed to fit on the operator's head and chest, leaving both hands free to operate the switchboard. The receiver clips over the head and one ear; the transmitter rests on the chest and extends out and up in front of the mouth. Transmission power is supplied by storage batteries.

The ringing generator is an alternating current generator, producing current similar to that of the magneto generator of each telephone. The operator works the generator by pulling forward on the front or back key. Power to run the generator is usually taken from the local electric supply.

3.3 The Completion of a Local-to-Local call. The circuit of a local-to-local call through telephone and switchboard parts within a

magneto exchange is illustrated in figure 6. The heavy lines emphasize the line circuit, or secondary circuit. The light lines trace signaling circuits and the transmitter or primary circuits (in the calling telephone and the operator's telephone). Several operations and circuits are involved in the completion of a local-to-local call. It will be to your advantage to locate and follow these circuits as operations are described, since they are basic to manual switching, as well as to this particular switchboard. Most magneto lines are party lines; therefore, the subscriber who wishes to place a call usually must first listen in on his telephone to see if the line is busy. In the calling telephone, picking up the handset connects the receiver across the line wires at the upper contact of the hookswitch. Then, any voice currents already on the line flow through the receiver, and the calling subscriber hears them. If the line is busy, the subscriber hangs up and waits a few moments before listening in on the line again.

If the line is idle, the subscriber replaces his handset (disconnecting the receiver) and cranks the magneto generator briefly, connecting it across the line wires and sending out a-c current of about 20~per second to the central office switchboard. Although the passing of this current may ring the bells (permanently connected across the line wires) of the other telephones on the party line, the operator's code is rung, signaling other parties not to answer.

After cranking the magneto, the calling subscriber picks up his handset, connecting the receiver across the line wires as before. This completes the "subscriber loop," or one-half of the secondary circuit (heavy lines). Also, as a result of picking up the handset, the transmitter or primary circuit of the telephone is completed by the lower hookswitch contact, so that steady direct current flows from (+) battery, through the hookswitch, the induction coil winding, to the transmitter, and back to (-) battery (light lines).

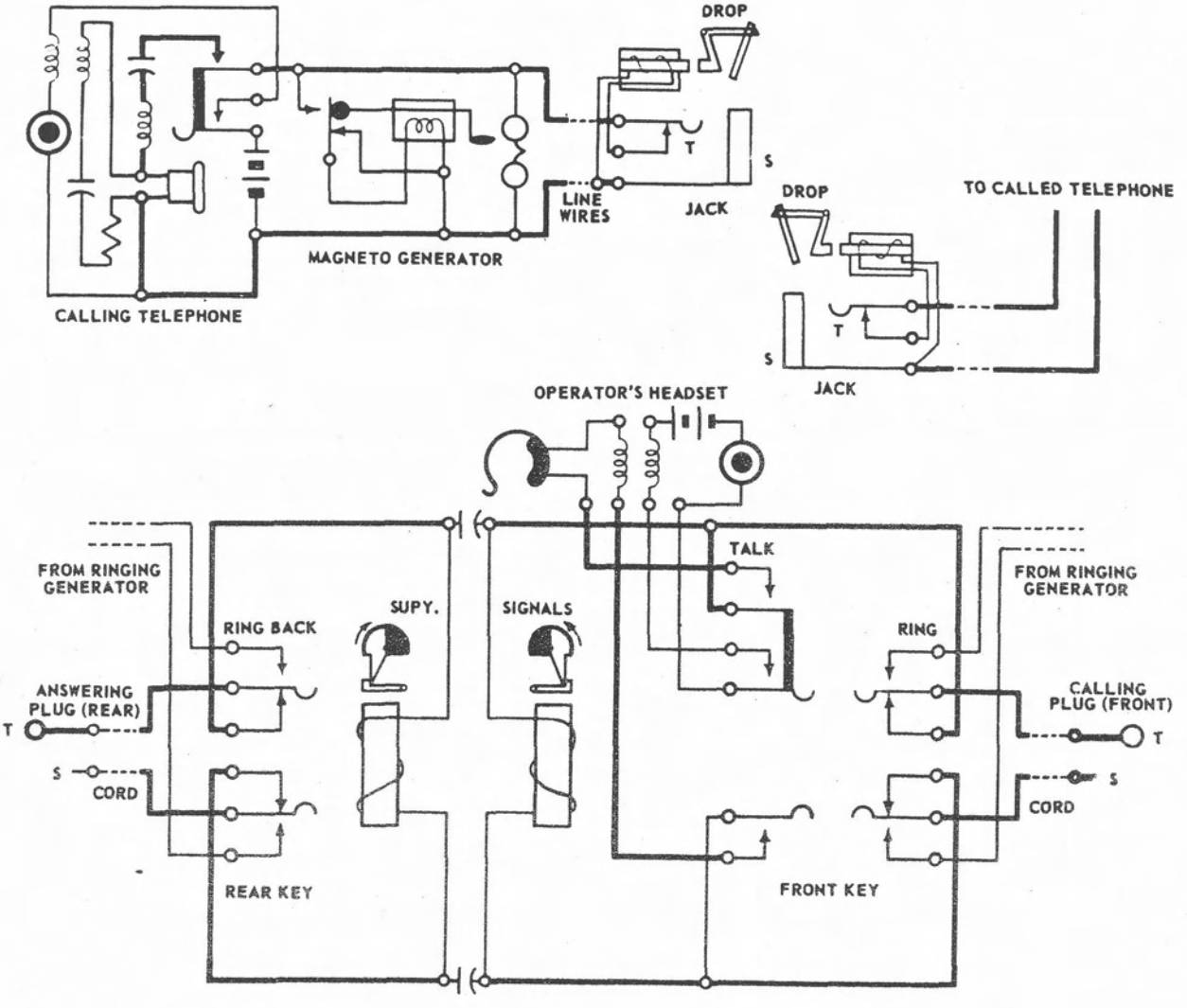

Figure 6. Circuit of Call Through Magneto Switchboard

When the current generated by the magneto reaches the switchboard, it passes through the jack contacts to the associated drop, magnetizing the drop relay. The relay then attracts the armature, which releases the drop. Then, the operator inserts the answering plug into the jack of the calling telephone line, which breaks the circuit to the drop and restores it mechanically. She also pushes the front key back into the talking-listening position, connecting all the key contacts, so that her telephone is bridged across the line wires via the cord circuit. Thus, the second half of the secondary circuit connecting the subscriber's telephone and the operator's telephone is completed (heavy lines), and the primary circuit in the operator's telephone (battery, induction coil winding, transmitter) is established (light lines).

The operator then asks the subscriber for the number of the station he is calling, and he replies. When she locates the line jack of the called telephone line, she inserts the calling plug into it. Finally, she rings the code for the called telephone, using the ringing position of the front key. When not ringing the called telephone, the operator puts the key into the talking-listening position, so she can hear when the called party answers. When he does, she restores the key to its idle position, taking her telephone out of circuit, and leaving the two subscribers to converse.

Conversation is transmitted over the primary and secondary circuits. When either subscriber speaks into his telephone transmitter, the transmitter resistance changes rapidly, causing the battery current to vary. This varying current flows through the primary inductance coil winding and induces a corresponding current in the secondary circuit. This secondary current flows through both telephone receivers, where it is translated back into sound.

To terminate the call, the subscribers hang up (disconnecting primary and secondary circuits) and "ring-off" or crank the magneto generators. The generator current in both cases flows over the lines, jacks, plugs, and into the respective relays, which control the clearing-out signals. Each relay is magnetized, and attracts the signal catch, which releases the signal into the "on" position. The operator now has supervision to "challenge" the line by cutting her headset into the cord circuit. If no further service is desired by either subscriber, she restores the plugs and keys to their unoperated position, terminating the call.

4. The Common Battery Switchboard

The common battery manual switchboard of forty years ago is the direct ancestor of today's auxiliary manual switchboards and the PBX switchboard. Further many of these manual switchboards are still in use and will be for some time to come. These are two important reasons why the telephone man should understand the manual common battery system.

The manual common battery system should also be understood in relation to automatic equipment. Automatic equipment is composed of electro-mechanical switches that perform the tasks formerly completed by an operator at a common battery manual switchboard. Automation is the only important difference between the two systems; that is, the basic direct current and voice current circuitry of both systems is very similar. In a manual system this circuitry can be seen and studied effectively, and then, may be applied to the more complicated circuits of an automatic system.

4.1 Switchboard parts and their arrangement. A comparision of the magneto switchboard in figure 1-b and the sketch of a typical common battery switchboard in figure 7 shows that the two are very similar, particularly in arrangement, and to a lesser extent in construction of parts. The similarities exist because the magneto switchboard had proven itself so workable that manufacturers retained its form for the common battery switchboard, and adapted its parts where possible. The main differences arise because signaling no longer is accomplished by means of magneto generators, and all telephones receive current from a common battery at the central office.

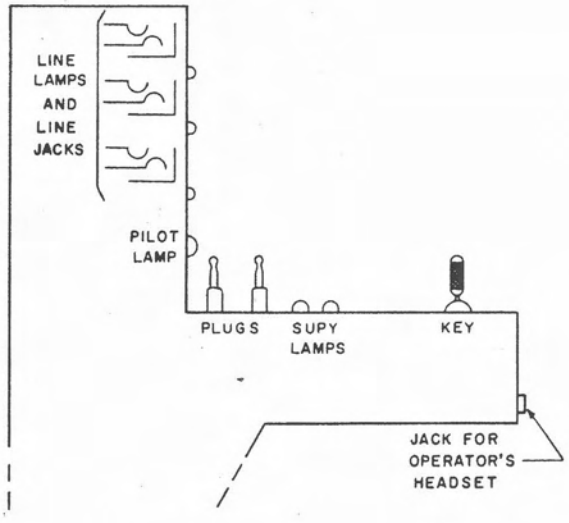

Figure 7. Common Battery Switchboard

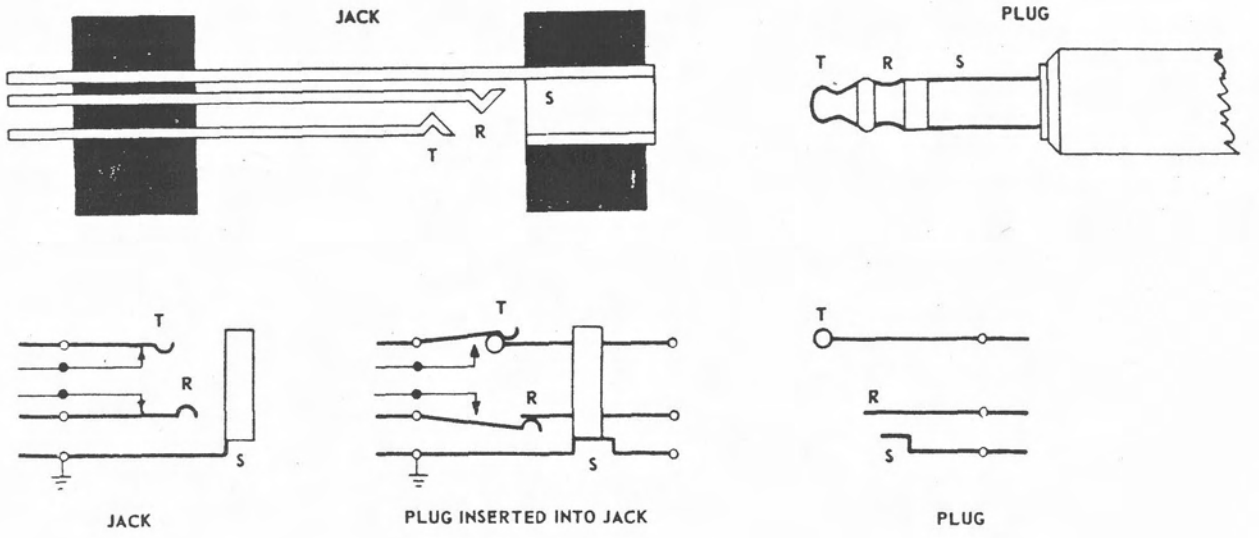

Figure 8. Common Battery Switchboard Plug and Jack

The line lamps and supervisory lamps of the common battery switchboard which replace the drops and supervisory signals of the magneto switchboard are the most obvious difference between the two. The operation of these lamps depends upon a second less obvious but more important difference. If you will compare the jacks of the common battery switchboard illustrated in figure 8 and the jacks in the diagram in figure 3, you will notice that an extra contact has been added to the jacks of the common battery switchboard, making a total of three contacts. A comparison of the plugs in figures 4 and 8 will show that the plugs for common battery use also have three contacts. Exact drawings and schematic representations of typical 3-conductor jacks and plugs are shown in figure 8

The new contact on the jack and plug is called the ring. It is placed between the tip and the sleeve contacts in the plug and the jack. To it is attached the (+) line wire. The two line wires in common battery usage thus are termed tip and ring, (+) and (-). The sleeve contact, which was attached to the (-) line wire in the magneto switchboard, now is free for exclusive use in the signaling circuits of the common battery switchboard. Both line wires are also involved in the signaling circuits, but to a lesser degree.

The switchboard lamps, for which the third contact in the plug and jack was created, are small cylindrical light bulbs. Their d-c circuits are controlled by relays in the sleeve and line wire circuits at the switchboard.

The common battery switchboard in figure 7, as you may notice, is equipped with only one key, while the magneto switchboard had two. This particular switchboard is not designed for handling delayed toll calls; thus, the ring-back key is not included.

4.2 Completion of a local-to-local call.

4.2.1 Operator's procedure. The procedure followed by an operator in completing a local-to-local call on a common battery switchboard is precise, but not difficult. To complete any call the operator needs only one cord circuit and the associated key and supervisory lamps.

When a subscriber lifts his telephone handset, the line lamp beneath his jack lights, along with the pilot lamp located below the group of jacks containing his individual jack. When the operator, who focuses her attention on these pilot lamps, sees one lit, she finds the lit line lamp, and inserts the back plug of a set into the corresponding line jack. Then she pushes the key associated with the set of plugs used to the "talk and listen" position, and asks "Number, please?"

When the operator learns the number of the phone to be called, she locates the called phone's line jack. If it is busy, she informs the calling party of that condition. If the jack is free, she inserts the front plug of a pair used. The cord-pair front supervisory lamp lights. Then the operator pulls the ringing key back momentarily. The front supervisory lamp remains lit and the operator rings from time to time until the called party answers. Then the lamps go out, the operator stops ringing, and the parties converse.

When the conversation is terminated both parties hang up and the supervisory lamp for

each plug lights. The lit lamps signal the operator to take down the connection. When this is done, the lamp goes out, and the cord circuit is ready to handle another call.

Notice that a dark lamp indicates that nothing need be done by the operator, but a lit lamp signals her to act. When a lamp in the switchboard vertical face lights, it is an "off-hook" signal, telling the operator to answer a new call. When a lamp in the switchboard horizontal keyshelf lights, it is an "on-hook" signal, telling the operator either to keep ringing a called party who has not answered or to take down a connection because both parties have hung up. A flashing rear supervisory lamp indicates that the caller is jiggling the hookswitch, and wants to talk with the operator to give her additional instructions, to ask for information, etc.

4.2.2 Circuit description and operation. The circuit diagram of a typical common battery switchboard is shown in figure 9. The voice transmission battery circuit is of the capacitor-inductor type. The heavy lines emphasize the line or voice transmission circuit. The light lines trace signaling circuits, transmitter circuits, and the battery feed circuit. In the following paragraphs the actions of the subscriber and the operator are described again, and coordinated with the responses of the switchboard.

When the subscriber at the calling telephone picks up his handset, the action of the hookswitch completes a signaling circuit to the switchboard lighting the line lamp and the pilot lamp corresponding to his telephone line. The signaling circuit is from ground or (+) battery at the switchboard over the tip jack contact to the calling telephone, back over the ring contact to the line lamp relay and negative battery. The line lamp relay closes the line lamp circuit, which includes a pilot lamp relay. The pilot lamp relay closes the pilot lamp circuit. Both the line lamp and the pilot lamp are now lit.

The operator sees the lit lamps, and inserts an idle answering plug into the line jack. Both the line lamp and the pilot lamp go out, since the insertion of the plug breaks the circuit controlling the line lamp. (See figure 8.)

The insertion of the plug also sets up a direct current circuit through the calling telephone, from positive battery, through one winding of the battery-feed relay, out the tip line, through the telephone, back through the ring line to the second winding of the battery-feed relay and negative battery. Notice that the battery-feed relay opens the circuit to the rear supervisory lamp, so it does not light at the time.

The operator throws the key back into the talking-listening position, which places her telephone circuit across the side of the cord circuit

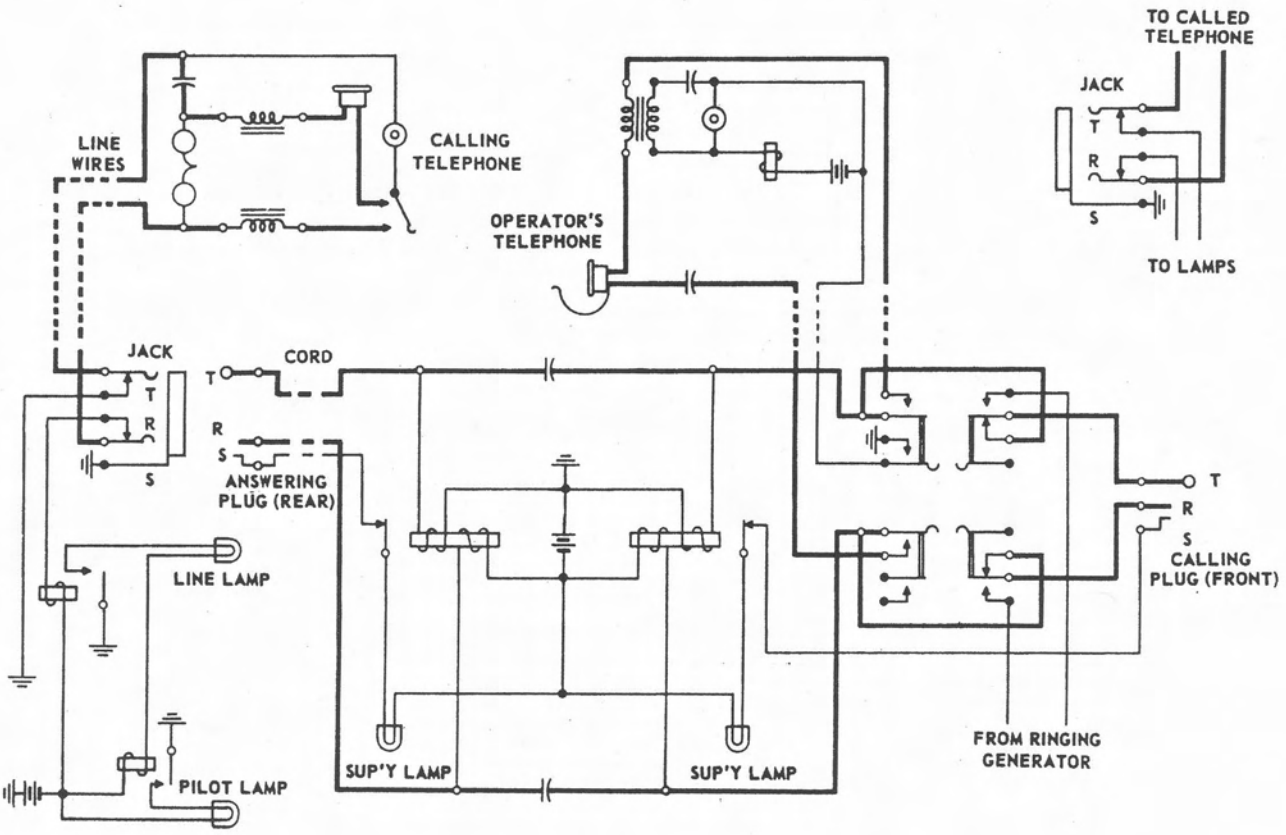

Figure 9. Circuit of Common Battery Switchboard

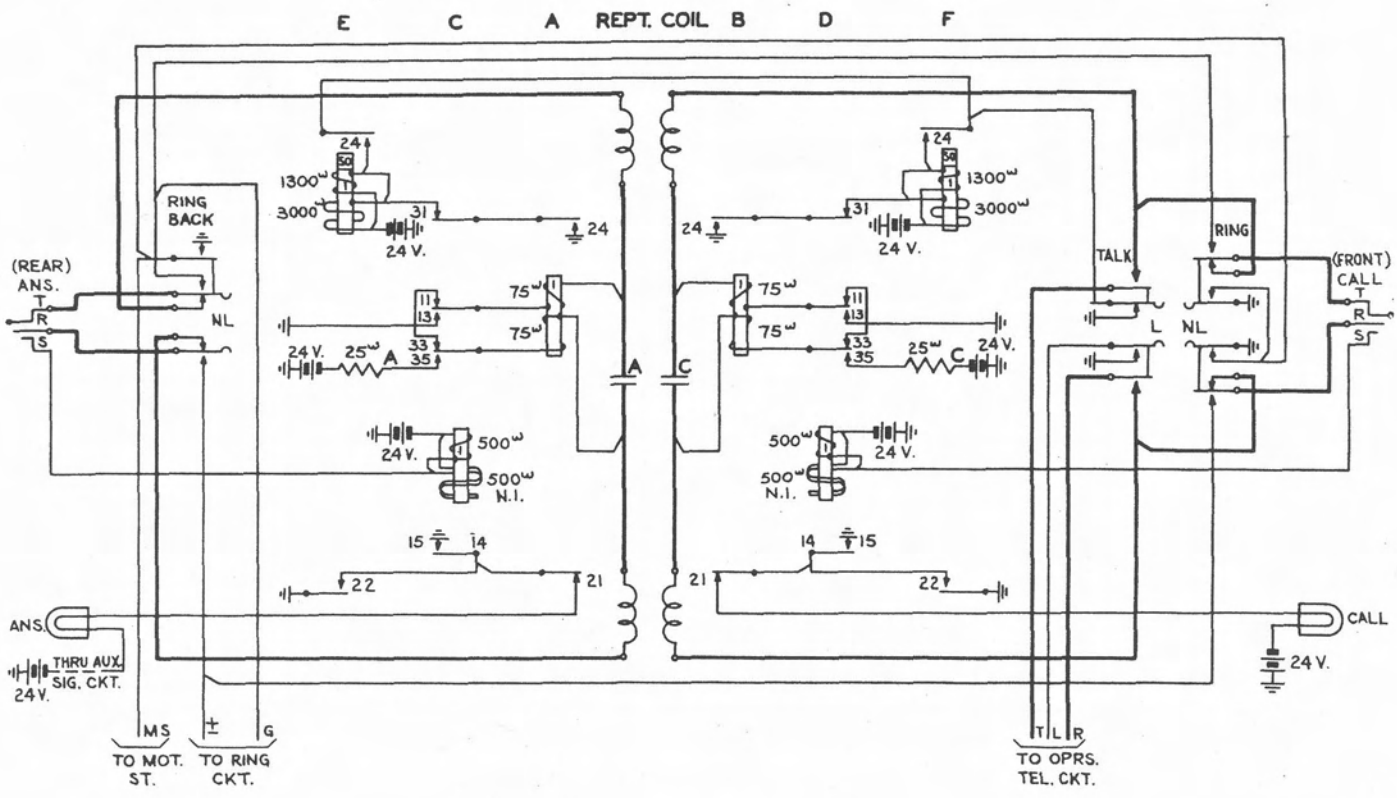

Figure 10. Universal Cord Circuit

opposite that of the calling telephone. Again, the other battery-feed relay opens the sleeve circuit, this time to the front supervisory lamp, preventing it from lighting. The operator may now speak to the party at the calling telephone. Battery current is supplied to the two telephones through the battery-feed relays, and voice currents pass over the two capacitors, since the inductance of the battery-feed relays keep the voice frequency off the battery.

Upon receiving the number of the telephone to be called, the operator looks to see if that line is busy, and if it is not, she plugs into the jack. Then she throws the key forward momentarily into the ringing position. Through these actions she has taken her telephone out of the cord circuit, substituted for it the called telephone, and sent ringing current out to the called telephone bell, by means of the make contacts of the front key position.

Throwing the key into the forward position also caused the front supervisory lamp to light, as the insertion of the calling plug into the called jack put ground on the sleeve contact of the supervisory lamp circuit. At the same time the removal of the key from the listening position disconnected the operator's telephone, opening the circuit to the battery-feed relay, while the other circuit involving it--that of the called telephone--remained incomplete as the handset was not yet lifted. Therefore, no current flowed through the relay and it released the break switch to the supervisory lamp, thus completing its circuit from ground (in the jack) to negative battery.

The operator continues to ring the called telephone from time to time until the front supervisory lamp goes out, signaling that the called telephone has been answered, and its direct current circuit is complete (activating the battery-feed relay which thus switches out the lamp circuit). Conversation now occurs between the parties on each telephone, over the tip and ring line wires and the cord circuit through the capacitors.

When terminating the call, both parties hang up, breaking the direct current circuits, and lighting both supervisory lamps. If neither lamp flashes (by hookswitch action) the operator knows that the call is over and she may pull down the cords. Thus all the established circuits are broken and the call is ended.

5. The Universal Cord Circuit

The universal cord circuit is a cord circuit designed to connect common battery and magneto lines. It also provides some supervision of the magneto line with ordinary switchboard lamps. In short haul toll areas containing both magneto and common battery systems, or in local systems where both magneto and common battery telephones are employed, the universal cord circuit is most important.

Figure 10 is a circuit diagram of a universal cord circuit that employs the repeating-coil inductor voice transmission system. Jacks on a switchboard using this cord circuit are three-conductor jacks corresponding with the cord circuit, and common battery practices. When a two-conductor magneto line is attached to such a jack, its tip and sleeve wires are connected, respectively, to the tip and ring contacts in the jack, leaving the jack sleeve dead. Thus upon insertion of a plug into a magneto line jack, no current flows over the sleeve to relay C, and switches to the battery are maintained in open positions 11 and 33, keeping common battery off the local battery (magneto) line.

In a switchboard system having both common battery and local battery lines, a common battery line subscriber reaches the operator, answers the telephone, or hangs up as usual, with hookswitch control. The operator proceeds with connections under lamp supervision in the established manner. Inside the switchboard when either the calling or answering side of the cord circuit is placed on a common battery line, battery-feed and supervisory signals are controlled by relays C and A, or B and D, through contacts 13 and 35, 15 and 21.

The magneto subscriber also reaches the operator, answers, or rings off in the usual manner. However, the operator in extending a call to a magneto line receives no answer supervision, so she must stay on the line until she hears the party answer. When a call is over, the ring-off current pulse given on a magneto line momentarily operates relay A or B, respectively, closing its contact 24. This enables relay E or F to lock up on its own contact 24 (with ground at the normal contacts of the "talk" key) and close 22. Meanwhile, contact 21 has been released and with 22 closed, the supervisory lamp lights, giving the operator disconnect supervision.

6. Multiple Switchboards

Multiple switchboards were first introduced, with moderate success in magneto exchanges; but, it was not until common battery switchboards became the standard that multiple switchboards came into their own. Refinements in the size of jacks, plugs, and line lamps made it possible for one operator, with a complete multiple within her reach, to handle as many as 10,500 lines. This eliminated the need for much intra-office trunking, and enabled even distribution of calls among operators.

Figure 11 is an illustration of a four-position multiple switchboard. Each operator's position is designated 1, 2, 3, 4, etc., while switchboard positions are designated A, B, C, in multiple groups of three. With the addition of extra multiple jacks at the end positions, each operator has a complete multiple within her reach and can complete any local call coming into the office. As traffic within the office increases, more multiple switchboard positions can easily be added.

The circuitry of this switchboard is basically that of the one-position common battery switchboard already described, except that each line jack and lamp is multipled to every third multiple switchboard position. When a subscriber picks up his telephone, all line lamps associated with his multiple jacks light. Any idle operator, then, can handle his call.

The main difficulty of this system when first introduced was that an operator could no longer see if the called line was busy. But, a busy test associated with the third line, or sleeve, of the called party's jack was soon developed. The operator opened her talking-listening key, and tapped the tip of the plug against the sleeve of the jack of the called line. If the line was busy, current was flowing through

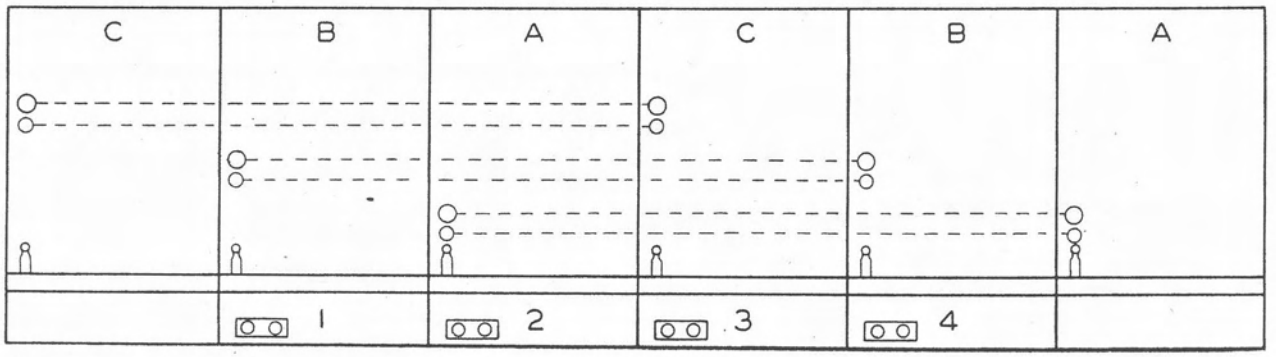

Figure 11. Schematic of 4-Position Multiple Switchboard

this sleeve contact. The operator then heard a click when the plug tip hit the jack sleeve. The click notified her that the line was busy without an intrusion into the conversation in progress. This test has since been termed the tip busy test.

7. A-B Manual Switchboard

When several offices were set up in an area, it was more efficient to handle all incoming calls through one siwtchboard and all outgoing calls through another. This was the basic principle behind the A-B manual switching system. All incoming calls were made through an A-board operator who connncted the calling party to a B-board operator. The B-board operator then connected him to the called party's line.

Figure 12 is an illustration of an A-board with trunks to a B-board within the office and to a B-board in another office. When the calling subscriber picks up his telephone, the A-board operator answers. After the party gives her the number called, she connects him by trunks to either the B-board operator within the office for a local call or the B-board operator in an outside office for an extended area call. The A-operator then relays the number to the B-operator who connects him to the desired party.

7.1 The A-board. The A-board is similar in construction to the common battery board previously described. The incoming line jacks and line lamps terminate on the lower portion of the vertical face of the switchboard, while the outgoing trunk jacks terminate on the upper portion. (The exact placement depends upon the individual office.) The horizontal shelf consists of approximately 15-20 cord circuits (two plugs) the associated supervisory lamps and talking-listening keys (the only keys provided at this board). Since the A-B switchboard system was installed in larger offices, the A-board was also of the multiple-type with as many operator positions as necessary to handle the traffic.

7.2 The B-board. The B-board is quite different from the A-board in construction, though it, too, may be of the multiple-type, traffic warranting. The vertical face of the B-board contains only the outgoing line jacks

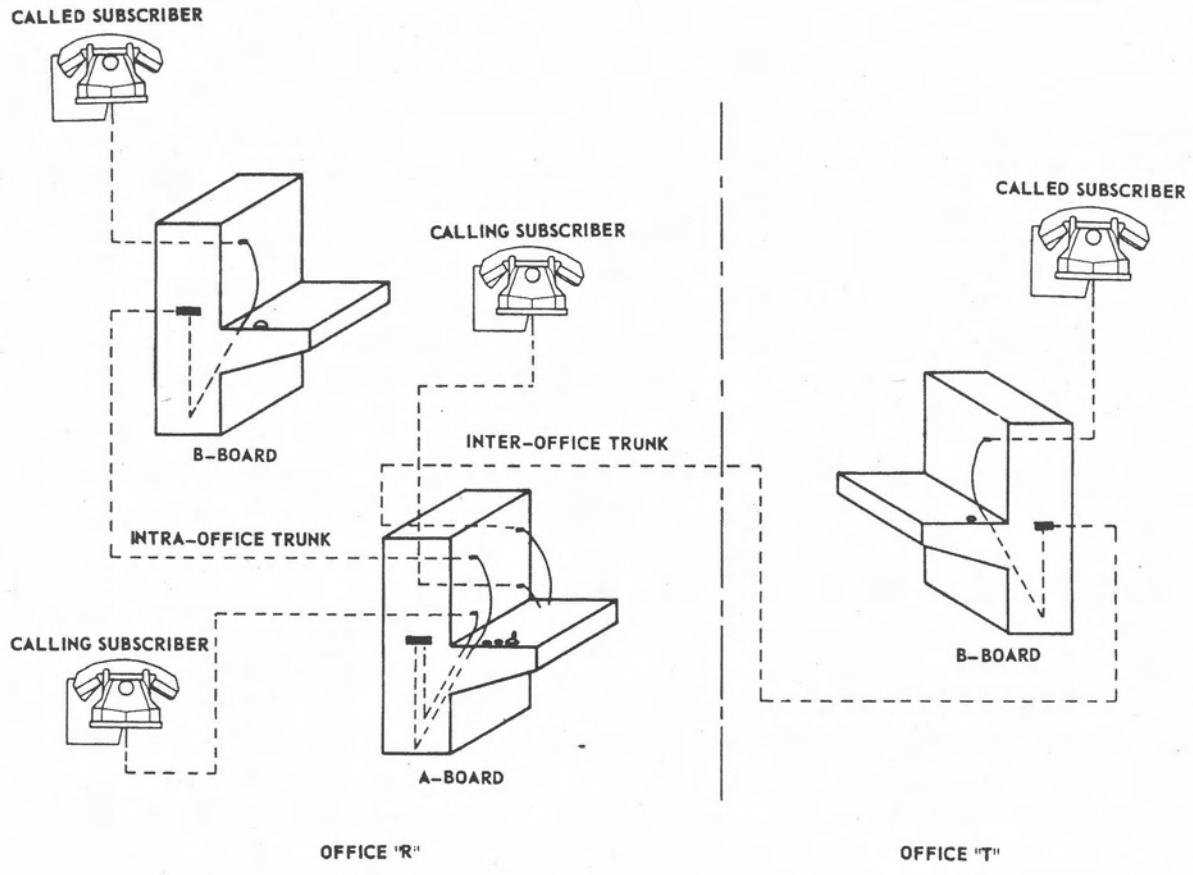

Figure 12. Schematic of A-B Switchboard Connections

to each subscriber with a set of busy-back jack at the bottom, into which the operator can insert the calling plug to automatically send back a busy tone when the called line is is use.

The horizontal shelf of the B-board contains 48 to 50 single-plug cord circuits with one supervisory lamp per circuit and in most cases, no keys. Only one plug is necessary for a cord circuit, as the trunk line from the A-operator is automatically connected to an idle cord circuit and to the B-operator's headset. This automatic connection plus the inclusion, generally, of an automatic ringing feature eliminates the need for any keys at the B-board.

The single supervisory lamp serves several purposes. A flashing supervisory lamp indicates that the B-operator's headset has been automatically connected to the cord circuit and associated trunk line from an A-operator position. A steadily lit supervisory lamp indicates that a call is waiting to be connected to the B-operator's headset if she is already handling another call. A lit supervisory lamp with the corresponding plug in a subscriber jack indicates to the operator that the call has been completed and she is to take down the connection.

7.3 Completion of a call through A-B switchboards. When a calling subscriber lifts his receiver to place a call, his multiple line lamps on the A-board light. An A-operator inserts the back plug of a pair into the corresponding line jack appearing at her position, throws the associated key into the talking-listening position, and asks, "Number, please?" The A-operator can tell by the number given in which office, local or outside, the called party is located. She, then, must relay the number to the proper B-board operator. She can do this in two ways: by the call circuit method or by the straightforward trunk method.

In the call circuit method, the A-operator depresses the call circuit button located at the end of the horizontal face of the switchboard, and connects her headset through this call circuit to the B-board operator at the office in which the called subscriber is located. She repeats the number to the B-operator over this circuit, without the calling subscriber's hearing it. The B-operator, then directs the A-operator to an idle trunk into which she can insert the calling plug (front plug) and the B-operator completes the call from there.

In the straightforward trunk method the A-operator makes the tip busy test on the trunks to the B-board of the called office. When she finds an idle trunk to the B-board, she inserts the calling plug into the trunk jack. A "beep" tone will notify her that the B-operator's headset has been automatically connected to the trunk circuit, and that she may repeat the number to the B-operator. In this way, the subscriber can hear the number repeated, and make corrections, if necessary. This method is somewhat more efficient than the call circuit method, and is more commonly used.

When the B-operator receives the number, she makes a busy test on the called subscriber's outgoing line jack. If the line is busy, she inserts the plug into a busy-back jack which automatically sends busy tone to the calling subscriber and causes the supervisory lamp at the A-board to flash. If the called line is idle, the B-operator inserts the plug into the jack of the called subscriber lighting his supervisory lamp at the A-board. Ringing current is automatically sent out on the called line and ring-back tone is generally provided for the calling party.

If the called party does not answer (or if the called line is busy), the calling party's supervisory lamp will light when he replaces the receiver. The A-operator will then take down the connection. Taking down the connection at the A-board causes the supervisory lamp at the B-board to light, thus notifying the B-board operator to take down the connection. If the called party ansers, his supervisory lamp at the A-board goes out, and the two parties are free to converse.

When the parties terminate their conversion and replace their receivers, the supervisory lamps at the A-board light. This notifies the A-operator to take down the connection. When this is done, the B-board operator's supervisory lamp lights, notifying her to take down the connection. The call is now completed with respect to both switchboards.

Note that the B-operator has no direct disconnect supervision from either of the conversing parties but receives this disconnect supervision from the A-operator alone. Neither does the B-operator have any means of cutting back in on a line once a connection has been made.

8. AUXILIARY MANUAL SWITCHBOARDS

In any telephone system, whether automatic or manual, a certain amount of specialized manual equipment is necessary to handle such services as toll calls (long distance), information, repair, etc. Though the objective of the telephone industry today is a nation-wide dialing system, manual position must still be installed to handle reverse charge and person-to-person toll calls; and until this conversion to nation-wide dialing is complete, board that will extend calls from and to automatic exchanges and manual exchanges must be provided.

The scope of this bulletin will not allow a complete discussion of each type of auxiliary manual switchboard, but it is essential that the telephone man have at least a nodding acquaintance with the most important types and their chief functions.

8.1 Toll boards in a manual office. Toll boards in a manual office are adaptations of the B-board described in the preceding section, the major differences being that a visual busy signal is usually provided for outgoing trunk lines, and there are no subscriber lines terminating on the toll board. Toll calls are extended from the A-operator to the toll operator who receives the necessary information from the subscriber and records the call. She then extends the call to the distant station. If the distant station is manual, she will extend the call over a trunk to that office and repeat the necessary information to the incoming toll operator who will complete the call from there. If the distant office is automatic, the toll operator may extend the call as for a manual office, or, if her position is equipped with a dial, she may send dial pulses over the trunk line and, through the automatic switches at the distant office, connect directly to the called subscriber.

The toll operator also completes calls from a distant manual or automatic station. If the station is manual, she will answer the call over an incoming trunk line and receive the necessary information from the distant toll operator. In a small office, the toll operator's switchboard may be so placed that she has access to the outgoing subscriber lines on local boards, but, in most cases, she will relay the number over a call circuit to the B-operator who will extend the call to the subscriber. The toll operator may receive a call from an automatic office in two ways. The method described for extending a call from a manual office may be used, or, if her board is equipped with a call indicator panel, the distant toll operator can dial over a trunk to her position. The dialed number of the called subscriber will appear on the call indicator panel, and the toll operator is then able to relay the number to the B-operator for completion of the call.

8.2 Toll boards in automatic exchanges. The primary function of the toll board in an automatic exchange is to receive and record toll calls from subscribers in the automatic exchange and its tributaries and to extend these calls to subscribers in distant towns and cities. The toll board is also used to extend incoming calls from subscribers in distant towns and cities to subscribers in the automatic exchange and its tributaries and to switch through incoming calls to other toll centers.

Automatic Electric Company manufactures two types of toll boards for automatic exchanges, cord and cordless. The latter is somewhat more efficient, but the former is more generally used in all but the largest installations. Maintenance of the cord type is simpler and initial cost lower, but both have exactly the same function.

8.2.1 Cord type toll board. The cord type toll board is provided in multiples of 2-position, 5-panel sections, and may be classed as universal or segregated. The term, "segregated," describes those installations in which the various classes of toll services (CLR, Inward & Through, and TX) are divided among the several positions. The Inward & Through position operator handles calls from distant toll centers, which are to be completed locally or extended to other toll centers. The chief function of the CLR (Combined Line & Recording) operator is to record and extend outgoing calls from local subscribers to the subscribers in distant toll centers. The TX (Delayed Call) operator's function is to handle those calls which cannot be immediately completed at the CLR position.

In most recent practice, though, the TX position is done away with (but many remain in older offices) and delayed calls are handled by two other methods. If the called station does not answer, the CLR operator herself will hold the call for a short time, making one or two more attempts to complete the call. If the called station still does not answer, the calling subscriber is asked to place the call again at a future time. When the called party is unavailable on a person-to-person call, the CLR operator will leave her operator number, the name of the calling office, and the number of the calling party with someone at the called station. When the called party becomes available, he will call the long distance operator at her office, and she will connect him, by either a ring-down trunk through the Inward & Through operator or by dialing a special WH code, to the CLR operator in the originating office. The CLR operator will then ring back the calling party and inform him that the called party is now on the line and conversation may begin. This practice for handling delayed person-to-person calls is known as the WH (we have) method.

The universal or combination toll board handles all classes of service at one position. In general, the segregated type of service is more efficient for larger installations, while the universal type is quite adequate for small or medium size offices.

A. Physical features of cord type toll board. Figure 13 pictures one position and three panels of a 2-position, 5-panel cord type

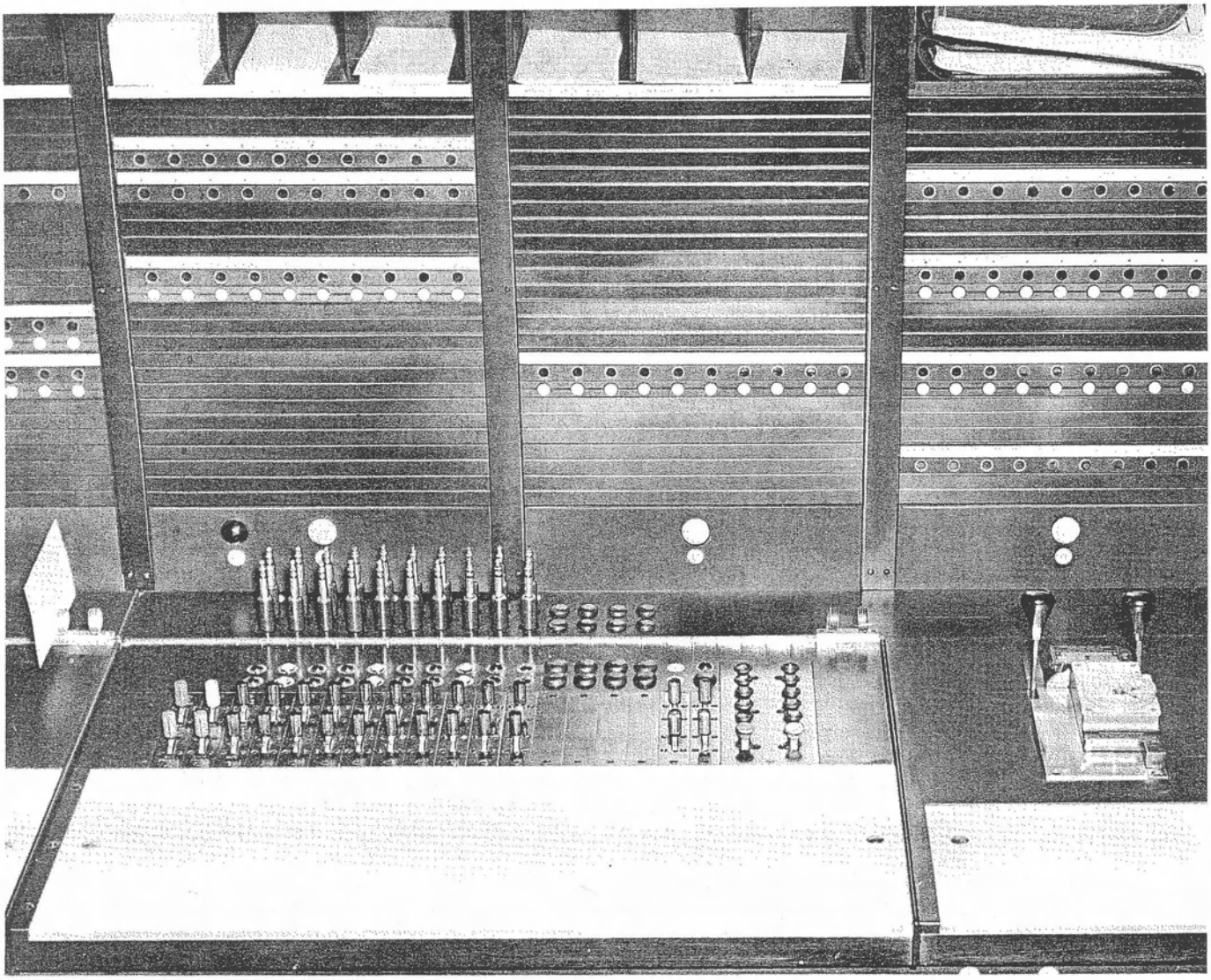

Figure 13. Cord Type Toll Board (with Keysender)

toll board. The second operator's position and remaining jack panels would be to the immediate right, and multiples of the toll board would be located on either or both sides.

The jack panel of a cord type toll board is normally equipped with ten-per-strip jacks and jack lamps, with as many strips as necessary to handle the trunks. The jack lamps indicate busy and idle trunks, though exactly how this is done varies from one type of switchboard to another. The Automatic Electric type 30 toll board is so arranged that the jack lamps will light beneath busy trunks, idle trunks being indicated by dark lamps. The type 31 switchboard is arranged for "idle line indicating." Only the lamp beneath the next idle trunk within a group will light, indicating to the operator that this is the trunk to be used on a call to a particular office. This switchboard is also arranged for the usual "tip busy test" if the visual signal is omitted in small circuit groups or during light-load periods. Space may also be provided above the jack panel for ticket compartments or directory files.

The keyshelf is equipped for an ultimate number of 10 to 15 cord circuits, with 2 supervisory lamps and 2 keys per cord circuit. Ten cord circuits are provided on TX and CLR positions; twin ticket pockets are located between each two cord circuits in the cord circuit key positions for separation of toll tick- etc. Inward & Through positions are equipped with 14 or 15 cord circuits, depending upon the switchboard type, with only one or two ticket holders provided, as very few toll tickets are made at this position.

The cord circuits and supervisory lamps serve the same purpose as those of other manual boards, but the keys perform slightly different functions. Pushing the

back key rings over the back plug to the calling party, while pulling this key forward rings out on the trunk line. Pushing the front key allows the operator to talk to and hear both parties on the line, while pulling this key permits her to monitor a conversation without being able to interrupt. An additional key, a double-throw cut-off rear and cut-off front, is also provided at the left of the keyshelf which, when operated with any talk key, will allow the operator to talk to either the calling party or the called party without the other's hearing. If the particular board is to handle toll calls from paystations, keys are provided at the left for the collection and return of coins.

The left section of each keyshelf is arranged for keysenders. If a dial is used instead of the key set, it is mounted on the key set blank. A dial release key is then provided to release the toll switches when a mistake in dialing is made. Key sets, which are now preferred to dials, consist of 10 digit keys (lettered and numbered), a red DISC (disconnect) button to control the release and seizure of senders, an ERROR key to release the toll switches when an error is made, and a pilot lamp, which glows steadily when the key set is ready for keying. The operator dials over the toll trunk, with either a dial or keysender, by operating the talk key only. When she wishes to dial over the back plug, she operates a "dial rear" key located next to the key set or key set blank and proceeds as for dialing forward.

To dial with a key set, the operator presses down the digit keys in the order they appear in the called number. When she completes the keying, she presses the DISC button. The keysender then automatically sends out the dial pulses over the toll trunk, and the pilot lamp flashes telling the operator that she must not attempt to key another call. When the pulses have all been sent, the pilot lamp restores to the steadily lit condition.

Each operator's position is equipped with sufficient space for the writing of toll tickets, and between the two positions of each section, some time recording device, usually a Calculograph, is provided which records on the toll ticket the time elasped during a call.

B. Completion of a toll call on a cord type toll board. In an automatic exchange, a subscriber wishing to place a toll call accesses the toll board most generally by dialing a code number such as "110" or "211." (In small offices, the general operator position "0" may be used.) The lamp jack will light beneath the incoming trunk seized by the subscriber, and any idle operator (a CLR operator in a segregated office) may answer by inserting the back plug of a cord circuit pair into the associated trunk jack. The operator receives from the subscriber and records on a toll ticket the information necessary for extending the call. Then the operator, leaving her talk key operated, inserts the front plug of the pair into a jack corresponding to an idle trunk (indicated by one of the methods described) to the office of the called subscriber. This busies the trunk line to other operators and prepares the switches at the distant office for the following dial pulses. Next the operator dials--with either a dial or key sender--the number of the called subscriber.

In older toll boards using dials, a busy line is indicated by an audible busy signal, and the operator must continue monitoring the call to ascertain the condition of the line. In the newer types, though, a flash busy is made available, and the dialing of the first number automatically disconnects the operator's headset from the circuit and frees her for other calls. In any board using a keysender, a flash-busy signal is provided, and the operator may remove her headset from the circuit as soon as she has pressed the DISC button. When the called line is idle, automatic ringing is generally sent out to the subscriber through the switches at the distant office, though some offices require that the operator momentarily operate the ring forward key to start the automatic ringing. Through the supervisory lamps, the operator has the same answer and disconnect supervision of other manual boards, and disconnects the parties in the usual way.

If it is necessary for the toll operator to go through an intermediate toll center to complete a call, she does this over a ring-down trunk. The toll operator inserts the front plug into the jack of an idle ring-down trunk to the intermediate office and momentarily operates the ring forward key. This connects the operator to an Inward & Through position at the intermediate toll center, and she may then give the name of the office to which she wishes to be connected. When the connection has been established, she may dial into the distant office and complete the call in the usual manner.

8.2.2 Cordless type toll boards. The cordless type toll board is outstanding for its efficiency and ease of operation. It performs the same

functions as the cord type board, but without the use of conventional plugs and jacks for connections, eliminating much operator fatigue. The switchboards are provided in multiples of 2 or 4 position sections, and may be equipped to handle all classes of service; that is, CLR, TX, Inward & Through, or Universal.

A. Physical features of the cordless type toll board. The keyshelf is similar to the keyshelf of the cord type board with the cords removed and an extra set of keys and lamps added to control the functions of the link circuits which replace the cord circuits. Each operator's position is equipped with a variable number of link circuits and associated keys, depending upon the traffic through the position. From the back of the keyshelf to the front, each link circuit position consists of a link busy lamp, a rear supervisory lamp, a front supervisory lamp, a link release key, a double-throw ring forward or ring back key (omitted when automatic ringing is provided), and a double-throw talk or monitor key. Each position is also equipped with auxiliary common keys which operate with any link that is being used. The double-throw cut-off rear or cut-off front key is provided along with the dial rear key, keys for collection and return of coins (if the position handles calls from paystations), a double-throw release rear or release front key for releasing only one side of a connection, and a delay key, which, when operated, prevents further calls from being connected to the operator's headset if she wishes to complete delayed calls.

   A key set is provided at the right side of the keyshelf which will access two channels to the pulse senders. This allows the operator to key a second call while the pulses of the first call are being sent out.

   What was the jack panel of the cord type board, now becomes the operator's turret of the cordless type board. The turret is much lower in design and mounted upon it are strips of group identity and group busy lamps with several compartments provided for the filing of toll tickets. A group identity lamp is provided for each group of toll lines, paystation lines, heavy toll users' lines, etc., which lights when the talk key associated with the link to which the line is connected is operated. A group busy lamp will light when all trunks of a group are busy, thus giving advance all-circuits-busy information to the operator.

B. Completion of a toll call on a cordless toll board. To prepare for receiving calls at a cordless toll board, an operator pre-operates the talk key of an idle link. When the subscriber dials the toll operator access code, he is automatically connected to this idle link, and the operator is informed of this by a "zip" tone and the lighting of the link busy and group indicator lamps. She then receives the necessary information for extending the call from the subscriber and records this on a toll ticket. The pre-operation of the talk key preseized a channel to the pulse sender equipment, and she may immediately begin keying the call. She first keys the access code of the trunk to the office of the called party and then continues keying the number of the called party. When keying is completed, she presses the DISC key of the set and the pulses are sent out. If the line is busy the link busy lamp will flash. If the line is idle, the front supervisory lamp will light when the connection has been established, and, in most cases, automatic ringing will be sent out. When the called station answers, the supervisory lamp goes out, and either the operator will ask for the desired party on a person-to-person call or conversation will begin immediately. When the conversation is completed and the parties hang up, the front and back supervisory lamps light, and the operator presses the link release key to end the connection.

8.3 Information desks. The function of the information desk in a telephone exchange is to provide subscribers with local, toll, and intertoll information, toll rates and routes, and intercept service. Information desks in manual offices are again variations of the B-board, which are reached through the A-operator. Files or books are provided for looking up numbers and the positions may or may not be equipped for extending calls, but the latter is more generally true.

The information desks in automatic exchanges are of several types. One of the more common types resembles the cordless toll board quite closely in operation and to some extent in physical features. The most apparent difference is the mounting of the keyshelf equipment in the turret (figure 14). As calls are not usually extended at this board, only one or two line link positions equipped with only one double-throw key, for talking and link release operations, are provided. The group indicator lamps are also mounted on the turret so that class of information (local, toll, intercept, etc.) may be predetermined. Calls are automatically extended to idle operators by dialing an information access code such as "114" or "411," or by having dialed a number which for some reason has been put on intercept service. The board is designed for use with the book-type information file.

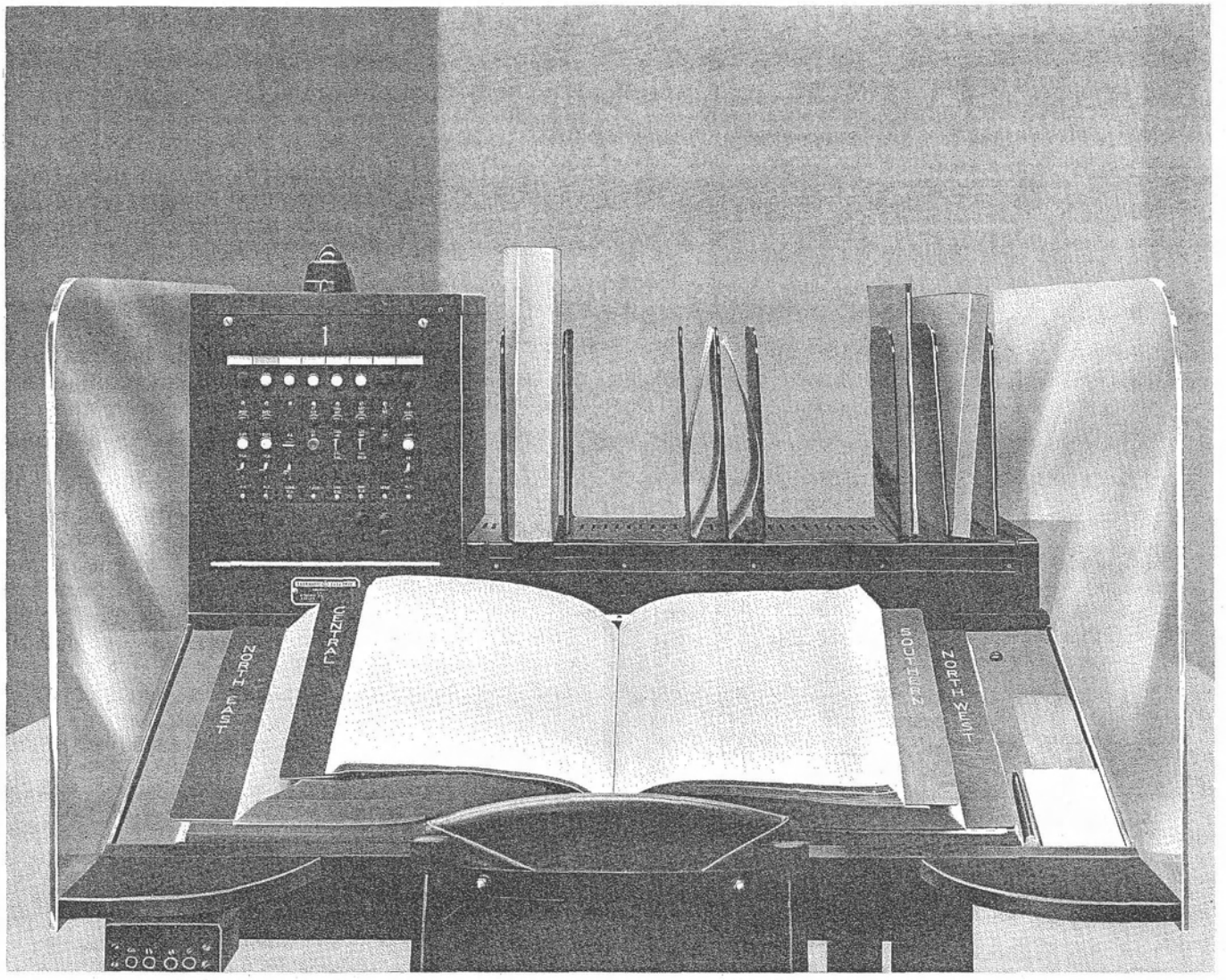

Figure 14. Information Desk

Two other of the commonly used information desks for automatic offices are the low-turret cord type board and the flat-top key desk. Calls are automatically extended to both boards by means of an access code, but the cord type board is used where it is desirable to extend the information and intercept calls from this board by means of conventional plugs and jacks. The flat top desk is designed for answering calls by means of keys and signal lamps, and is used primarily with rotary files. This board cannot be used to extend calls.

8.4 Repair clerk's desk. The repair clerk's desk is primarily designed to accommodate the clerical work necessary in handling repair and complaint calls. It may be of the cord type for a manual office, accessed through the A-operator, or of the cordless key type in an automatic exchange, accessed through a dial code such as "113" or "13." Several link or cord circuits are provided at each repair clerk's position but as calls terminate at this position, no provisions are necessary for extending them. Adequate space for writing is provided, and one or more card compartments are included for filing the record cards used by the repair clerk.

8.5 Test desks. Test desks are of three basic types: local, toll, and combination. The size, equipment, and operation of each type will vary with the line capacity and particular needs of the office in which it is installed, but certain functions are standard.

The local test desk (pictured in figure 15) is designed to test lines and trunks (outside of the plant) on which trouble has been reported and to make routine tests on subscriber lines to discover line trouble before it becomes serious enough to warrant a subscriber complaint. Two meters are generally provided: one for measuring line voltage, resistance, and current, and the other for dial speed and percent make tests. A Wheatstone bridge is usually available for accurately locating cable and open-wire faults. A howler tone may also be impressed from this

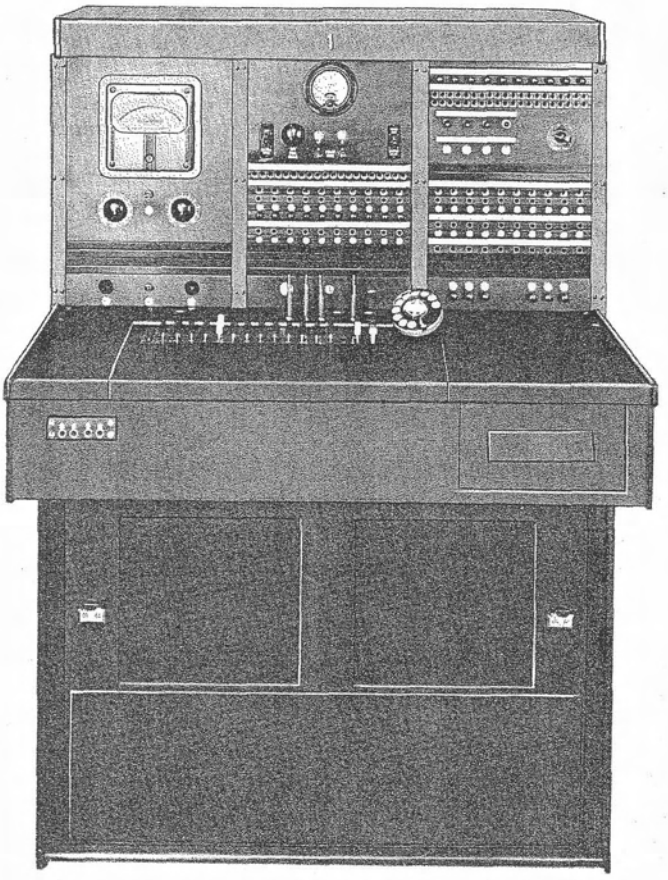

Figure 15. Local Test Desk

test desk on a subscriber line when a phone has been left off the hook for a certain length of time.

The toll test desk's function is to make tests on toll circuits. Toll line testing is, of necessity, more complex than local testing as toll circuits require a better grade of service. Toll lines are also longer and need acutely sensitive meters for measuring voltage, current, resistance, insulation leakage, impedance, and inductance. The location of outside line faults must be more accurately determined with Wheatstone and impedance bridges within the office. Equipment is also provided for testing signaling with 20~, 135~ and 1000~ ringing current for making trouble tests with a voltmeter and 150-volt test battery, and for the sending out of trouble tone.

The combination test desk is exactly what the name implies--a combination of toll and local testing at one desk. It is used primarily in offices where toll testing is essential, but the amount done does not warrant the installation of a separate toll testing desk.

9. THE PRIVATE BRANCH EXCHANGE

It is quite obvious to all in the telephone industry that automation is rapidly replacing manual telephony in all phases where it is practical, and has been doing so for a number of years. One of the last strongholds of manual telephony (and one of the few completely manual boards that a telephone man will come in contact with repeatedly) is the Private Branch Exchange (PBX) switchboard, though this, too, is rapidly giving way to the Private Automatic Exchange (PAX) and the Private Automatic Branch Exchange (PABX).

The PBX board is designed to connect manually all calls within an office building or factory, and, in most cases, to provide manual connections to the nearest public exchange so that telephone calls may be made to and from outside subscribers, both local and long distance. An operator must be in attendance at all times to set up the connections. The PAX is designed to automatically set up connections within an office or factory by dial operation. In this system there is no need for an attendant, but no provision is made for connection to the public exchange. The private exchange which incorporates the outstanding features of both the PBX and PAX is the PABX--a private exchange in which calls to and from the public exchange are extended manually by an attendant, but calls within the

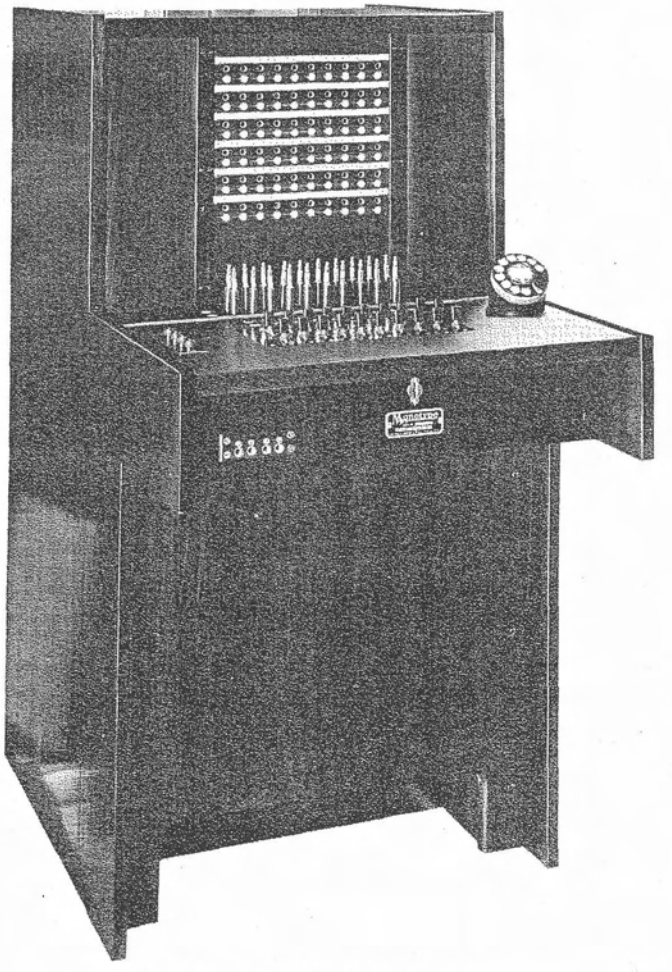

Figure 16. PBX Switchboard

private office are completed automatically by dial operation. (More information on PAX's and PABX's may be obtained by consulting Technical Bulletin 818, Private Automatic Exchanges with PABX Appendix.)

9.1 Physical description of the PBX board. Figure 16 is picture of the keyshelf and face equipment of a typical PBX board. The face equipment consists of ten-per-strip line jacks and line lamps. The lower strip is generally reserved for the jacks of the trunks to the public exchange, while the upper strips are associated with the jacks of the individual telephone lines within the office.

The keyshelf is equipped with a varying number of cord circuits, depending upon the type of PBX and the traffic requirements. Associated with each cord circuit are the front and rear supervisory lamps and two keys for ringing and talking. A dial is provided at the right for dialing into the local public exchange, if it is automatic. The four turn keys at the left are used to set up night connections. These night connections, with certain cord circuits previously established, allow calls to be automatically extended to and from the public exchange without the aid of an attendant. On the left side of the keyshelf front are jacks for plugging in one or two attendant's headsets. A crank, mounted on the right, is supplied on request for use when automatic ringing current fails.

9.2 Attendant's procedure. To complete an interior call, the attendant inserts one plug of a cord circuit pair into the jack of the line demanding service (indicated by a lit line lamp). The rear plug is most generally used in answering, for convenience when extending the call. (Some switchboards provide for only rear plug answering of interior calls.) The attendant then throws the front key forward to the talk position and is given either the name or extension number of the party wanted. She then extends the call to the proper party by inserting the remaining cord circuit plug into the proper jack. If the call was extended on the front plug, the attendant operates a key to the ring forward position momentarily. If the call was extended on the back plug, she operates a key to the ring rear position. (The ring forward and ring rear positions may appear on one key, or be divided, one position on each of two keys.) Normal answer and disconnect supervision is provided by the two supervisory lamps.

To extend a call to the public exchange, the operator answers in the same way, but inserts the remaining cord circuit plug into the jack of a trunk to the public exchange. If the individual telephones are equipped with dials, the party may dial the number himself, or, if not, he will give the number to the operator and she will then dial it. Disconnect supervision only is given by the two supervisory lamps.

To complete a call from the public exchange, the operator inserts a plug of a cord circuit pair into the trunk jack over which the call is coming in (indicated by a lit lamp). (In some switchboards, calls may be extended and received over the front plug of a cord pair only.) The operator opens her talk key, and will give the name of the company, etc. Often the calling party will not know the extension number of the called party and in some cases, he will be able to give only the general nature of the call. The operator must then assist him in reaching the proper party. When the name or extension number of the desired party is ascertained, she will insert the remaining cord circuit plug into the proper jack, and continue as for an interior call.

9.3 Cord circuit of an interior PBX call. The circuit in figure 17 is a modification of a standard PBX board cord circuit designed only to show the general operation of a cord circuit on a call between two parties within the PBX installation. Cord circuits will vary in different types of PBX boards as each is designed to perform under specific conditions. In no case is the reader to take this as a complete PBX cord circuit.

When the attendant answers a call originated at one of the telephones terminated at the PBX board, the STA (rear) plug is inserted into the corresponding line jack operating cut-off springs on the line jack which extinguish the line lamp. Relays A and C operate over a circuit from battery through the primary winding of the A relay, out over the ring side of the plug to the calling telephone, back over the tip side to ground on the secondary winding of the A relay. Relay C disconnects the STA (rear) supervisory lamp from direct ground on the sleeve of the plug. The TRK & STA (front) supervisory lamp lights over a circuit from ground on the plug sleeve through the contacts of relay B to battery. Relay A supplies transmission battery to the calling line.

When the operator throws the talk key into position, a transmission circuit is completed from her headset over the R lead out the ring side of the plug to the calling telephone, back over the tip side and out the T lead to her headset (heavy lines). When she receives the necessary information, she inserts the TRK & STA plug into the proper line jack which again disconnects the line lamp by operation of cut-off springs. Direct ground is connected to the sleeve of the line jack so that relay D will not operate at this time.

The attendant now restores the talk key and pulls it to the ring TRK & STA position. Relay F operates over a circuit from battery at relay F through the springs of the ring key operated to ground on the sleeve of the STA (rear) plug. Contacts 4 and 5 of relay F close, operating relay E over a circuit from battery at relay E, through contacts of the ring key operated, through contacts 4 and 5 of relay F operated and out to ground on the sleeve of the STA plug. Relay E disconnects the STA plug from the TRK & STA plug. Ringing current is supplied to the called line from the ring supply lead, through the contacts of the ring key operated, through contacts 10 and 11 of E operated, out the ring side of the line to the bell of the called telephone, back over the tip side, through contacts 2 and 3 of E operated, through contacts of the ring key operated to the ring supply G lead. Restoring the ring key restores the E and F relays and prepares the circuit for talking.

When the called party lifts his receiver, relay B operates and opens contacts 1 and 2 extinguishing the TRK & STA lamp. A complete talking circuit is established to the telephones over the tip of the STA plug to the tip of the TRK & STA plug out to the called telephone, and back over the ring side of the TRK & STA plug to the ring side of the STA plug to the calling telephone (heavy lines).

When the calling party hangs up, relay C restores, closing contacts 1 and 2 causing the STA (rear) supervisory lamp to light. When the called party hangs up, relay B restores, closing its 1 and 2 contacts lighting the TRK & STA supervisory lamp. When the operator takes down the connection both lamps are extinguished.

Revision March 1958

Printed in U.S.A. by Brookes & Sons Company 2000 4-58

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