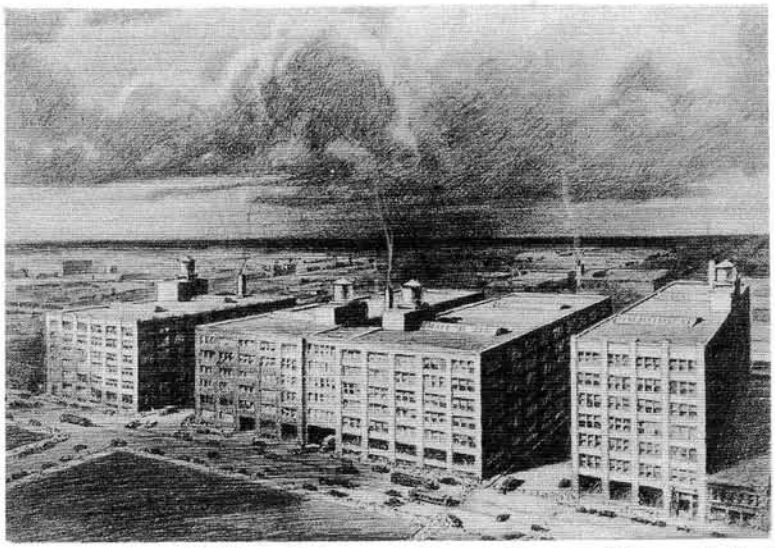
Manual Switchboards

BULLETIN 820

AUTOMATIC ELECTRIC

MAKERS OF TELEPHONE, SIGNALING AND COMMUNICATION APPARATUS
ELECTRICAL ENGINEERS, DESIGNERS AND CONSULTANTS

1033 W. Van Buren St., Chicago, U. S. A.



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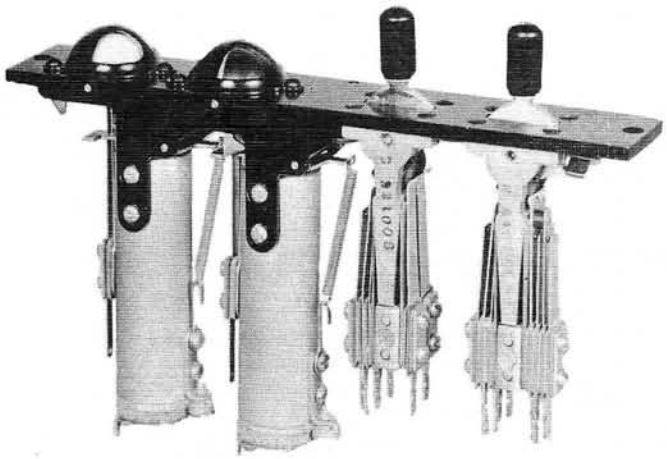
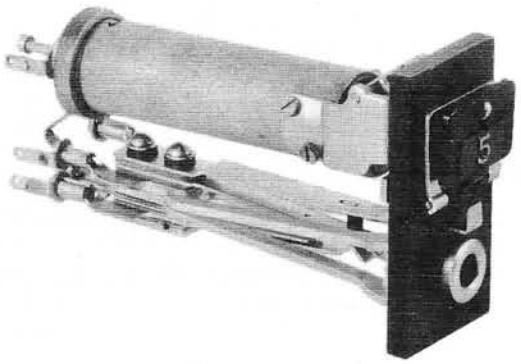


PLATE A. THE KEYS AND VISUAL INDICATORS ASSOCIATED WITH A MAGNETO CORD CIRCUIT



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MANUAL SWITCHBOARDS

1. INTRODUCTION

Although the trend is toward automatic switching, manual equipment is still so common and the interconnection between automatic and manual so frequent, that some knowledge of the fundamental principles of manual operation is imperative.

Manual equipment may be separated into two broad classes; namely, common battery and local battery. The latter system, commonly known as magneto, is the older and hence will be described first.

2. MAGNETO EXCHANGES

This type of equipment is particularly applicable to rural districts where the subscribers' stations are not concentrated in large groups. Such localities require exchanges comprising the simplest and most inexpensive equipment. The simplicity of design, the ease of operation and maintenance, and the low first cost of magneto exchange equipment have caused its wide adoption in such districts. For economic reasons, however, the manual magneto exchange is being supplanted by small automatic and semi-automatic exchanges which decrease the operating costs and improve the service. (See Fig. 1.)

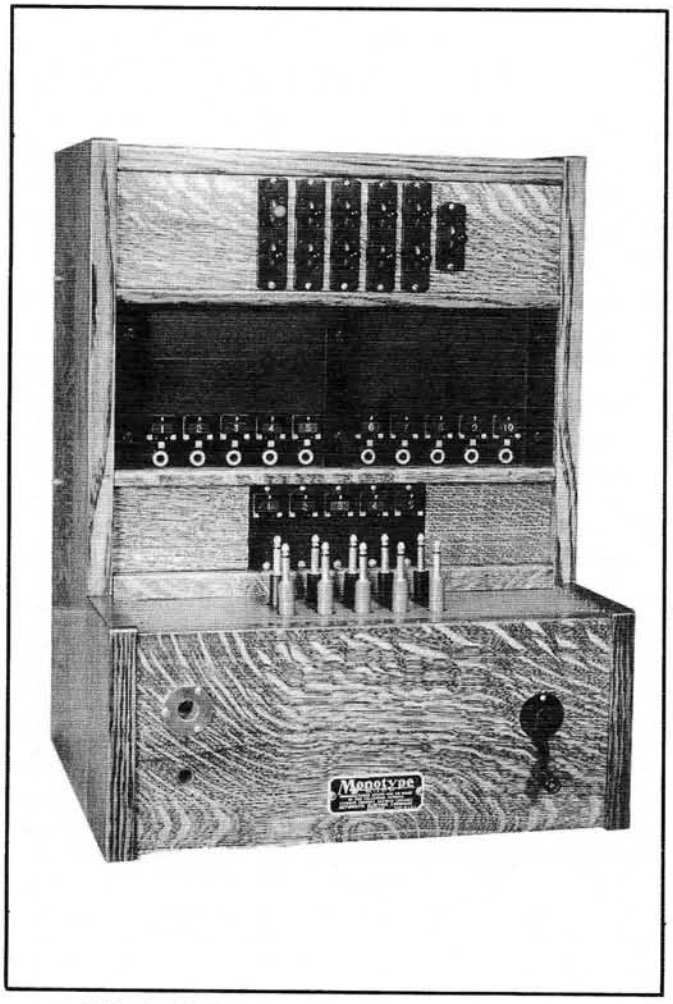

FIG. 1 A SMALL MAGNETO SWITCHBOARD

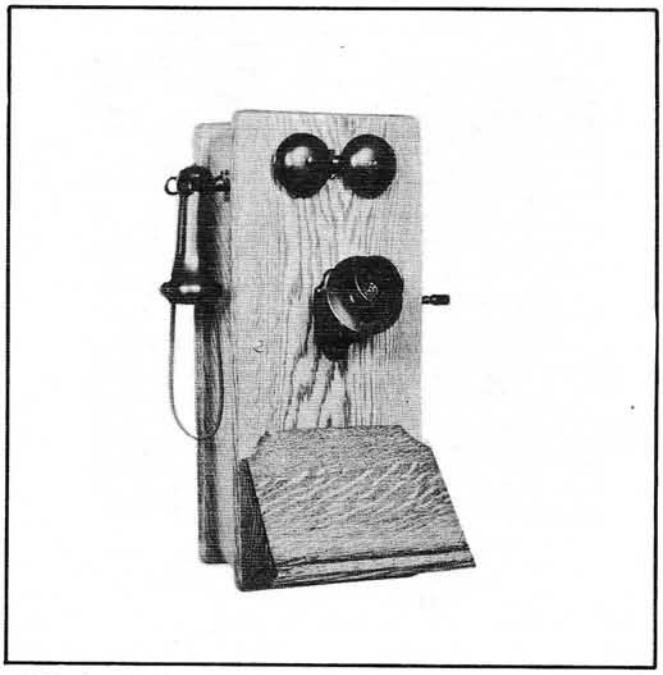

FIG. 2 FAMILIAR TYPE OF MAGNETO TELEPHONE

Rural lines are usually quite long and are generally party lines. There are reasonable limits to the number of subscribers that may be connected to one line, ten being usually considered the ultimate, though this number is sometimes exceeded.

Much of the early telephone development, in rural districts, was due to the adaptability of the magneto exchange. As a local battery system, it could be operated successfully on grounded lines, thus reducing the necessary capital out-lay from that required on a full metallic line (two wires). It has, however, been the general policy for many years to replace grounded lines with full metallic circuits due to the freedom from noise of the latter. The subscriber's station and the switchboard are, with the exception of the ground connections, the same in either case.

2.1 Magneto Exchange Equipment

Each subscriber's station furnished with a magneto exchange provides its own transmission battery current

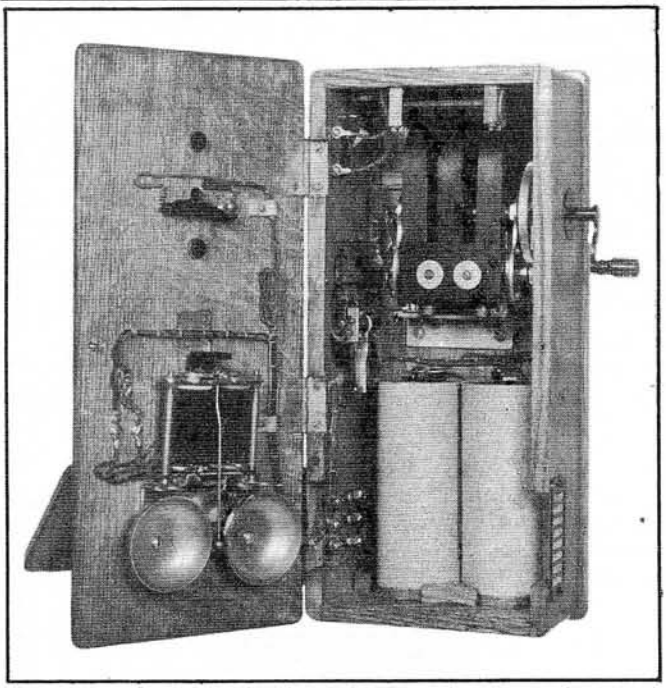

FIG. 3 INTERIOR OF A MAGNETO TELEPHONE

as well as the ringing current with which to signal the operator. The subscriber's station consists of the following equipment: (See Fig. 3.)

(a) A transmitter.
(b) A receiver.
(c) A ringer.
(d) An induction coil to connect the local talking circuit to the line.
(e) A set of dry cells to furnish transmission current.
(f) A hand generator to enable the calling person to signal the operator.

The switchboard consists only of the equipment necessary to actually connect the lines of two subscribers together and such signalling equipment as is necessary to bring the operator's attention to a call that is being placed and, in turn, to enable the operator to signal the called person.

The major units of the switchboard equipment are:

(a) The drops; one of these is associated with each line as a signal and consists of a hinged piece of metal held in a vertical position by a catch. When a subscriber turns his generator, the catch is momentarily released; the drop falls forward to mark the line and closes an audible signal circuit. The drop is restored when the operator answers the call. (See Fig. 1 and Plate B).

(b) The jacks; all the lines are terminated on jacks which are mounted directly below the associated drops. (See Fig. 1 and Plate B.)

(c) The cords; in a magneto switchboard, each cord consists of two insulated wires terminating in a plug. One wire is connected to the tip of the plug

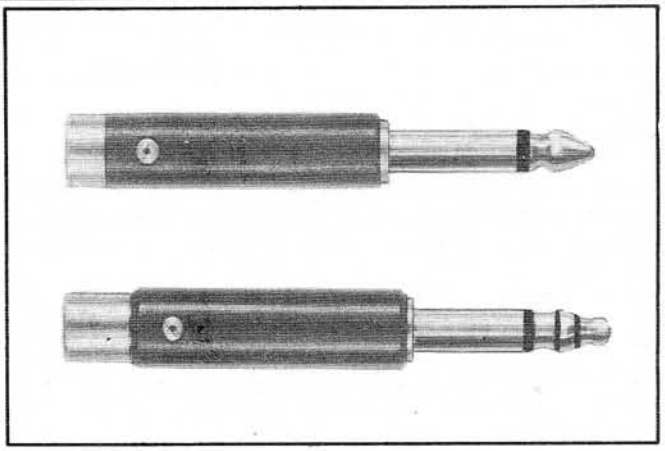

FIG. 4 A TWO-CONDUCTOR PLUG;
A THREE-CONDUCTOR PLUG

and is, therefore, termed the "tip;" the other is connected to the ring of the plug and is termed the "ring." An answering cord and its associated calling cord comprise the connecting link between the calling and called telephone lines. (See Fig. 4.)

(d) The keys; these are hand operated switches which enable the operator to perform the several functions necessary to complete a connection. Each key may have several contacts (both break and made) which are opened or closed in one operation. (See Fig. 1 and Plate A.)

(e) Clear-out (visual) signals; in order that either the called or the calling party may resignal the operator after a call has been plugged up, some type of visual signal on magneto switchboards must be available. This signal may be a drop like that in Plate B but without the jack below. Such a drop is shown in association with each cord on the switchboard in Fig. 1. With a single drop, operator cannot tell which of the two parties on a conversation has rung off. In Fig. 1, the keys associated with each cord circuit are located above the jack panel.

If however, it is desired that the operator know whether the called party or the calling party is the one which has rung off, the modern-type key and visual indicator unit, shown in Plate A, is used. This gives double supervision. When the party associated with the front cord plug and the front key "rings off," the front signal shutter will turn white. When the operator operates the associated key to the "TALK" position inorder to challenge the line, the indicators are restored mechanically.

These clear-out indicators are equipped with hemispherical shutters, half black and half white, placed under dust covers having transparent windows. Normally the black portion of the signal is seen through these windows, but in response to ringing-off current from either or both parties' telephones, the appropriate signal or signals operate and display the white shutter surfaces, which stand out in bold contrast to the black of the surrounding keyshelf.

2.2 Description of Circuits and Operations

Fig. 5 shows a complete circuit of a call within a magneto exchange. The connection is set up in the following manner:

The calling person should first determine whether the line is busy or idle. If the line is idle, the receiver is replaced.

The calling person now turns the crank on the hand generator to signal the operator. This generator or rather magneto, as it is called, is shown in Fig. 3 and is an integral part of the telephone. Turning the crank causes the generation of an alternating current at fifty to ninety volts. This current flows through the normal contact of the hook-switch and over the line. Although the bells of other subscribers on the line will ring, the subscribers will not answer unless their code has been rung. The generator current also flows through the winding of a line drop coil mounted behind the operator's switchboard. When the coil is, thus, energized, an armature associated with the drop catch is attracted to the core releasing the metal drop which falls forward by gravity and closes alarm contacts. The drop rests in a horizontal position against a retaining spring.

Having signalled the operator, the calling party will remove his receiver from the switch and wait for the operator to answer. Removal of the subscriber's receiver or handset will automatically connect the local battery (dry cells) shown in Fig. 5 into the transmitter circuit.

The operator, noticing the fallen drop, plugs the answering cord into the jack mounted directly below the drop. The action of plugging-in breaks the circuit to the drop winding and, by means of a mechanical arrangement, causes the drop to restore. The subscriber's talking loop will now be completed through the answering cord, contacts of the ring-back key, and through the "clear-out" drop. The clear-out drops may be of the type shown in Fig. 4 and Plate A or, for single supervision, that in Fig. 1.

Immediately after plugging in the answering cord, the operator, by operating the talk key, connects her telephone set to the side of the cord circuit, opposite the subscriber's loop. She will then ask the calling person what number is desired and, upon receiving this information, will plug the calling cord into the proper jack and then operate the ringing key, which will cause the bells of the called subscriber's telephone to ring. Since she receives no answer supervision on a magneto board, the operator must listen in from time to time to see if the connection has been established. When the called person answers and the connection is completed, the operator restores the talk key, removing her telephone from the circuit.

When the receivers are replaced, after the conversation is completed, it is necessary for at least one of the subscribers to turn the hand generator in order

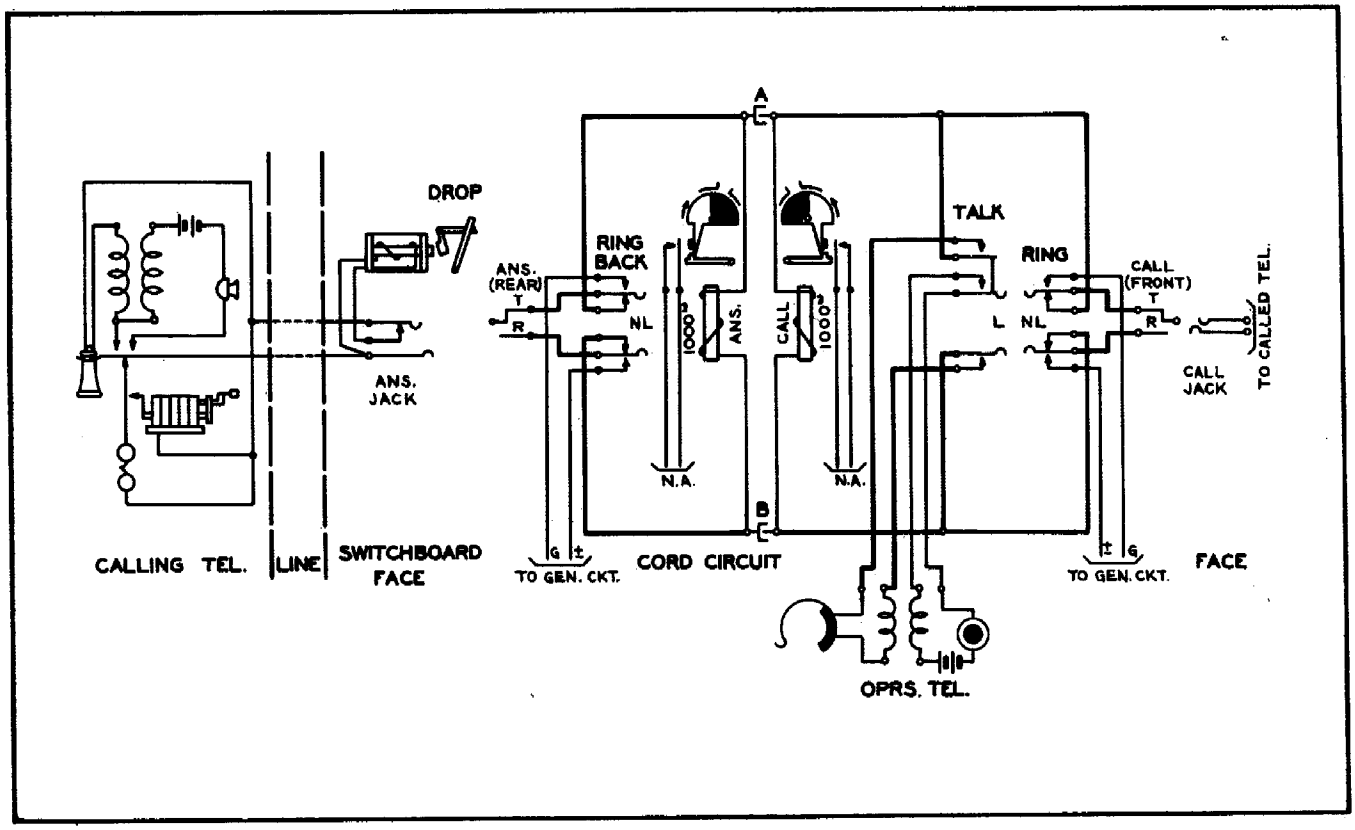

FIG. 5 CIRCUIT OF A CALL WITHIN A MAGNETO EXCHANGE

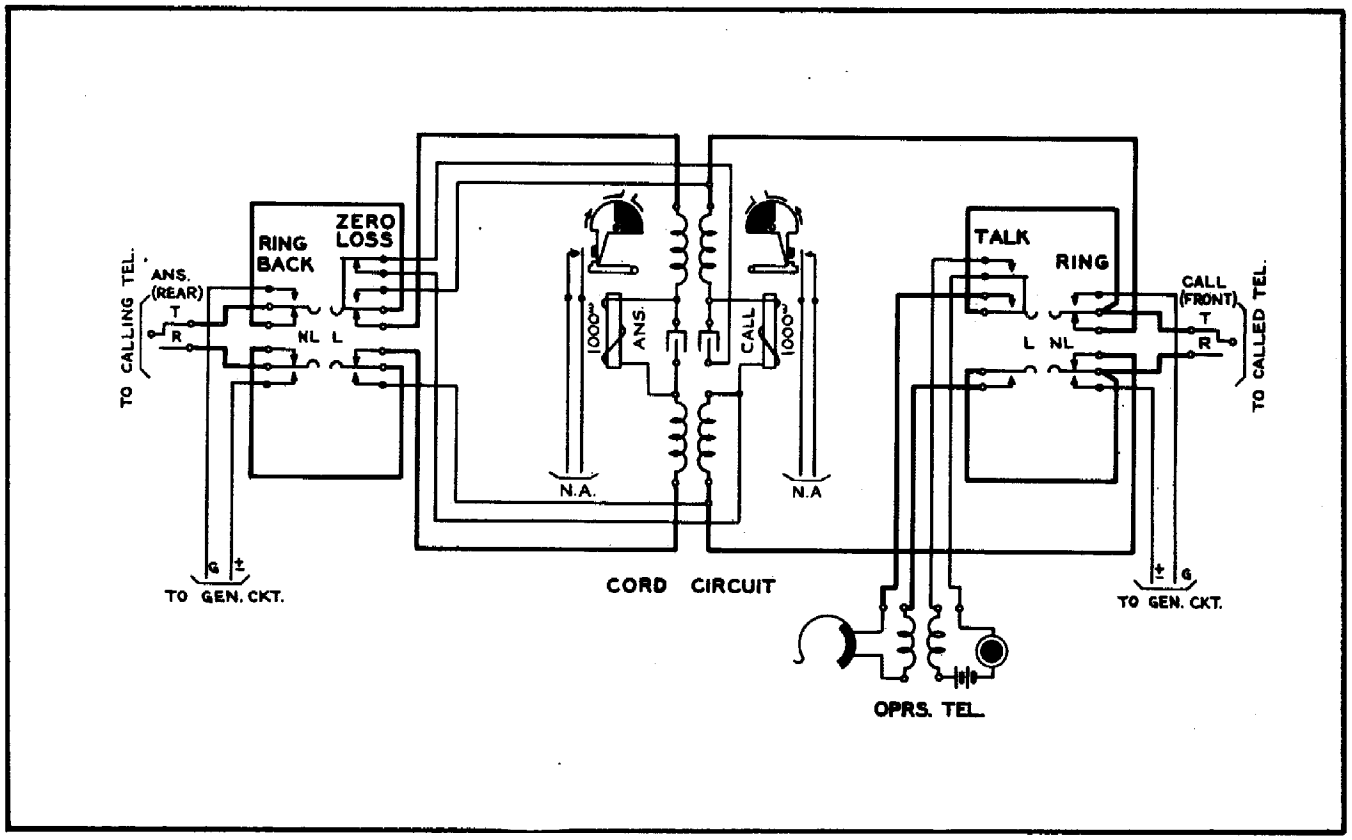

FIG. 6 MAGNETO CORD CIRCUIT WITH REPEATING COIL

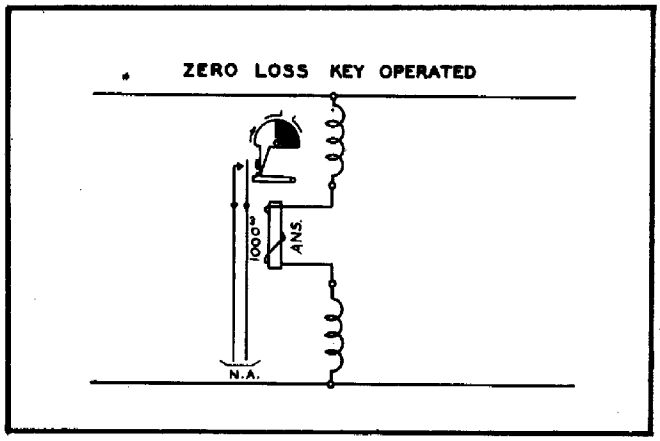

FIG. 7 ZERO LOSS KEY OPERATED

to "ring-off" the connection. The alternating current thus placed on the line will cause the operation of one of the clear-out signals, giving the operator disconnect supervision.

Before removing the plugs, the operator will operate her listening key and challenge the line in case either of the parties desires further service.

2.3 Zero Loss Key

The cord circuit shown in Fig. 6 employs a repeating coil to couple the calling circuit to the called. This arrangement has certain advantages over the simple A and B condenser arrangement of Fig. 5. However, there are times when it is desired to eliminate the transmission losses introduced by the repeating coil. For this reason, a "zero loss" key is provided.

This feature is to enable trunks to be tied directly together on a toll-to-toll connection. The operation of this key merely switches half the repeating coil out of the circuit, thus eliminating some of the losses which would otherwise occur. This feature is usually present on only two out of fifteen cords. See Fig. 7.

It is possible to connect lines directly together only when they are of the same characteristics. Lines of different characteristics, such as grounded and metallic, must be tied together through a repeating coil in order that the two lines may be effectively balanced. As toll lines are generally metallic, no difficulty is encountered on direct connection of a through toll call.

This latter cord circuit may be used on a magneto P.B.X. board. If it is so used, the zero loss key might be employed to set up a night connection, enabling the central office operator to ring the extension telephone directly and vice versa.

3. COMMON BATTERY EXCHANGES

The common battery exchange has certain advantages over the magneto exchange, in that it allows the use of a simpler subscriber's instrument and also makes possible the centralization of the transmission battery supply and the source of signalling current. The

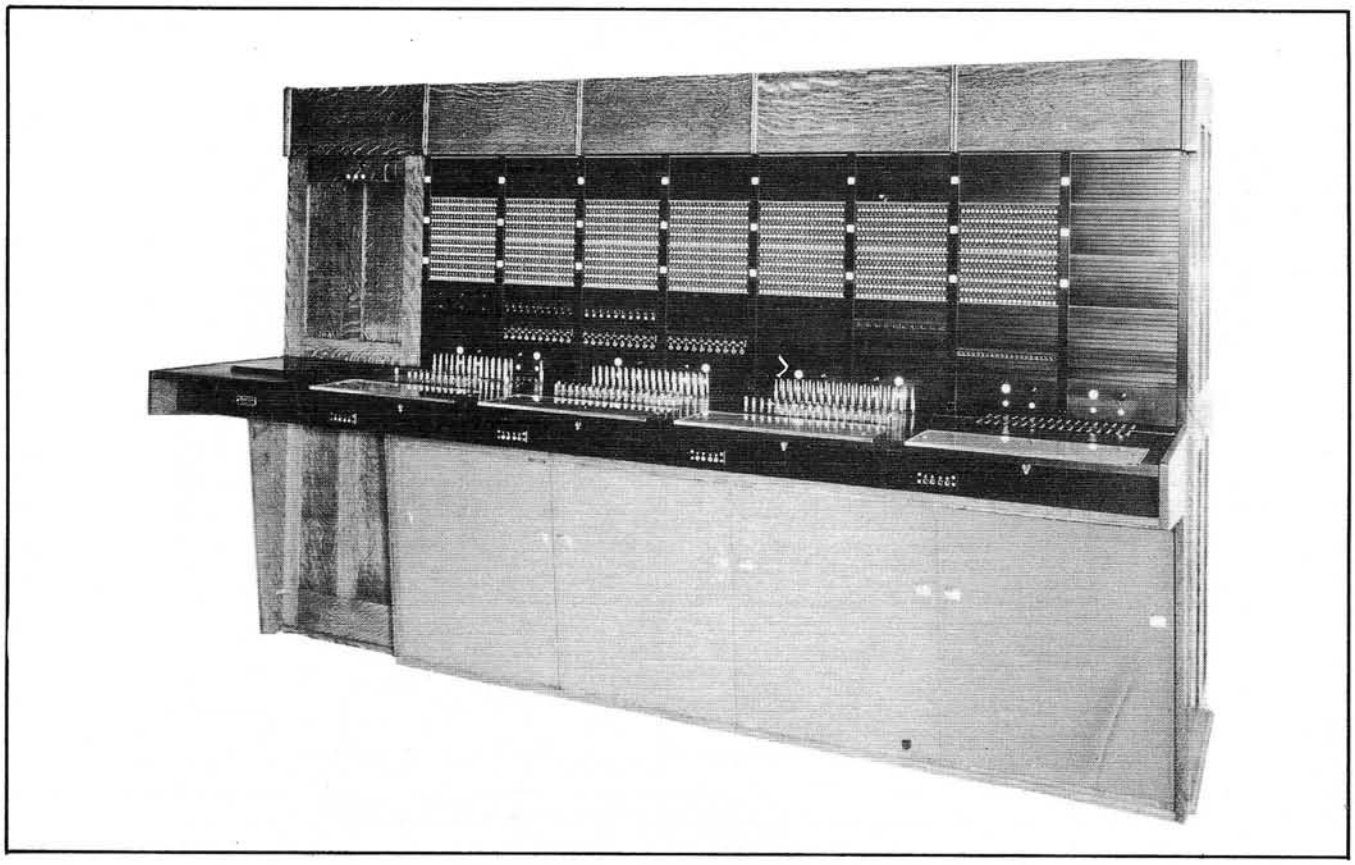

FIG. 8 FOUR POSITION SWITCHBOARD

common battery system delivers a higher grade of service than the magneto but necessarily entails out-side lines of less loop resistance and less line leakage. Also, the central-office switchboard is more complex.

The larger the manual exchange, the more the advantages of the common battery system are apparent. For many rural regions, the magneto exchange has proved the most economical, but for any congested district, the common battery system is far superior. (See Fig. 8.)

3.1 Common Battery Exchange Equipment

The subscriber's station equipment consists of a transmitter, receiver, ringer, a condenser, and usually an induction coil. The arrangement of these parts may be such as to conform with any one of several telephone circuits. It is not necessary to furnish a hand generator, for the removal of the handset from the cradle completes a circuit to the central-office switchboard and the common battery, which will signal the operator.

The lines terminate at the switchboard on jacks, as on a magneto board. Instead of the drops, however, the line equipment consists of two relays which control a line-signal lamp. One is the line relay which is normally connected to the line and which operates when a handset is removed from the cradle. The other is the cut-off relay which operates at the time the operator plugs the answering cord into the associated jack. An exception to this type of line circuit is the "Direct-Lamp-Type," Sub-Section 3.5.

The answering and connecting cords of a common battery switchboard are three-wire conductors. The two wires used for the transmission are called the "tip" (positive) and the "ring" (negative). The third wire in each cord is termed the "sleeve" and is not used for transmission of voice currents, but only for supervision and control. This wire operates the line cut-off relay and the supervisory signal lamps. (See Fig. 13.)

The common battery switchboard, in addition to being the means of connecting one subscriber's line to another, furnishes the battery current for the conversation and the alternating current for ringing the called telephone. Although the common battery voltage varies with different installations, it is generally twenty-four volts.

3.2 Operation of a Simple Cord Circuit

Fig. 13 shows a diagram of a connection between two telephones within a common battery manual exchange.

The calling person removes the handset from the cradle, completing a circuit from (+) battery through break contact "3" of the cut-off relay CO, over the

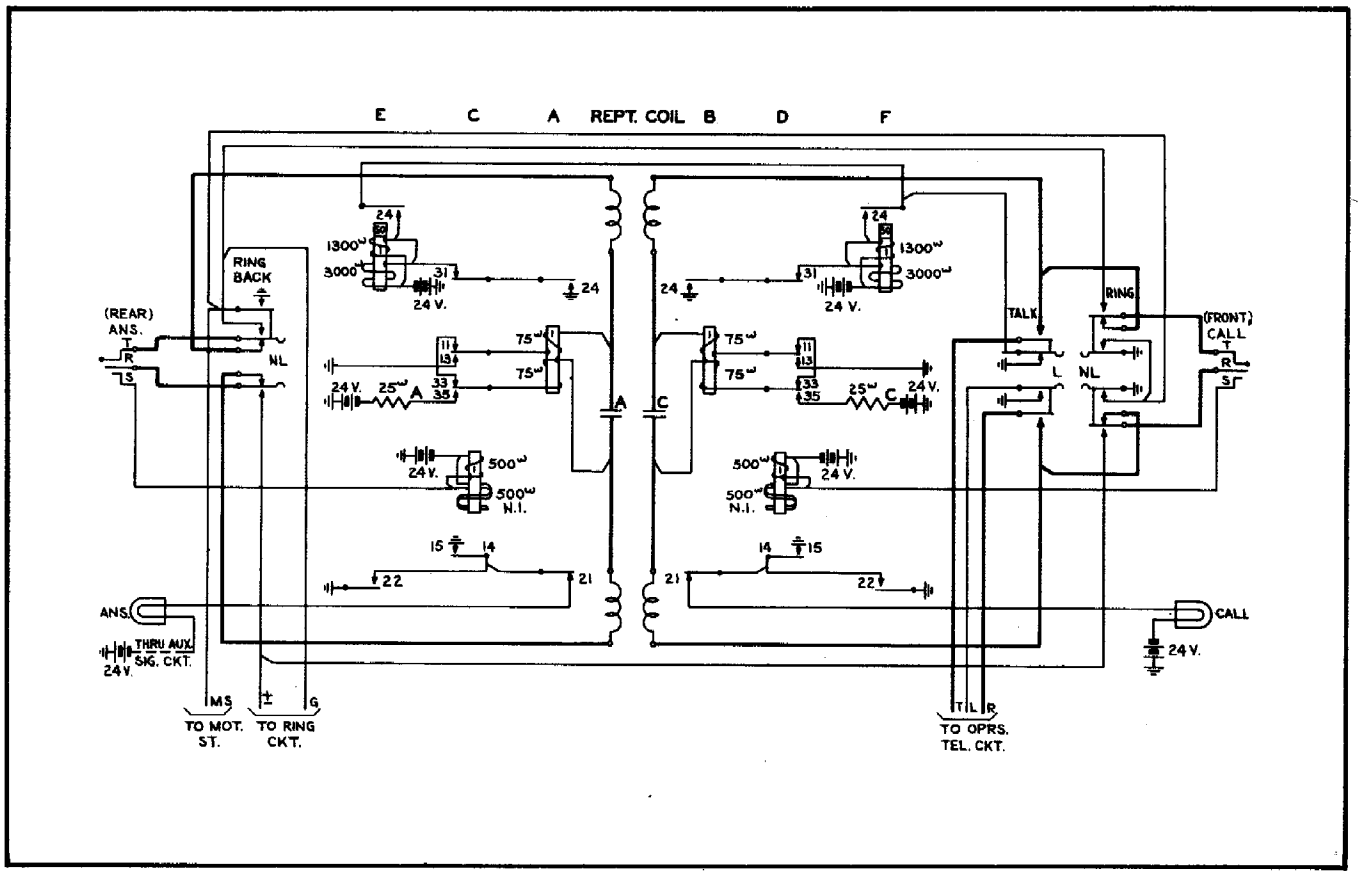

FIG. 9 THE UNIVERSAL CORD CIRCUIT

"T" line, through the telephone, over the "R" line, break contact "4" of the cut-off relay CO, and through the winding of the line relay "L" to (-) battery. The line relay "L" operates, causing the line lamp to glow, notifying the operator that a call is being originated.

The operator, noticing this signal, plugs the answering cord into the designated jack and operates the "talk" key. The answering cord completes a circuit through the sleeve S, from (-) battery, winding of relay "C", through the sleeve contact, winding of the cut-off relay CO to (+) battery. Both relays operate in series. Relay CO breaks the circuit to the line relay "L" which releases and extinguishes the line signal lamp. Relay "C" prepares the circuit to the supervisory lamp No. 1 at 22, but the circuit is held open by relay A at 21. "A" remains operated until the calling party replaces his handset. This action causes the supervisory lamp to light. The supervisory lamps No. 1 and No. 2, which are associated with each pair of cords, are mounted on the key shelf.

The operation of the talk key places the operator's telephone across the call side of the cord circuit. The operator is now in a position to ask the calling person which number is desired. Upon receiving the number, the operator plunges the connecting plug into the jack associated with the called telephone line. The cut-off relay of the called line and relay "D" of the cord circuit operate in series, clearing the line of bridges and connecting the "T" and "R" lines through to the windings of relay "B". The circuit to supervisory lamp No. 2 is completed at relay "D" over contact 25, causing it to glow until the called party answers.

The operator next throws the ringing key, thus placing the ringing current directly upon the called line. When the called subscriber answers, a circuit is completed through the line loop and the windings of relay B. (This circuit is completed only after the ringing key has been returned to normal.) Relay B operating breaks the circuit to supervisory lamp No. 2 at 21, thus notifying the operator that the call has been answered.

The transmission current is supplied to the two lines through relays A and B. These two direct current circuits are separated by means of condensers C1 and C2 through which the voice currents flow.

Replacement of the handset by either subscriber will cause the battery-feed relay, A or B, connected to that line to release and operate the supervisory lamp. When both subscribers have released, both lamps will glow, thus notifying the operator that the call has been completed and that she may remove the cords from the jacks. Note that in this circuit calls may proceed in only one direction. No provision has been made for ringing through the "Answer" plug.

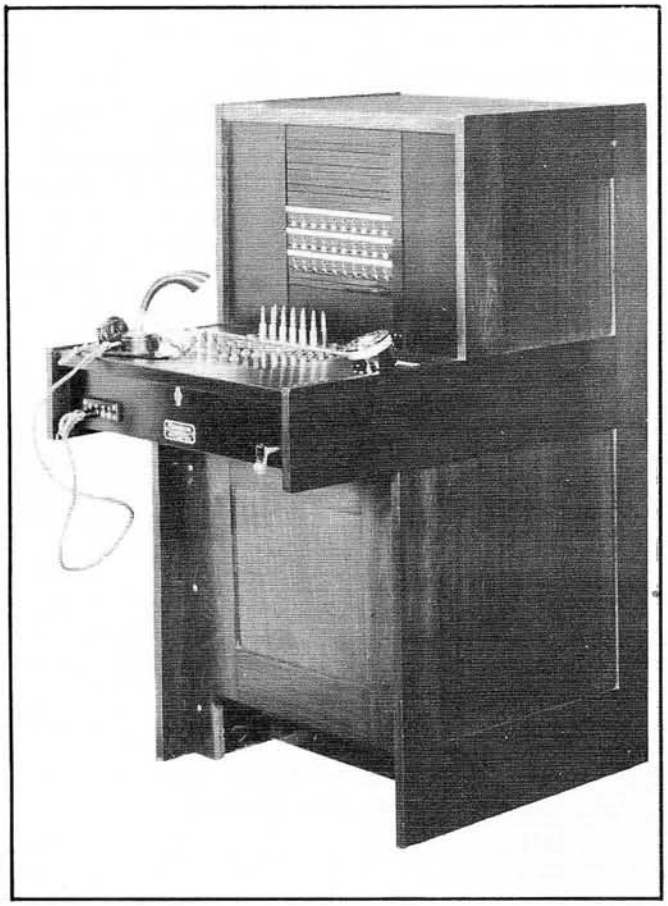

FIG. 10 P-B-X SWITCHBOARD

3.3 The Universal Cord Circuit

The "universal" cord circuit shown in figure 9 may be used on either magneto or common battery lines. In addition, the arrangement of this circuit is such that either answering or connecting cords may be used to connect or to answer. That is, the call may proceed either way through such a cord circuit, and the operator is not required to answer a call with the answering cord and vice versa. This enables her to transfer the cords from one call to another without regard to the order of connection.

In cases where both magneto and common-battery lines terminate on the same switchboard (Fig. 8), this type of cord circuit may also be used. In such a case, the subscriber rings-down his line drop by turning his hand generator as in Section 2.2. The operator plugs in the cord, completing a connection to the cord circuit through the tip and ring contacts. The sleeve "S" will now encounter no potential with the result that relay "C" will not operate.

When the person on the magneto line replaces his receiver, he will give the hand generator a few turns--the ring-off signal. This pulse of current will momentarily operate relay "A". Since "C" is not operated on magneto calls, ground at contact 24 of relay "A" is placed momentarily on relay "E". "E" operates and locks-up on its contact 24 which is grounded at the normal contacts of the "talk" key. "E" holds ground on contact 22 (lower left) whose circuit to the supervisory lamp is closed when "A" falls back at the end of the magneto impulse. The operator is, thus, given ring-off supervision by the same lamps as are used for supervising common battery calls. In the calling position of the cord, relays "B" and "F" operate in an exactly similar manner. Relay "E" on the answer side and "F" on the call side are, thus, lock-up relays for magneto lines.

3.4 Private Branch Exchanges

When a manual switchboard is used for private interior communication as, for example, in a factory or office building, it is called a private branch exchange (P-B-X). An operator must be in attendance at all times to set up connections between the telephones located in the various offices and at other locations. Such a telephone exchange usually has a connection to the nearest public exchange so that telephone calls may be made to and from subscribers in the surrounding community.

In recent years, automatic switching equipment has largely taken the place of the isolated P-B-X. Such an automatic exchange is called a P-A-X; i.e., a private automatic exchange. When such an exchange is connected to the adjacent public exchange, it is called a P-A-B-X; i.e., a private automatic branch exchange. It is truly a branch of the public exchange, but since outside public subscribers usually have no way of knowing the P-A-B-X extension numbers and often do not know even the name of the party to whom they wish to speak, an operator is necessary to answer all incoming calls. This operator usually has a manual switchboard, attendant's type, in front of her. Thus, manual switchboards have a number of applications which they serve very well.

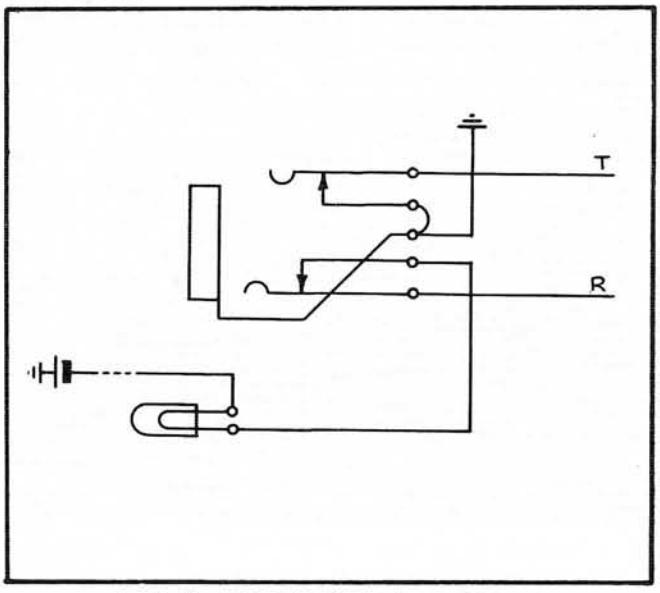

FIG. 11 DIRECT-LAMP LINE CIRCUIT

3.5 Direct-Lamp-Type Line Circuit

Sometimes, the line circuit does not have the line and cut-off relays "A" and "B". Fig. 11 shows the line circuit of a P.B.X. private branch exchange switchboard. No such relays are necessary, because the lines are generally short and will not prevent the operation of the signal lamp. The lamp circuit is broken mechanically by the insertion of the plug.

3.6 Busy Test

The operator on a single position common battery board can see if any given line is busy by noting whether there is already a plug inserted in the line jack. On a multiple board of several positions where each operator has a complete multiple of lines before her, an operator has no way of knowing whether the line is engaged unless a busy test is made.

The "natural busy test" requires that the operator throw her talk key and touch the tip of her plug to the sleeve of the called jack. A click will warn her if the line is busy. In order to receive this tone, a double wound coil with its center point grounded must be across the TR leads of the OPRS. TEL. CKT.

When a line is free, its associated jack sleeves are grounded through the CO (Cut-Off) relay winding. If, however, an operator has plugged into a jack, battery from her cord circuit will be placed on the jack sleeve. When a second operator touches the tip of her plug to the jack sleeve of a multiple appearance of the line, battery will pass over the tip of the call plug through the operated talk key and through the center tapped coil to ground giving the operator a "click" indicating a busy condition.

The "relay busy test" circuit provides another method which usually obviates the necessity of operating the talk key at each busy test. Battery, received on the plug tip when testing a busy line jack, passes over the back contact of a relay in the cord circuit (usually the sleeve relay) to the tertiary winding of the operator's head set.

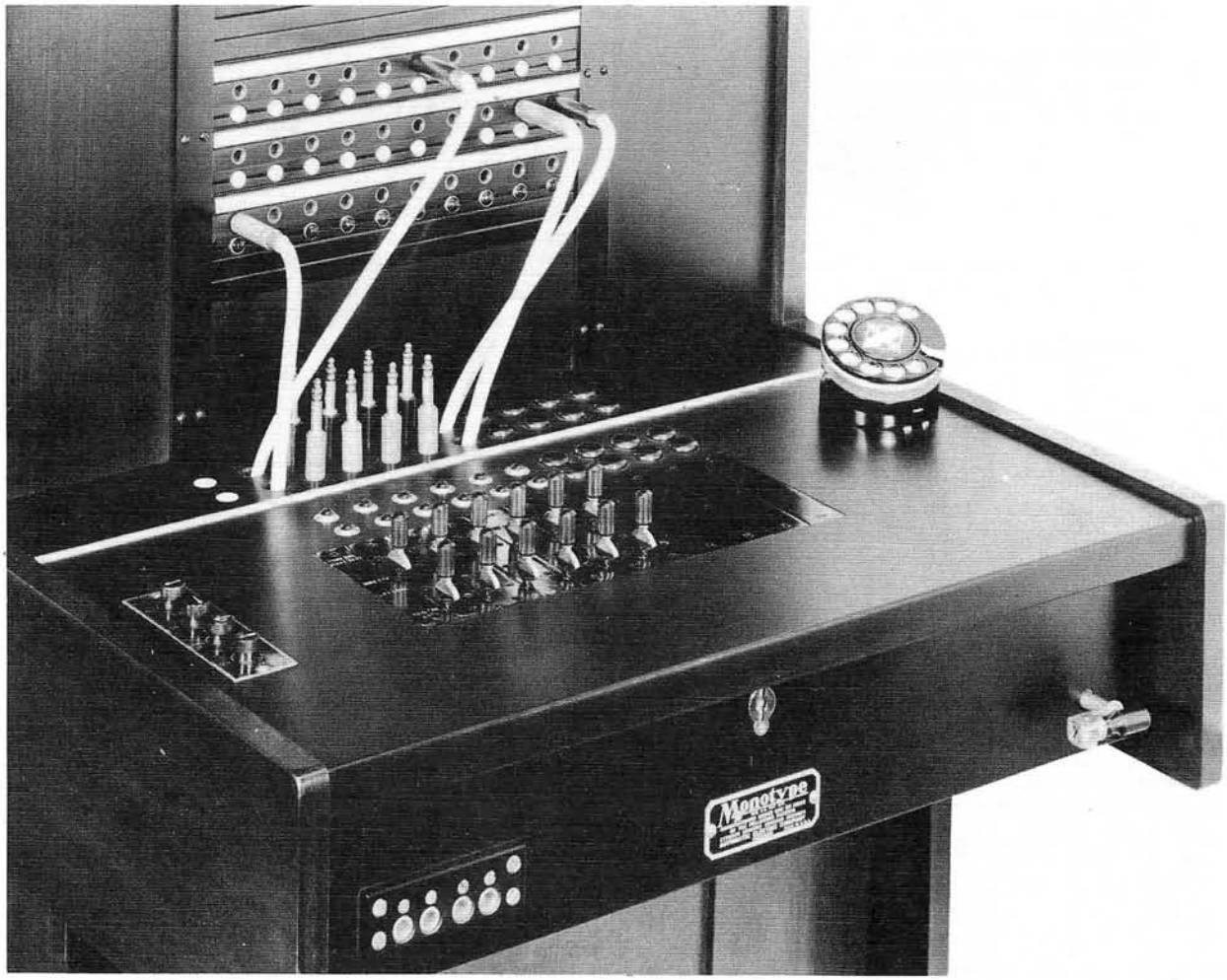

FIG. 12 KEYSHELF AND FACE EQUIPMENT OF A PRIVATE BRANCH EXCHANGE

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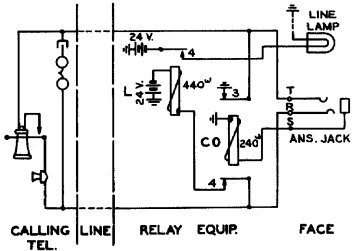

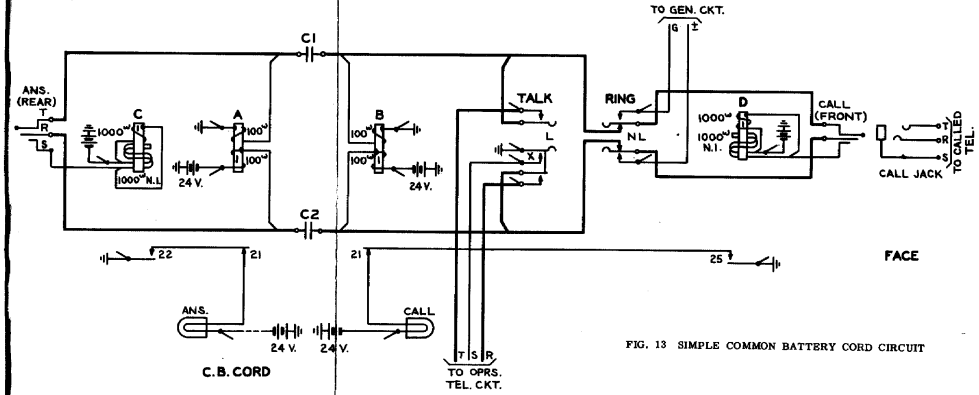

FIG. 13 SIMPLE COMMON BATTERY CORD CIRCUIT

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