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MONOCORD SWITCHBOARDS OF UNITS

TYPE EE-2 AND TYPE EE-2-A

AND

MONOCORD SWITCHBOARD OPERATOR'S SET

TYPE EE-64

Wire Communication Pamphlet No. 2
(Second Edition)

PREPARED IN THE OFFICE OF THE
CHIEF SIGNAL OFFICER

August, 1921



WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

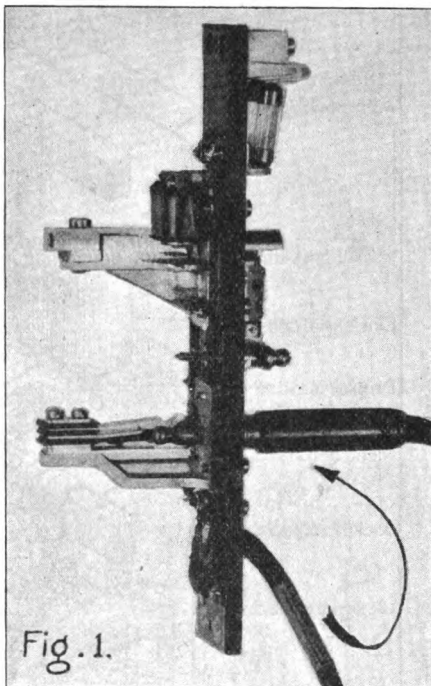
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(5)

MONOCORD SWITCHBOARDS.

1. Telephone intercommunication between Army units is frequently such that a temporary, quickly installed and flexible type of small central exchange is essential. The switchboard which has been designed to meet this requirement is called the monocord switchboard. Monocord switchboards are made up to accommodate 4, 8, and 12 lines. They are small, light, and readily portable. Two of these switchboards may be installed at one exchange in such a way as to make one switchboard if it is necessary to accommodate more lines than handled by one board. Monocord switchboards are made up of units, there being a unit for each line. These units are easily removable, and if defective can be replaced by another unit without disturbing the rest of the switchboard. There are two types of monocord units, which are described below. Type EE-2-A units will not be issued until the stock of Type EE-2 units is exhausted. A type EE-2 unit is shown in fig. 1.

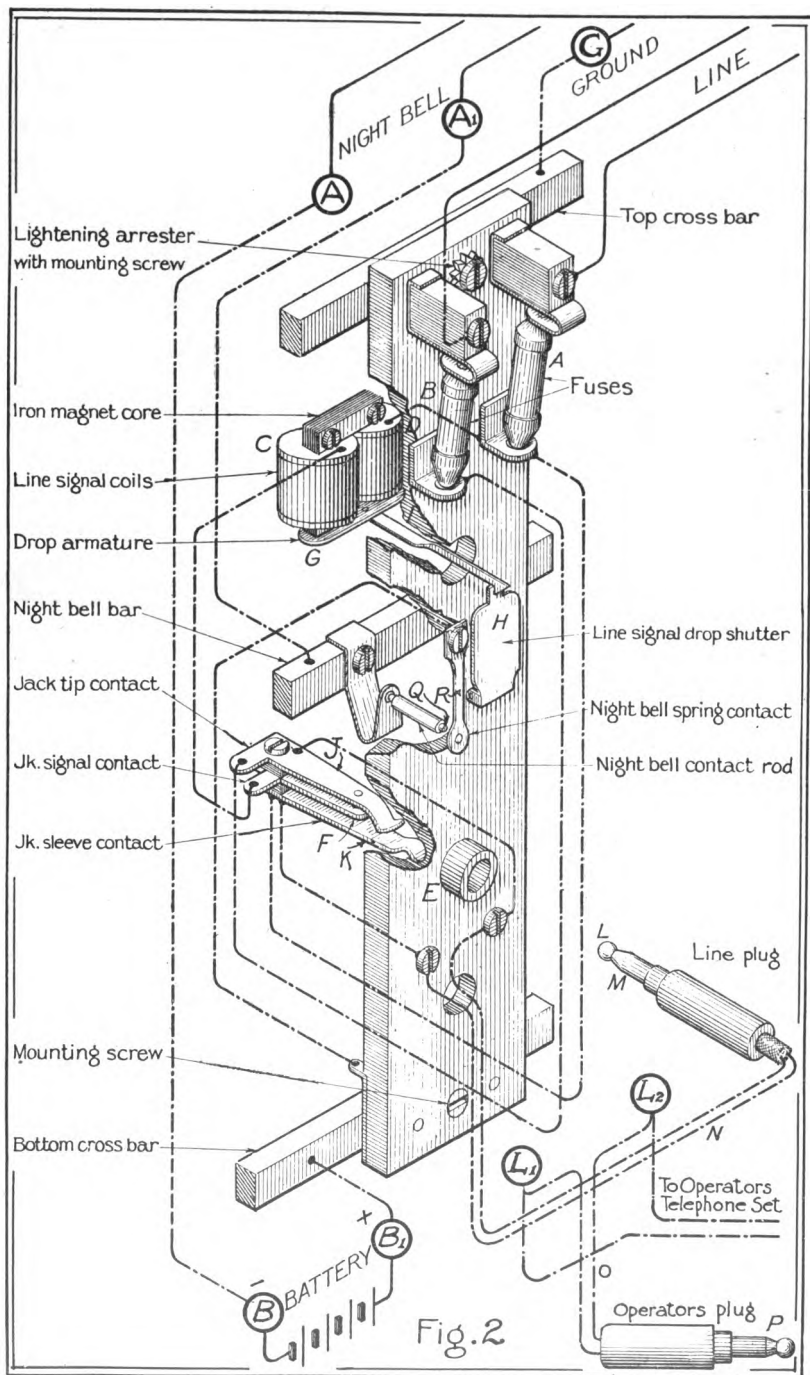


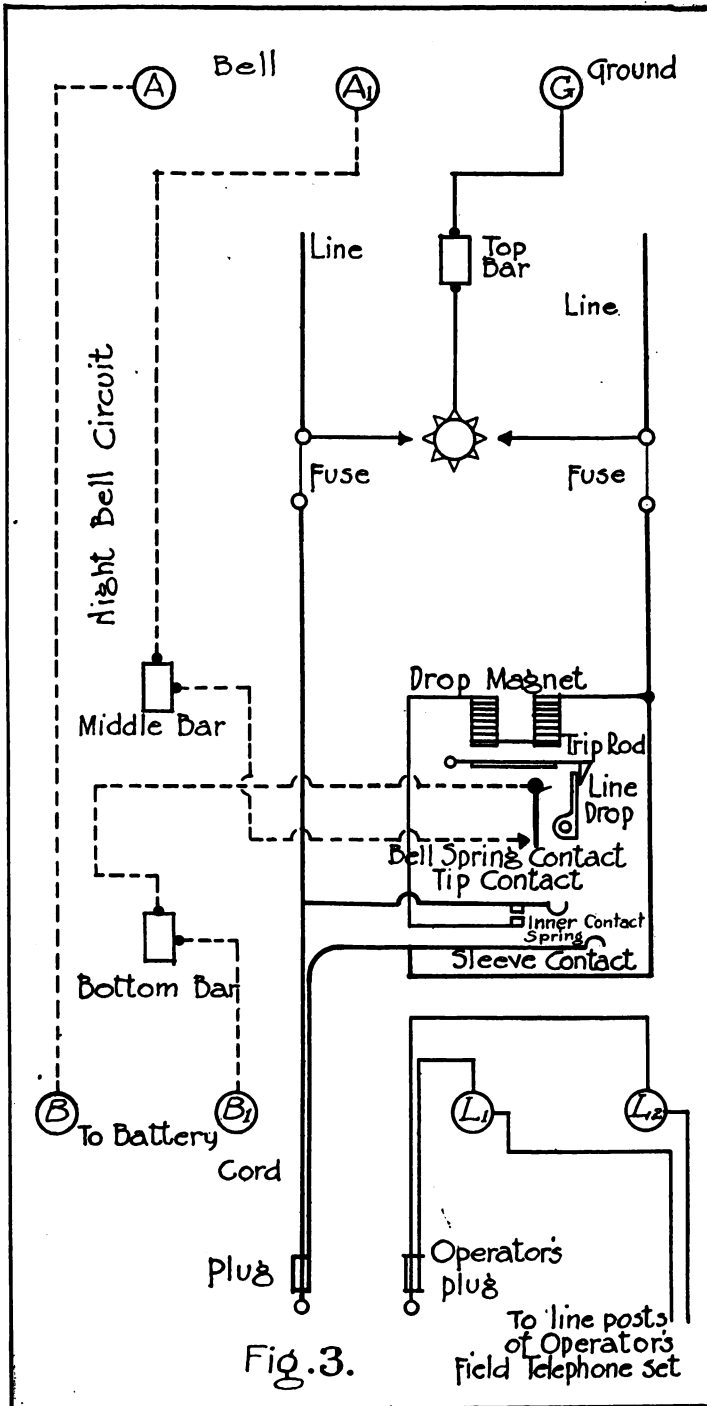
THE MONOCORD SWITCHBOARD UNIT TYPE EE-2.

2. Each unit comprises all the necessary apparatus for the exchange terminals of one line (two wires). A skeleton drawing of a unit is shown in figure 2 and the schematic wiring diagram in figure 3.

Terminals labeled A, A₁, G, B, B₁, L₁, and L₂, in the figures are not parts of the unit proper but are parts of the switchboard in which the units are assembled. The various parts are listed below according to their position on the panel from top to bottom:

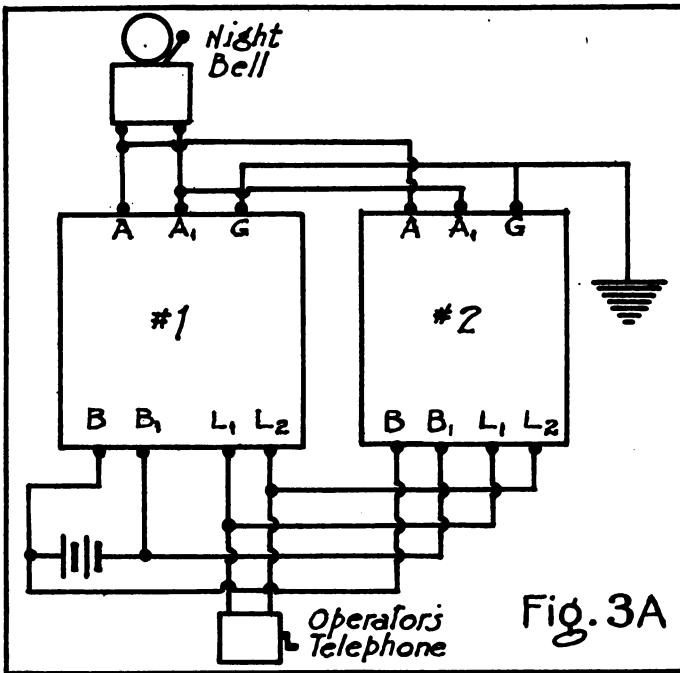
- Two connecting blocks for the line wires.
- Lightning arrester between these blocks.
- Two fuses.
- Line number plate.
- Line drop signal and night bell contact.
- Spring clip for locking line drop.
- Jack.
- Cord and line plug.





3. Each unit is held in the frame by means of two machine screws, one at the top and one at the bottom of the unit, which engage the brass bars in back of the switchboard and hold the unit firmly in place. Rigidity of construction is essential, as constant use and transferring from one place to another tend to loosen the units from the frame and disturb the sensitiveness of the adjustment of the line drop.

4. The lightning arrester is a simple toothed washer held against the panel by the upper supporting screw. This screw is grounded through the upper brass bar. If lightning comes in on the line



Connections of two switchboards of Type EE-2 units in parallel.

wires, the main portion of it jumps the small air gap from the binding post to the grounded washer and thence passes to ground, so that only a small portion of the high potential current flows through the switchboard apparatus. If the latter portion is at all heavy the fuses burn out, opening the circuit through the switchboard with a much wider gap and hence higher resistance than that in the circuit to ground across the arrester.

5. Two glass-inclosed removable fuses, which fit into spring connections, are provided to protect each side of the line from excessive currents. In order that burned-out fuses may be readily seen, the panel is painted white behind them. The glass is usually smoked

up more or less when a fuse burns out and this against the white background is quickly noticed.

6. The line number plate is a small white celluloid strip on which the line number is written. This number may easily be erased if it is necessary to change it.

7. The line drop signal consists of a shutter H, figure 2, held normally in a vertical position by a brass trip latch. This trip latch is attached to the armature G of a small electromagnet C, which is normally connected across the line through the inner contact spring F, and the jack tip contact spring J, of the switchboard jack. When the coils of the magnet are energized by a current sent over the line from a calling station, the armature and trip latch are lifted, thereby releasing the shutter which falls by gravity to a horizontal position and attracts the attention of the operator. The electromagnet is adjusted to operate on a very small current. For locking the shutter in the vertical position and protecting it from mechanical injury during transport, a flat spring lever is provided which may be turned up from a pivot at one end to press against the shutter.

8. The night bell contact Q, figure 2, is located on the front of the panel. The battery and bell circuit through this contact is closed when the line signal drop shutter is released by the electromagnet, thus forcing the spring R, back against the contact point Q. The night bell spring contact R, consists of a narrow flat brass spring, screwed at one end to the top mounting plate. The contact pin is mounted on the back of the panel, the rear end of this pin being connected with the night bell bus bar through a heavy spring permanently mounted on the bar, against which the pin presses when the panel is screwed in place on the bars along the back of the switchboard. This construction is shown clearly in figure 2.

9. Each unit is provided with a jack and plug. The jack consists of a cylindrical opening E, in the panel of the unit, behind which are arranged the tip contact spring J, the sleeve contact spring K, and the inner contact spring F, figure 2. The tip spring is connected through one of the fuses to one of the line wires. The inner contact spring is connected to the other line wire through the electromagnet coils and the other fuse. The circuit is normally closed across the line when there is no plug in the jack, as the tip spring and the inner contact spring are then in contact. A current coming in over the line, then, would energize the coil. The sleeve spring of the jack is connected directly to the same line wire as the inner contact spring. It is a standard two-contact type, the tip and the sleeve making direct connection to the line.

MONOCORD SWITCHBOARDS OF TYPE EE-2 UNITS.

10. The monocord switchboard is made up of unit panels, on each of which is mounted all the apparatus necessary for the central exchange end of one telephone line. These panels are made of insulating material and are mounted in special wooden frames in

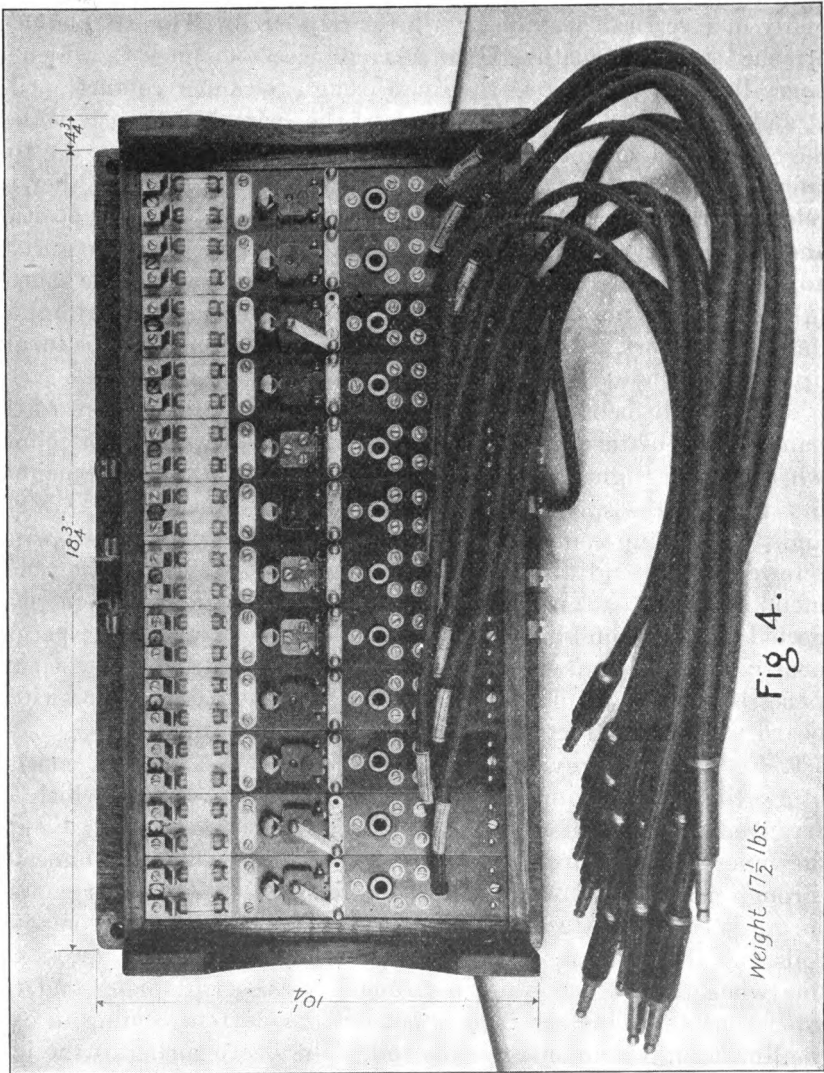


Fig. 4.

Weight 17½ lbs.

groups of 4, 8, or 12 units, thus making a 4, 8, or 12 line switchboard. Each unit is removable from the frame, thereby lending flexibility to the board and facilitating repair and replacement. Generally, this

There are on hand a few units and switchboards of French manufacture. In these switchboards the clips are replaced by binding posts. The upper posts are marked S_1 , S_2 , and T , respectively; the lower binding posts are marked Z_s , C_s , P_1 , and P_2 , respectively.

type of board is used only for a small number of lines, as the operating facilities do not permit speedy connections, and it is good practice to use only three lines on a four-unit board and 11 lines on a 12-unit board in order to have a spare unit immediately available. A 12-unit board is shown in figure 4. The first two drops are locked as for transportation; the second two as in normal operation; the third two down as in normal ring down. The upper Fahnestock clips from left to right are those represented in figures 2 and 3 by A, A₁, and G; the lower clips from left to right are those represented in figures 2 and 3 by B, B₁, L₁, and L₂. The cord coming from the bottom of the switchboard is the operator's cord. The complete board weighs 17½ pounds.

11. The switchboard frame is made of hard wood, varnished in order to make it moisture proof. Its function is to hold the various units together and to protect them from dust and mechanical injury. In back of the frame there are three horizontal brass bars extending the width of the board. In addition to providing a mechanical support for the various units, the top bar serves as a common ground connection and the middle and bottom bars as common night bell and battery connections for all units.

12. Carrying cases made of fiber and provided with hand straps are furnished with monocord switchboards to provide a convenient means of carrying them and to protect them from damage during transportation. These cases are made so that they will hold not only the frame with the assembled units, but also the switchboard cords.

13. In installing a switchboard it should be set up in a dry place. It may be hung from a suitable support or may be placed on a table or stand. The bottom of the switchboard should be securely fastened so that the plugs can be easily removed without disturbing the position of the switchboard. The line wires should be run direct to the line terminals on the several units. If terminal strips or additional arresters are used, they should be run first to the terminal strips or arresters and then cross connected to the switchboard. On long aerial lines, some type of protection should be used in addition to the small arresters on each unit.

INSTALLATION OF MONOCORD SWITCHBOARDS OF TYPE EE-2 UNITS—NOT USING THE MONOCORD SWITCHBOARD OPERATOR'S SET.

14. Any material needed at the exchange not a part of the monocord switchboard as described in this pamphlet is called the operator's equipment. This material consists of any complete local battery telephone set, night bell with its battery and wire for connections.

15. The night bell is connected by independent wires to the upper clips marked A and A₁. A good ground should be made and con-

nected to the upper clip marked G. The night bell battery is connected to the lower clips marked B and B₁. The line terminals of the telephone used are connected to the two lower clips marked L₁ and L₂.

16. If it is desired to use two or more multi-unit switchboards at one exchange, they may be connected so as to use only one night bell, one battery, one ground, and one operator's telephone for the whole exchange. This is done by connecting the corresponding clips of each switchboard. Figure 3A shows the necessary connections.

CARE AND ADJUSTMENT OF SWITCHBOARDS OF TYPE EE-2 UNITS.

17. Care must be exercised when a board is installed to make sure that the frame is in a vertical and level position. When assembled at the factory, all adjustments are made with the board in a vertical position, and all operations conducive to satisfactory service depend on this prerequisite being observed.

18. The line signals of monocord switchboards are of the gravity type and require careful adjustment. Any adjustment further than that done at the factory should be made by an expert who is thoroughly familiar with this work. During transportation and installation of the board the line drop shutters should be held closed by the flat spring previously described.

19. The burning out of a fuse when excessive current comes in on a line is detected by an open circuit on that line. A bad fuse generally shows up plainly against the white background on the panel. However, if it is not possible to see whether or not the fuse is burned out, the line may be short-circuited momentarily by means of a piece of bare copper wire placed across the two line terminals. The operator's plug is then inserted in the jack of the unit under test, and the magneto crank turned. If the fuse is burned out, the crank will turn over easily; if not, it will turn hard, indicating that the open circuit is elsewhere on the line. A burned-out fuse should be replaced immediately in order to keep all lines working. Several spare fuses should be kept on hand at all times, but in case no fuse is available a strand of small copper wire may be connected across the upper and lower fuse clips. To remove a fuse, take the bottom metal cap of the fuse between the thumb and finger and push upward against the spring holder on the line terminal block, at the same time pulling outward. To install a fuse, hold it in the same manner and put the other end of the fuse in the upper spring contact, forcing it upward until the bottom end will slip into place.

20. Care should be taken to keep the small air gap between the toothed washer and the line terminals clean. If this precaution is not taken, and the air gap is allowed to clog up with dust and dirt,

it will introduce a leak to ground or between wires with resulting poor transmission.

21. All mounting screws and all wire connections should be kept tight. Whenever a unit is damaged, it should be replaced by another one, the damaged unit being sent for repair. To remove a unit from the frame, it is only necessary to disconnect the line terminals and remove the top and bottom screws which engage the brass bars behind the board.

OPERATION OF MONOCORD SWITCHBOARDS OF TYPE EE-2 UNITS—NOT USING THE MONOCORD SWITCHBOARD OPERATOR'S SET.

22. In handling the switchboard cords they should be grasped by the plug, not by the cord. The connection of the wires to the tip and sleeve of a plug will break if subjected to undue strain or abuse, and by taking hold of the plug when inserting it and pulling it out, the

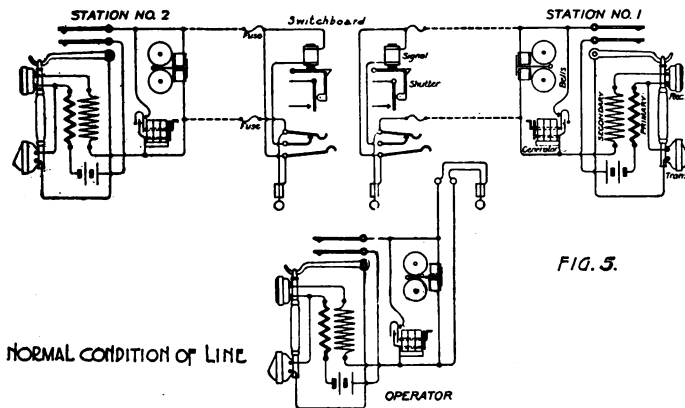


FIG. 5.

likelihood of breaking the internal connections and wearing out the wires will be reduced to a minimum.

23. In the following paragraphs, the operation of a monocord switchboard is outlined in detail, showing how the operator is called, how two stations are connected, and how the board is cleared after a conversation. In each of the wiring diagrams referred to, the heavy lines indicate the metallic circuit in use when the connections shown in the various diagrams are made.

24. The normal condition of the line is shown in figure 5. Stations 1 and 2 are each connected to their respective monocord switchboard units. These units are parts of a complete board which, together with the operator's apparatus, is installed at a central telephone exchange. All receivers being on the telephone hooks, the lines are clear. Bridged across the lines are the signal drop electromagnets of the central switchboards and the call bells and magnetos of the local stations.

25. When the party at station No. 1 desires to call the operator, he turns the crank of the magneto or uses his buzzer. This sends current through the electromagnet of the monocord switchboard unit to which it is connected, figure 6. The moment the magnet is energized the trip latch is lifted, the signal shutter drops and the aux-

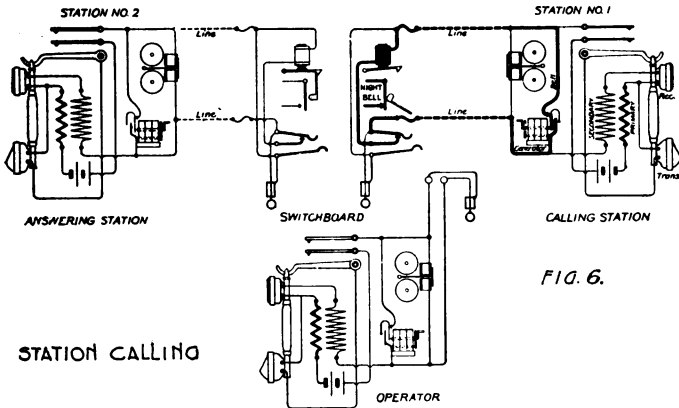


FIG. 6.

iliary night-bell circuit is closed. When an operator is constantly on duty at the board, the night bell is not used. The signal is then given simply by the dropping of the shutter. However, there may be periods when but few calls are made and the use of the night bell permits the operator to give his attention to other things.

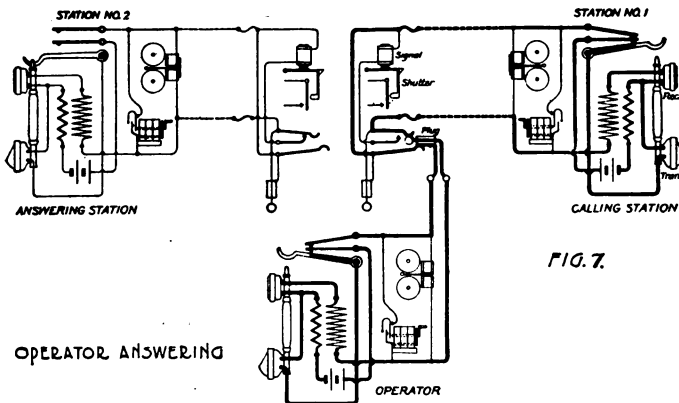


FIG. 7.

26. The operator, having received the call signal from station No. 1 (dropping of the shutter and ringing of the night bell), inserts his plug in the jack of the calling station panel and closes the drop shutter. This gives the connections shown in figure 7. The operator's plug is shown inserted and the signal magnet circuit open, as the tip spring of the jack is lifted off the inner contact spring by

the plug. At the same time, the calling station and operator having taken their receivers off the hooks, the circuits are closed in such a way that both telephone sets are in metallic connection with each other and the calling party can converse with the operators.

27. *The operator, receiving from the calling station the number desired, removes his plug from the switchboard jack of the calling*

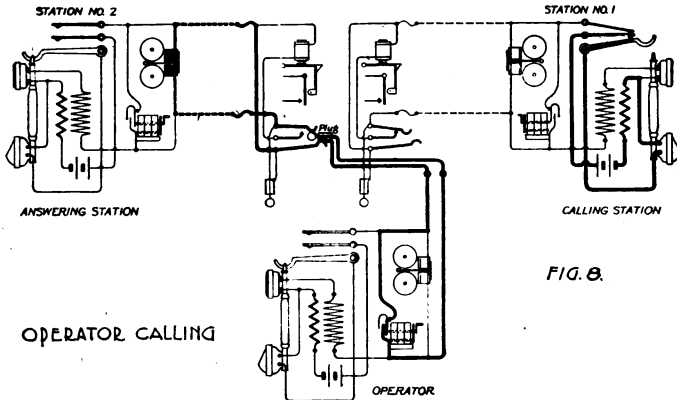


FIG. 8.

station and inserts it in the jack corresponding to station No. 2, the station called. He then replaces his receiver on the hook and turns his magneto crank in order to ring the bell of station No. 2. This operation gives the connections as shown in figure 8. During this time, the calling station still has the receiver off the hook. The party at the called station takes the receiver off the hook and answers with

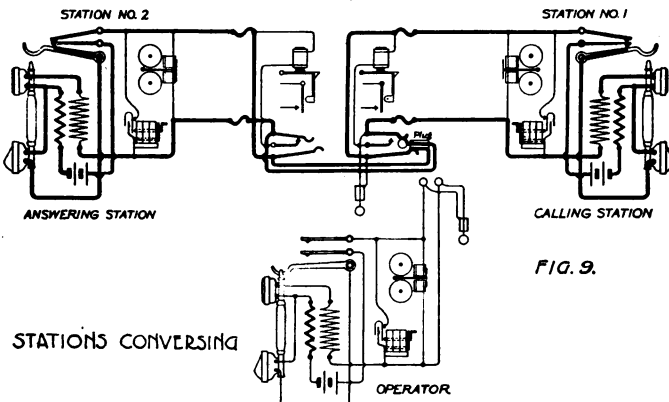


FIG. 9.

the number of the line or name of the military organization connected.

28. After having received an answer from station No. 2, *the operator removes his plug from jack No. 2, and inserts the plug of the station called in the jack of the calling station. This employs the circuit indicated in figure 9 showing both stations in direct connec-*

tion with each other. Conversation may now be carried on. It will be noticed that the bells of the calling and answering stations and the drop magnet of the answering station remain connected across the line while the conversation is carried on. This does not interfere in any way with the operation of the line, as the impedance of the bell winding and magnet coils is considerable at frequencies corresponding to voice modulations, and the voice impulses take the path of least impedance and follow the circuit indicated by the heavy lines.

29. In actual field work the operator may not wait for an answer from station No. 2, but insert the plug of station No. 2 as soon as he has rung it in the jack of station No. 1, assuming that the call will be answered. Then if other calls do not claim his attention, he may leave his operator's plug in the jack of station No. 2 and listen in for the expected answer. If it is not received promptly, he will ring

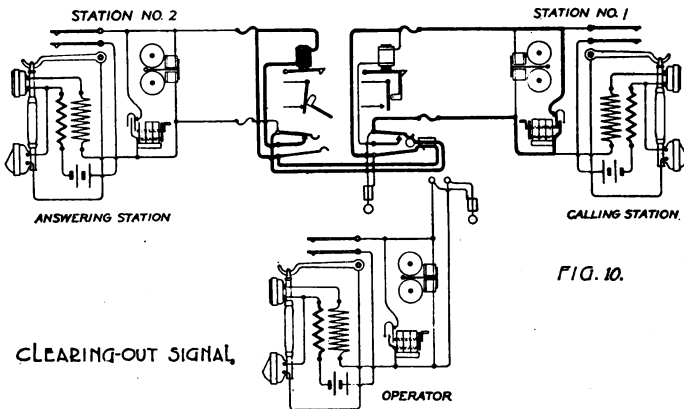


FIG. 10.

again, first making sure to remove the plug of station No. 2 from the jack of station No. 1, otherwise the party at station No. 1 will also get the ring in his telephone. The operator can supervise the line at any time by inserting his plug in the jack of the station called.

30. When the conversation is finished the receivers of both stations are placed on the hooks. The calling station party operates his magneto which energizes the line drop magnet of the other switchboard unit, figure 10. The operation is then the same as outlined for the calling signal. *The shutter drops, and the operator then removes the plug from the switchboard jack and closes the line drop signal.* This clears the line and puts it in readiness for subsequent calls.

31. Conversation between more than two parties can be effected on the monocord switchboard. In the event that stations Nos. 1, 2, 3, and 4 desire to converse simultaneously, plug No. 1 is inserted in

jack No. 2, plug No. 2 in jack No. 3, and plug No. 3 in jack No. 4. The clearing out signal may then be given by any one of the four stations.

MONOCORD SWITCHBOARD UNIT TYPE EE-2-A.

32. The monocord switchboard unit type EE-2-A is an improvement on the type EE-2 unit. There are no fuses nor arresters in the new design. Fahnestock clips are replaced by a spring type binding post. Knurled head screws are used to fasten the units in place in the switchboard so that no tool is required to replace one unit with another. The cord terminals are on the front of the unit so that it is not necessary to remove a unit from its board to replace a defective cord. The line drop signal with its locking spring is not changed, but changes have been made in the connection of the night bell contact, in the jack and plug, and in the circuits. Figure 11 shows several views of the type EE-2-A units. The type EE-2 units and the type EE-2-A units are not interchangeable.

33. The night bell contact differs from the old model as follows: The spring, mounted on the middle bar of the type EE-2 unit, has been discarded and the contact (Q, fig. 2) wired to a plate at the bottom of the unit. The other contact of the night alarm is wired to a similar plate at the top of the unit. These connections are plainly shown in the schematic wiring diagram of the unit, figure 14.

34. The jack is arranged so that when a plug is inserted three contacts may be made and two may be broken. When no plug is in the jack, the circuit is from the line terminal, Ground, through the tip contact spring J, through the upper inner contact spring F, through the line drop signal magnets, and thence to the other line terminal. The plug attached to each unit has no ring, but the sleeve of the plug, M, makes contact with both the sleeve of the jack, K, and the ring spring, R. Inserting the plug in the jack, therefore, produces contact between the sleeve of the plug, M, and the sleeve of the jack, K, and also between the sleeve of the plug, M, and the ring spring of the jack, R. It also produces contact between the tip of the plug, L, and the tip contact spring, J. At the same time the contact between the tip contact spring, J, and the upper inner contact spring, F, is broken, thus disconnecting the electromagnet from the rest of the circuit. The contact between the ring spring, R, and the lower inner contact spring, H, is also broken. It is seen that in this case the jack and plug act as if they had two contacts. The three contacts of the jack are used in connection with the monocord switchboard operator's set. This will be described later.

MONOCORD SWITCHBOARDS OF TYPE EE-2-A UNITS.

35. Monocord switchboards of type EE-2-A units differ from those of type EE-2 units in the fact that each unit is mounted so as to be removable without the use of any tools. Also a hinge cover and a carrying strap have been added to the containing case so that it can be closed for transportation. No outside carrying case, therefore, is necessary. Only two horizontal brass bars are used; one at

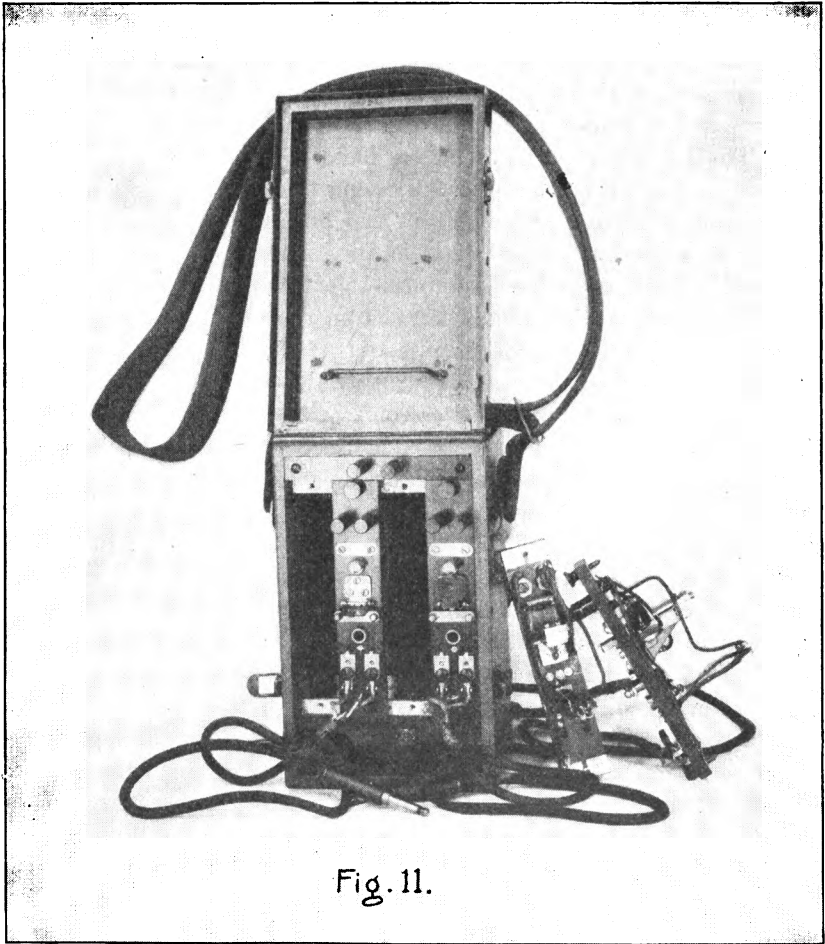


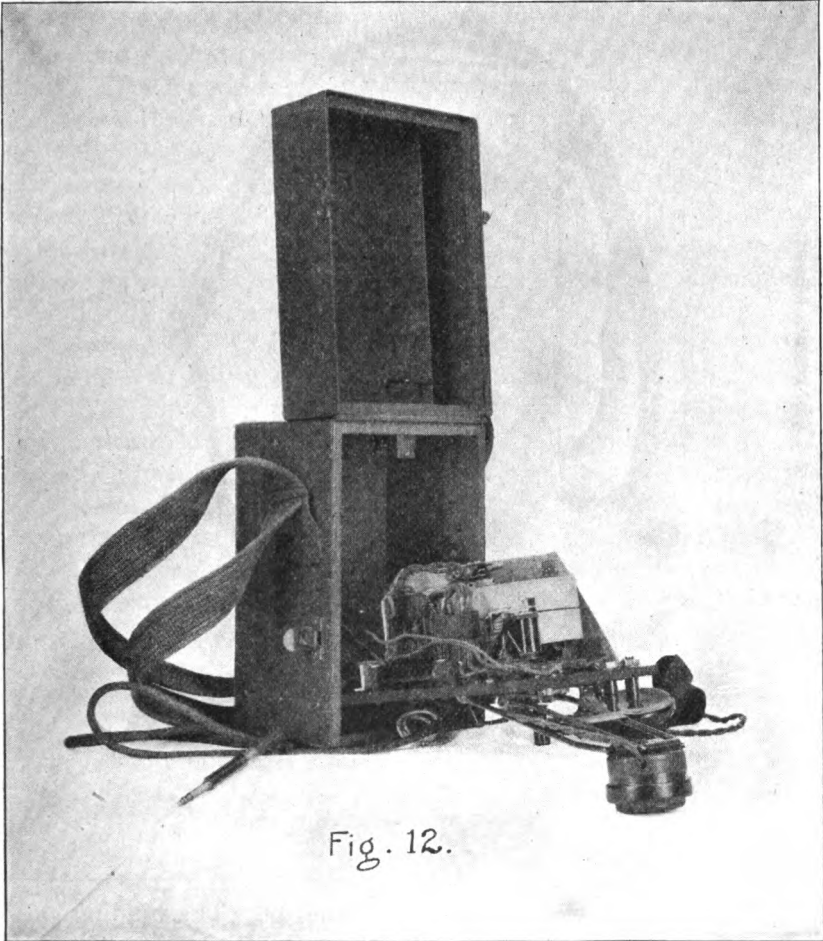
Fig. 11.

the top and one at the bottom. There is no operator's cord attached to this switchboard.

36. Monocord switchboards of type EE-2-A units are made in the 4-line and 12-line sizes. The 4-line switchboard weighs 9 pounds and its dimensions are $10\frac{1}{2}$ by $5\frac{1}{2}$ by $6\frac{1}{4}$ inches. The 12-line switchboard weighs 22 pounds, and its dimensions are $17\frac{1}{2}$ by $10\frac{1}{2}$ by $5\frac{1}{2}$ inches. A four-unit switchboard is shown in figure 11.

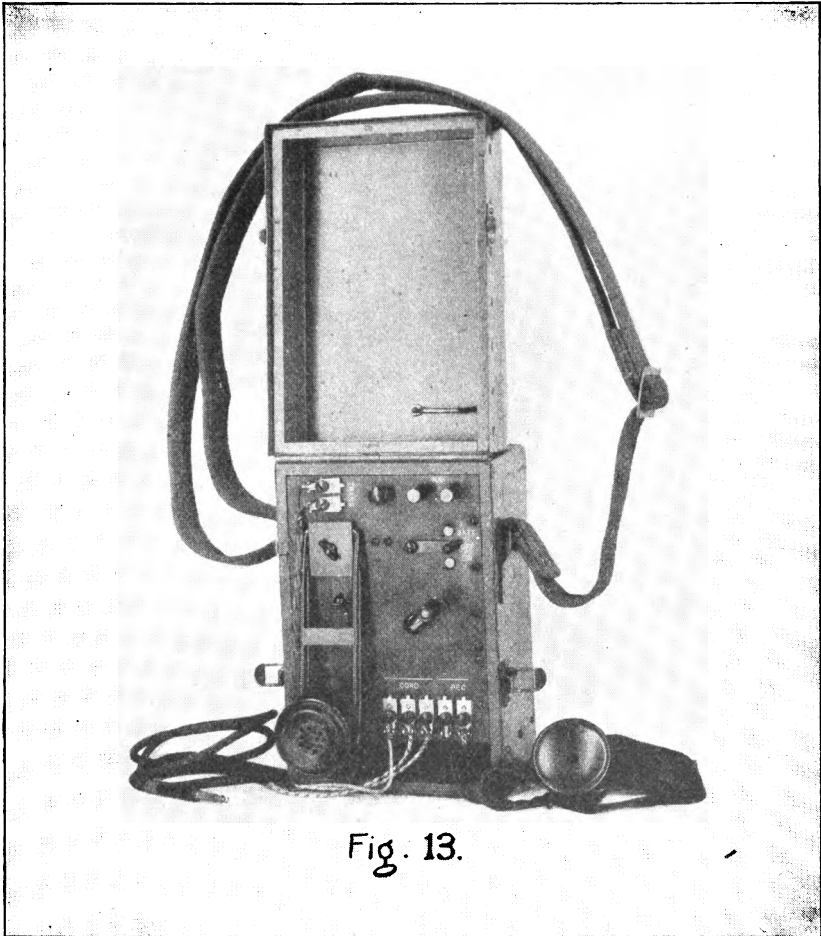
MONOCORD SWITCHBOARD OPERATOR'S SET, TYPE EE-64.

37. The monocord switchboard operator's set contains all the auxiliary apparatus necessary at a telephone exchange employing a monocord switchboard. This apparatus is all mounted in one container which has a cover and a carrying strap. It consists of a telephone receiver, transmitter, induction coil, hand generator, series buzzer, night-alarm buzzer, two type BA-1 batteries, the necessary



switches, and connecting cord and plug. This is all apparatus of stock type. The series buzzer is similar in action to a polarized bell. The night-alarm buzzer is a loud sounding buzzer of approximately 4 ohms resistance. The set weighs 15 pounds, and its dimensions are $6\frac{3}{4}$ by $7\frac{1}{8}$ by 10 inches. Views of the set are shown in figures 12 and 13.

38. In figure 12 the induction coil is in the foreground. Immediately behind the induction coil from left to right are the series buzzer, the key switches, and the night-alarm buzzer. The two-magnet generator with its automatic contact mechanism lies to the rear of the apparatus. The BA-1 batteries with their clips are not visible. They are, however, mounted inside the box.



39. Figure 13 shows the exterior of the set. The binding posts marked NA are the terminals of the night-alarm circuit. The knob to the left of these is a screw for fastening the front of the box in its closed position. The transmitter is mounted on a movable arm which is so arranged that the transmitter is always held in the correct vertical position for good operation. The key is just below the mounting of the transmitter. A metal projection on the transmitter arm is arranged so that when the transmitter is put down as for transportation, the key is pushed up. In this position of the key the

battery circuit is disconnected. The binding posts at the bottom of the panel are for the cord with its plug and the receiver. The three to the left are marked T, R, and S, and are the terminals of the tip, ring, and sleeve, respectively, of the cord and plug, which has three contacts. The watch-case receiver has a band to extend around the head, thus making it unnecessary to support the receiver with the hand while in use. The wiring diagram will be shown in the discussion on the operation of the set.

INSTALLATION AND OPERATION OF MONOCORD SWITCHBOARDS OF TYPE EE-2—UNIT—USING THE OPERATOR'S SET.

40. The general directions given in paragraph 13 should be followed. The operator's sets are wired for use with the new unit and a few easily made changes must be made in the sets when they are to be used with the type EE-2 unit switchboard. The ring and sleeve terminals, R and S, at the bottom of the panel must be electrically connected by a short length of wire. The tip terminal T must be electrically connected to the line terminal L_1 of the switchboard, and the sleeve terminal S connected to the line terminal L_2 . Any flexible wire may be used. The night alarm terminals on the operator's set, NA, are connected by suitable wires to the night alarm clips of the switchboard, A and A_1 .

41. The method of operating, after these changes have been made, is practically the same as described in paragraphs 22 to 30. The operator upon receiving a call *will not use the plug on the operator's set* but answers with the operator's plug on the switchboard. After receiving the number desired, the operator removes his plug from the calling line, inserts it in the jack of the called line, *throws the ringing and listening key of the operator's set to the lower non-locking position* and rings with the hand generator of the operator's set. Having received an answer from the called party, connections are made by inserting the plug of the called line into the jack of the calling line. On ascertaining that the two parties are conversing, the operator's plug may then be removed.

INSTALLATION AND OPERATION OF MONOCORD SWITCHBOARDS OF TYPE EE-2-A UNITS—NOT USING THE OPERATOR'S SET.

42. The general directions given in paragraph 13 should be followed. It is necessary to provide operator's equipment consisting of a small vibrating bell or buzzer, one or two standard dry cells, a single point switch, an additional cord and plug, and a complete magneto telephone. The plug and cord may be taken from a unit not in use if there are no extra ones on hand. The bell, dry cells, and switch are connected in series with the terminals on the switchboard marked NA. The terminals of the cord are connected to the terminals of the operator's telephone. The method of operating is identical with that described in paragraphs 22 to 30.

INSTALLATION AND OPERATION OF MONOCORD SWITCHBOARDS OF TYPE EE-2-A—
UNITS—USING THE OPERATOR'S SET.

43. The general directions given in paragraph 13 should be followed. The only necessary connection to be made is to connect by suitable wires each of the terminals on the operator's set marked NA, to the corresponding terminals on the switchboard also marked NA. Proper outside line protection should be used when necessary.

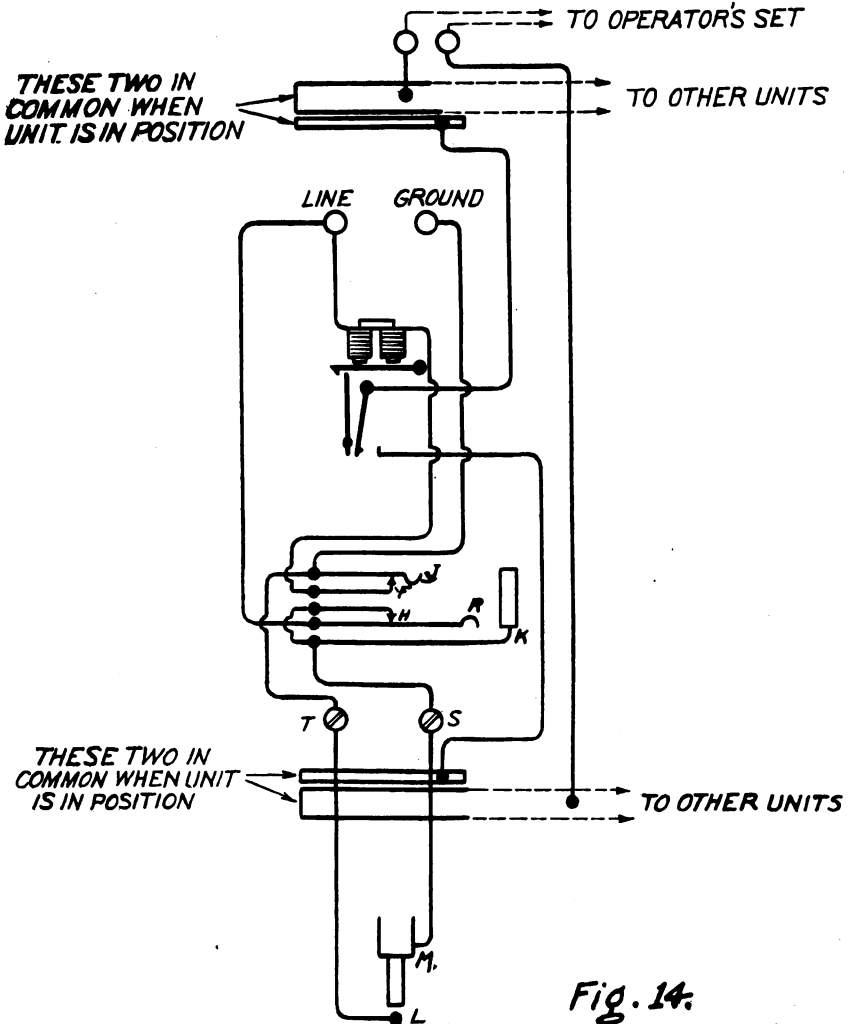


Fig. 14.

44. When the calling party turns the crank of his magneto the current passes through the line drop signal as described in paragraph 34. The operator inserts the plug of his set in the jack of the calling line and ascertains the party desired. The key is in the normal (center) position. The insertion of the plug breaks the circuit between J and F, and also between H and R, figure 14, at the same time making the tip, ring, and sleeve contacts between the jack and plug. The

circuit now is GROUND-J (fig. 14) T-R-S-I-N (fig. 15) R-Line (fig. 14). It is to be noted that at I (fig. 15) the talking circuit of the

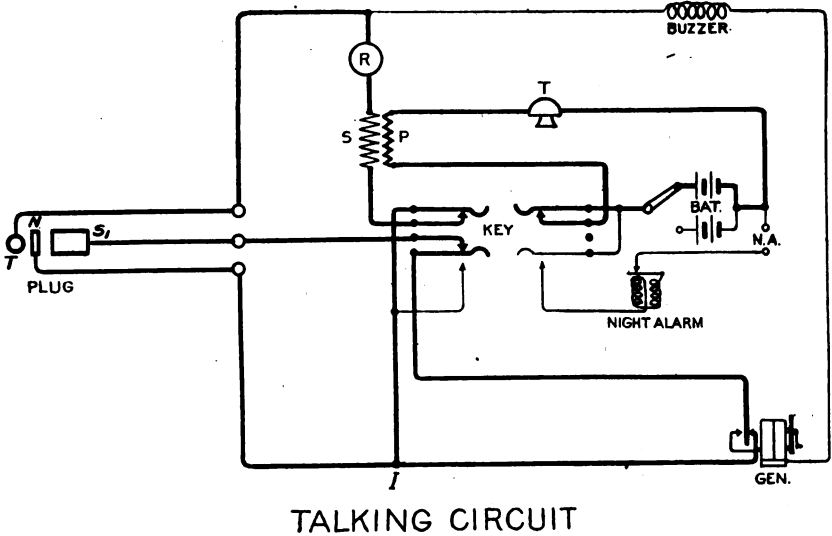


Fig. 15.

operator's set divides, one branch of it going to the sleeve of the plug. This circuit is not in use when the operator talks to the calling party. The operator, upon ascertaining the party desired, inserts the plug of

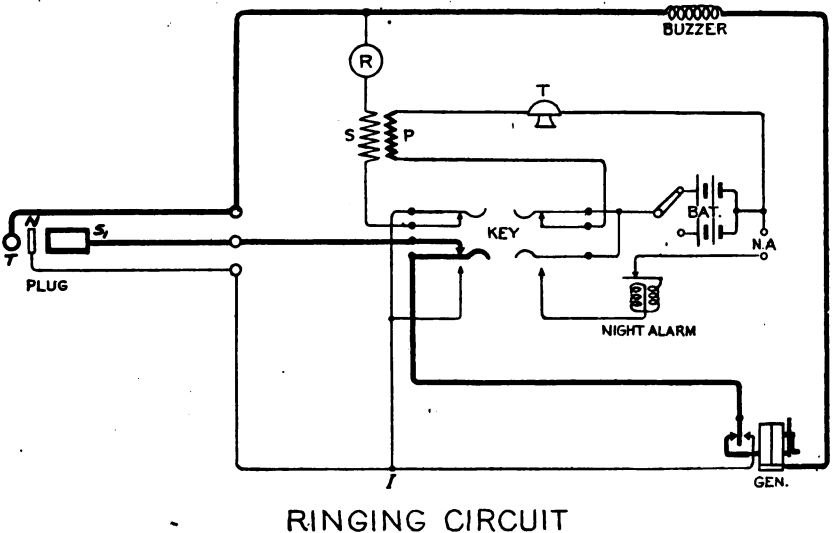


Fig. 16.

the calling line into the jack of the called line and turns his generator crank. The series buzzer should sound. If it does not, the circuit is broken either on the line to the called party or in the exchange apparatus. The ringing circuit in the operator's set is shown in figure 16.

From T the circuit is to J to L in the unit of the calling party (fig. 14) to J to GROUND of the called party's unit; through the line and ringer of the called party to Line—to R of the called party's unit—to M to K of the calling party's unit—to S_1 of the operator's set. The circuit of the called party's unit is identical with that shown in figure 14. It is to be noted that turning the generator crank automatically breaks one contact and makes another in the operator's set.

45. The operator may now talk to either the calling or the called party. The talking circuit between operator and calling party has been outlined in the preceding paragraph. The talking circuit between operator and called party is, starting from the secondary of the induction coil, S to R to T (fig. 15) to J to L in the unit of the calling party (fig. 14) to J to GROUND of unit of the called party

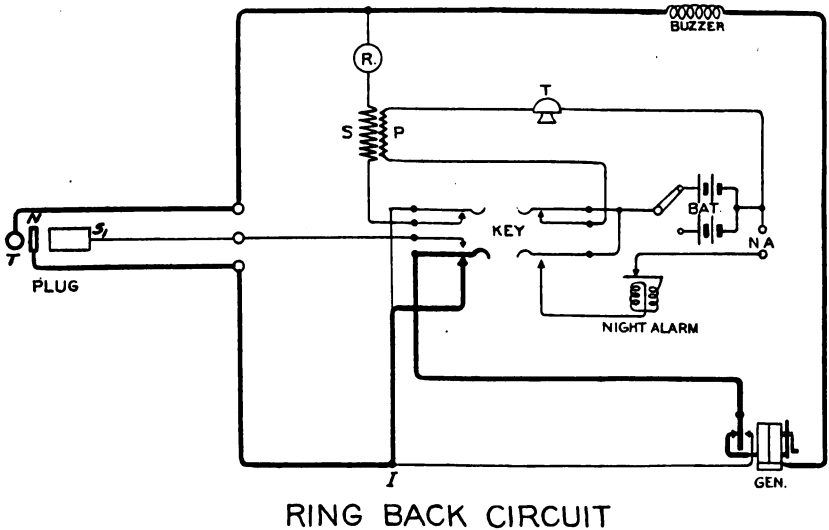


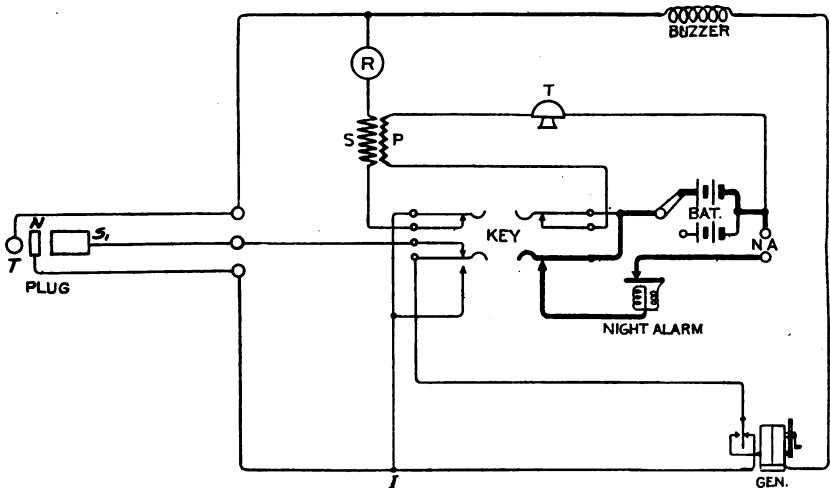
Fig. 17.

(same as fig. 14) through the outside line and telephone to Line to R of the unit of called party to M to K to unit of calling party to S_1 (fig. 15) to lower switch to I to upper switch to S. If necessary, the operator may ring the calling party. *To do this he throws the key to the lower position* and turns his generator crank. Figure 17 shows this "ring back" circuit in the operator's set. The reader should be able to trace the rest of the circuit by referring to figure 14.

46. When connections have been established the operator removes his plug. The calling and called stations are connected both when the operator's plug is and is not in the jack of the calling party's unit. When the operator's plug is not in the jack the circuit is Ground to J to L of the calling unit (fig. 14) to J to GROUND through outside line to Line to R of the called party's unit (same as

fig. 14) to M to H to Line of calling party's unit. When the operator's plug is in the jack of the calling party's unit, it must be remembered that the contact between H and R (fig. 14) of this jack is broken. The reader should trace the circuit referring to figures 14 and 15. The knowledge that this circuit uses the branch passing through the sleeve of the operator's jack (fig. 15) will aid in tracing out the circuit.

47. *When it is desired to use the night alarm, the key of the operator's set is thrown to the upper position.* This breaks the circuit of the battery through the telephone transmitter and closes it through the night alarm buzzer. The whole circuit can be easily traced by the reader. The falling of the shutter of the switchboard unit closes the open circuit from the top to the lower brass bar of the unit



NIGHT ALARM CIRCUIT

Fig. 18.

(fig. 14). The night alarm circuit in the operator's set is shown in figure 18. When summoned by the night alarm, the operator must throw the key to the center position before answering the call.

CARE AND ADJUSTMENT OF MONOCORD SWITCHBOARDS OF TYPE EE-2-A UNITS AND OF MONOCORD SWITCHBOARD OPERATOR'S SET.

48. Many parts of the discussion of the care and adjustment of type EE-2 units in paragraphs 17 to 21 are applicable, and these paragraphs should be read in this connection. Care should be taken to see that the operator's sets are equipped with fresh batteries at all times. If the set is packed for any length of time both batteries should be removed, as local action very often sets up in these cells. This is liable to corrode the terminals and possibly other parts of the instrument.

49. Periodical tests should be made to ascertain if the operator's set is in proper working order. If it is found that the conversation cuts off from time to time, this may be due to a broken operator's cord, which can be tested by means of battery and telephone receiver, and replaced if necessary. It may also be due to a broken receiver cord. The receiver cord may be tested by disconnecting the cord and receiver from the set and connecting the cord terminals to a cell and shaking the cord throughout its length. If the receiver cord is partially broken, there will be a grating noise in the receiver. If the receiver cord is entirely broken there will be no click in the receiver when the connection of cord and battery is made or broken. The transmitter circuit may be tested by short-circuiting the "T" and "R" cord terminals and tapping lightly on the transmitter. This will be distinctly heard in the receiver if the talking circuit and battery are in good condition. The night alarm may be tested by short-circuiting the binding post marked NA and throwing the switch to the upper or locking position. This should cause the buzzer to operate. The generator circuit may be tested by short-circuiting the "R" and "S" cord terminals, leaving the key in the center position. If the generator circuit is in proper condition, turning the generator crank should cause the series buzzer to respond and it can also be heard in the receiver.

50. When packing the operator's set for storage or transfer, the batteries should be removed; the transmitter should be folded down against the front of the switchboard; the battery switch should be turned to the "Off" position; the operator's cord and receiver should be stored in the lower compartment of the case, and the case closed and locked.

PARTS LIST.

51. The following parts lists give the drawing number and also the type number when one has been assigned. The drawing number serves to identify the part to the Office of the Chief Signal Officer only. Essential parts have been marked with an asterisk. In general, when a unit becomes unserviceable, it should be replaced by another unit and the unserviceable one returned to a post designated by the Chief Signal Officer for repair. The minor parts will not be issued for repairs.

MONOCORD SWITCHBOARD OPERATOR'S SET, TYPE EE-64.

	Drawing No.
Case.....	15004D2
*Generator.....	10101C1
*Induction coil.....	10201A1
*Key.....	15004B7
Switch parts.....	15004B8
*Transmitter, complete.....	15004D9

	Drawing No.
*Transmitter arm, detail 100.....	15004D9
*Transmitter arm, clamps, detail 101 and 103.....	15004D9
*Transmitter clamps, detail 102 and 104.....	15004D9
*Transmitter clamp screws, No. 8, 32 by $\frac{1}{8}$ inch, R. H. B. machine.....	15004D9
Night alarm binding post, type TM-34.....	10401B1
*Cord binding post, screw, detail No. 1.....	10403B1
*Night alarm buzzer.....	15004A10
*Series A. C. buzzer.....	11101C1
*Receiver, type R-11.....	11002D1
*Receiver cord, type CC-310.....	10501C1
*Transmitter cord, type CC-304, 8 inches long.....	10501C1
*Plug cord, type CC-56.....	10602C1
*Plug.....	10152B1
*Battery, type BA-1.....	
Mounting plate thumb screw, detail 31.....	15004B3
*Carrying strap with fittings, part No. 2.....	51901C1

SWITCHBOARD TYPE BD-9-A-4 LINE.

*Switchboard unit, type EE-2-A.....	15003D4
Case.....	15003D3
*Carrying strap with fittings, part No. 2.....	51901C1
*Suspension bracket, detail No. 11.....	15003D3

SWITCHBOARD TYPE BD-11-A-12 LINE.

*Switchboard unit, type EE-2-A.....	15003D4
Case.....	15009D2
*Carrying strap with fittings, part No. 2.....	51901C1
*Suspension bracket, detail No. 11.....	15003D3

SWITCHBOARD TYPE BD-11-12 LINE.

*Switchboard unit, type EE-2.....	15001B6
Carrying case.....	15001D2
Cabinet.....	15001D3
*Operator's cord, type CC-59.....	10602C1
*Operator's plug.....	15001B7

SWITCHBOARD UNIT TYPE EE-2.

*Jack, complete with mounting screws.....	15001D5
*Drop, complete with mounting screws.....	15001D5
*Number plate, detail 72.....	15001D5
*Fuse, detail 76.....	15001D5
Night alarm contact spring, detail 82.....	15001D5
Drop guard, details 84, 85, 87, and 88, assembled.....	15001D5
Lightning arrester, detail 90.....	15001D5
Fuse spring, detail 74.....	15001D5
Lightning arrester screw, detail 94.....	15001D5
*Unit mounting screw, detail 105.....	15001B6
*Cord binding screws, detail 103.....	15001B6
*Line binding screws, detail 92.....	15001B6
*Cord, type CC-59.....	10602C1
*Plug.....	15001B7

SWITCHBOARD UNIT TYPE EE-2-A.

Drawing No.

*Jack-----	10161A1
Jack mounting screw, No. 6, 32 by $\frac{1}{2}$ inch, R. H. B. machine screw with hexagon nut-----	
*Drop, complete-----	15003D4
*Unit mounting screw, detail 14-----	15003D4
*Cord anchor, detail 33-----	15003D4
*Number plate, detail 22-----	15003D4
Night alarm contact spring, detail 28-----	15003D4
Drop guard, details Nos. 24, 25, 26, and 27, assembled-----	15003D4
*Line binding post-----	10401B1
*Cord binding post screw, detail No. 1-----	10403B1
*Cord type CC-59 with No. 8 terminal on tie cord-----	10602C1
*Plug-----	15001B7



SIGNAL CORPS UNIVERSAL TEST SET, TYPE EE-65

WIRE COMMUNICATION
PAMPHLET NO. 7

(Second Edition)

PREPARED IN THE OFFICE OF
THE CHIEF SIGNAL OFFICER

SECOND EDITION REVISED BY THE
SIGNAL CORPS SCHOOL, CAMP ALFRED
VAIL, N. J.

November, 1921



WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

WAR DEPARTMENT
Document No. 1020
Office of The Adjutant General

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WAR DEPARTMENT,

WASHINGTON, *November 30, 1921.*

The following publication, entitled "Signal Corps Universal Test Set, Type EE-65," Wire Communication Pamphlet No. 7, is published for the information and guidance of all concerned.

[062.1, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

JOHN J. PERSHING,

General of the Armies,

Chief of Staff.

OFFICIAL:

P. C. HARRIS,

The Adjutant General.

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SIGNAL CORPS UNIVERSAL TEST SET, TYPE EE-65.

SECTION I.

PURPOSE OF SET.

	Paragraph.
Testing Equipment-----	1

1. *Testing equipment.*—This set has been designed to provide a wire chief's testing equipment in a compact, portable form, for use both in the field and in permanent central office installations. The complete testing, signaling, and talking equipment is installed in a substantial case, provided with a shoulder strap, and can easily be transported by one man. No additional equipment is necessary for its successful operation.

SECTION II.

DESCRIPTION OF SET.

	Paragraph.
Set box-----	2
The test unit-----	3
Test keys and their uses-----	4

2. *Set box.*—The set box consists of a wood case, metal bound, with hinged cover and is provided with a quick-acting latch lock, and in addition has two supports for attaching the carrying strap. The case acts as a support for the testing equipment; the entire set of keys, voltmeter, and generator, ringing and induction coil, together with the necessary wiring, being mounted on a hinged hard-rubber support. Within the case, a battery compartment is provided for the talking and testing batteries. A compartment on the left side of the test panel provides a carrying space for the transmitter and receiver, test cords, and clips. Inside the cover is a support for holding the ground rod and also a diagram of the wiring of the test set.

3. *The test unit.*—The test unit set up in position for service is shown in figure 1. The voltmeter at full scale reads 50 volts. Each space on the scale has the value of 1 volt, every fifth and tenth unit being shown by a longer line on the scale. The upper left-hand binding post is for the ground connection and is designated GND. The next two posts are the line terminals and are designated "L-1" and "L-2," respectively. The thumbscrew directly over the voltmeter locks the front panel in position. At the upper right-hand side are two binding posts for connecting any external source of electromotive force whose value it is desired to find. These posts are designated "BAT TEST," the left-hand one being the positive post.

The transmitter is connected to the two upper binding posts, located at the lower left-hand side of testing panel, and they are designated "TRANS." The testing receiver is connected to the next two binding posts, which are designated "REC." Two-way flexible cords are used for these connections, and in addition there is a supporting strand to take the strain from the terminals. The generator handle is located in the lower center of the panel. The two binding posts at the lower right-hand side of the panel provide terminals for an external testing battery, the upper one of the pair being the positive

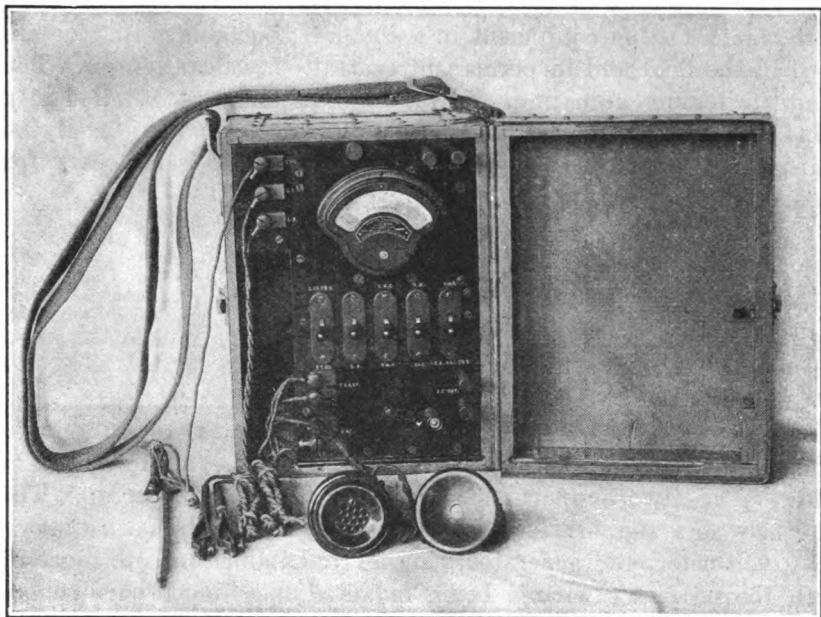


FIG. 1.—Universal test set ready for operation.

terminal. When an external battery is used, the battery within the case must be disconnected.

4. *Test keys and their uses.*—The various talking and testing circuits of the set are controlled by five keys mounted in a row in the center of the testing panel.

Key No. 1 when thrown up (locking position) is used for listening or talking. When pulled downward (nonlocking position) it is used for ringing out on the test leads, the generator crank being turned at the same time. The 80-ohm buzzer provides a signal to show whether or not the line is closed.

Key No. 2 can only be moved to the downward position and is used for reversing the test leads.

Key No. 3 when in the up position grounds the positive side of the test battery and also connects the other side of battery through the

voltmeter to L-1. This key is used when testing for grounds or a grounded foreign battery. When thrown to down position the voltmeter, in series with the testing battery, is connected directly across the test leads for locating crosses or making other resistance tests.

Key No. 4 when in the up position disconnects the testing battery and connects the voltmeter directly across L-1 (with key No. 3 toward "VMG") and ground. With the key in the down position, a means is provided for testing the voltage of the self-contained testing battery.

Key No. 5, in the up position, is used to reverse the terminals of the voltmeter. This relieves the tester from having to change his test leads when measuring external battery. In the down position the voltmeter is connected directly across the "BAT TEST" posts, for measuring any outside potential within the range of the voltmeter.

Various combinations of the above keys provide the necessary testing circuits for the usual magneto or common battery tests.

SECTION III.

GENERAL INSTRUCTIONS FOR USING THE SET.

Tests.....	Paragraph.
	5

5. *Tests.*—This set, as previously stated, has been designed to provide a means of making the usual tests for magneto or common battery requirements. In general the test set can be used either in a vertical or horizontal position. If the voltmeter fails to read "zero" with all keys normal, adjust the screw on the face of the voltmeter. The resistance of the voltmeter is approximately 3,000 ohms, and it is sufficiently sensitive to allow of measuring fairly high resistance.

The set can be used for making any one of several tests, detailed information and the theory involved appearing under the heading "Detailed Instructions for Using the Set."

SECTION IV.

DETAILED INSTRUCTIONS FOR USING THE SET.

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To talk to a magneto substation or office.....	8
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6. *To ring substation or magneto exchange.*—Key No. 1 down, generator crank turned at the same time. Party line ringing signals can be made by moving the key from normal to down the required number of times. In this case it may be necessary to reverse the test leads. To signal or ring on a grounded line, L-1 clip should be connected to the desired line wire and L-2 clip grounded. Conditions will then be similar to ringing on a metallic line.

7. *To signal common battery exchange.*—Key No. 1 up. Receiver and secondary induction coil is bridged directly across the line and provides the necessary shunt to operate the central office signal. Care should be observed to see that the test receiver is connected with proper polarity to prevent possible injury to magnets. To test for this polarity, remove the receiver cap while current is flowing through the receiver. If the magnet strongly attracts the receiver diaphragm, the receiver is poled correctly.

8. *To talk to a magneto substation or office.*—Key No. 1 up. Receiver of set is now directly across test leads. To talk and listen, in addition to above, press small button on transmitter which supplies the 3-volt battery to the testing transmitter.

9. *To talk to a common battery station.*—While this set is not wired to supply talking battery to a C. B. substation, it is still possible to do this by wiring the set as follows:

Key No. 1 up as for talking on magneto lines: Connect L-1 and L-2 by pair of wires to external battery posts, in series with a 165-ohm retardation coil, and to the desired line by means of the test clips. This should only be used as an emergency method, as the drain on the test battery is excessive.

10. *Test for continuity of a metallic circuit.*—Key No. 3 down. The voltmeter is then connected in series with the testing battery, the combination being connected directly across the test leads L-1, L-2. The voltmeter reading, as compared with the reading on short circuit, will be a measure of the resistance of the external circuit. The greater the reading of the voltmeter when connected to the external circuit the smaller the value of the resistance being measured. A table will be found in the back of this pamphlet giving voltmeter readings and the equivalent resistance in ohms. An open line will not show any deflection of the voltmeter needle.

11. *Test for continuity of a grounded line.*—Key No. 3 up. Connect the ground post "GND" to a water pipe, or, if using the set

in the field, drive the ground rod in moist earth. Connect the line to the L-1 bending post. If the line is closed the voltmeter will give a reading as in paragraph 10.

12. *Test for a ground on a metallic line.*—Key No. 3 up. Connect L-1 and L-2 to the desired line. Connect post "GND" to ground, or use ground rod, as in paragraph 11. If voltmeter shows a reading the wire connected to L-1 is grounded. Next operate key No. 2 down. If no voltmeter reading shows, the L-2 wire, which has been substituted for the L-1 wire, by the operation of key No. 2, is clear. A case may develop where both sides of the line are grounded, or where the line is crossed and one side grounded. In this case the voltmeter will show a reading when key No. 3 is thrown downward. A partial check on the trouble may be had by carefully observing the difference, if any, of the voltmeter reading when key No. 3 is up and key No. 2 has been moved to the down position. The wire giving the greater reading will in most cases be the grounded wire.

13. *Test for capacity.*—(Such as station with condenser in bell circuit.) Key No. 3 down. Move key No. 2 to down and back to normal, observing the "throw" of the voltmeter needle. The set can be calibrated by reading the deflection on lines having one bell and condenser, two bells and two condensers, and so on. The condenser at the station is charged and then discharged by the opening and closing of the circuit under control of key No. 2.

14. *Test for an open.*—Key No. 3 up. Connect one line wire to L-1 and connect "GND" to ground; move key No. 4 up and back to normal. This measures the capacity between the wire and the earth. (See also paragraph 13.) Change the other line wire to L-1, if a metallic line, and measure that one and observe the reading. The distance can be found approximately by a comparison of these two readings. In the above case, it is assumed that any equipment at the distant end has been disconnected, or that the equipment is known, so that allowance can be made for condensers. It is assumed also that the line is not grounded.

15. *Test for crosses on lines carrying current.*—Key No. 3 up. Connect "GND" to ground. Key No. 4 up. If the foreign line has its battery grounded, such as a common battery telephone line or a telegraph line, a voltmeter deflection will be shown reading directly in volts. The value of this reading will serve to designate the type of circuit that has caused the trouble. If the voltmeter needle tends to move off scale in the reverse direction, move key No. 5 up, to reverse the voltmeter. In making measurements of this nature some knowledge of the potentials that may be present on the line is necessary. The reason for this is the possible injury or burning out of the voltmeter by connecting to lines carrying high voltage.

It should be remembered that many telegraph circuits have an applied voltage in excess of 100 volts. If the needle goes off scale, the tester should immediately restore key No. 3 to normal position to open the voltmeter circuit.

16. *Test for crosses with other lines.*—In addition to tests outlined in paragraph 15, it may be thought that two lines, *a* and *b*, are crossed. In this case L-1 is connected to one side of line *a*, and L-2 to each side of line *b* in turn; key No. 3 down, being used. If no reading shows, change L-1 to the other wire of line *a* and repeat test. A reading of the voltmeter shows a cross. A similar test for crosses with grounded lines may be made, either by grounding L-2 or changing key No. 3 to up and using L-1 and the ground rod as in paragraph 14.

17. *Measuring an external battery voltage.*—Connect the terminal marked "BAT TEST" to the battery whose voltage is desired. Be sure to connect the positive terminal of the battery to the left-hand or plus post. Key No. 5 (down) connects the voltmeter directly across these posts and will read potentials, within the capacity of the instrument. Care should be observed not to expose the voltmeter to potentials outside the range of the instrument.

18. *Ring tests for crosses or grounds.*—This is a rapid means of testing a number of lines and is especially useful when a new system is being installed. To test for a cross, connect L-1 and L-2 to the desired line. Move key No. 1 down, rapidly turning the generator handle at the same time. If the line is open, the buzzer will not sound and the generator turns easily. If the line is closed—that is, the station bell connected to line—the generator turns readily and the buzzer sounds. A high resistance gives about the same test as a station. If the generator turns hard, the buzzer sounding also, a cross exists on the line under test. The degree of difficulty in turning the generator, and the loudness of the buzzer, may be taken as an estimate of the value of the resistance of the cross. To test for grounds, change L-2 to a ground connection and proceed as above. In making these tests it is best to operate the generator at a constant speed, so that the buzzer having once been adjusted may function correctly. Too high a speed increases the frequency of the alternating current given by the generator; it may be sufficiently high to give an inaccurate test by the non-response of the buzzer.

19. *To determine value of an unknown resistance.*—This method of testing is based on the principle that in any series circuit the various potentials in the circuit are proportional to the different resistances in the circuit. If the resistance of the voltmeter is known, the value of any other resistance may be calculated.

Let R = the resistance of the voltmeter.

Let V = the reading of the voltmeter when test leads are short-circuited. (Key No. 4 down.)

Let V' = the reading of the voltmeter when the test leads are connected to the unknown resistance, i. e., the voltage across the voltmeter. (Key No. 3 down.)

Then $V - V'$ = voltage across the resistance.

$$\text{Then } V' : V - V' :: R : X$$

$$\text{or } V' X = (V - V') R$$

$$X = \frac{(V - V') R}{V'} \quad (1)$$

Example: The voltmeter reads 39.5 volts when the test leads are shorted. When the test leads were connected to a tubular drop, the reading of the voltmeter was 32.5 volts. What is the resistance of the drop? Resistance of voltmeters averages 3,000 ohms. Substituting in (1) above:

$$\frac{(39.5 - 32.5) \times 3000}{32.5} = \frac{7 \times 3000}{32.5} = 646 \text{ ohms. Answer.}$$

Example: Suppose it is desired to find the insulation resistance of a certain line. The voltmeter reading on short circuit was 40 volts. When the set was connected to the line, the voltmeter reading was 12 volts. Resistance of the voltmeter is 3,000 ohms. Then substituting in (1) above:

$$\frac{(40 - 12) \times 3000}{12} = \frac{84000}{12} = 7000 \text{ ohms. Answer.}$$

This shows clearly that the smaller the reading of the voltmeter the higher the value of the resistance being measured. As the voltage of the battery falls off with age, frequent checks should be made when making resistance measurements.

20. *To determine the capacity between two wires.*—This method can be used roughly for determining the location of an open or break in the line. This method was referred to in paragraph 13; a simple method being shown for calibrating the set. To calibrate the set more accurately, proceed as follows:

a. Check the voltage of the test battery by operating key No. 4 to down position. Record this result.

b. Connect a 1 m. f. condenser (Type 21-M, Western Electric Co.) to the testing leads L-1, L-2. Move key No. 2 to down and back to normal. Read "throw" of needle and record.

c. A table can then be made as shown below:

Voltmeter battery reading, 39.5:

1 m. f. = 4.50

Therefore 2 m. f. = 9.00

3 m. f. = 13.50

4 m. f. = 18.00

d. An application of the above can best be understood by a practical problem. An unknown condenser was tested, the voltmeter "throw" being 2.25 volts. What is its capacity?

Let C = the value of the standard (1 m. f.)

Let C' = the unknown value

Let D = voltmeter reading on standard

Let D' = voltmeter reading on unknown.

Then $C : C' :: D : D'$

(Substituting) $1 : C' :: 4.5 : 2.25$

$$4.5 C' = 2.25$$

$$C' = \frac{2.25}{4.50} = .5 \text{ m. f.}$$

e. This same principle can be applied to the location of an open in a metallic line. If the distance, in feet or miles, between the two stations is known, the location test follows. The equipment at the terminal station must be disconnected. Test circuit for grounds and if clear proceed as follows:

Connect test lead L-1 to one line wire (the good one).

Ground the terminal marked "GND," operate the No. 3 key up.

Move key No. 4 up and back to normal, reading "throw" of voltmeter at the same time. Next change the other line wire to L-1. Read "throw" of voltmeter. Then the distance to the fault can be computed.

Let D = Voltmeter reading on first line wire.

Let D' = Voltmeter reading on second line wire.

Let L = Distance between stations.

Let X = Distance to fault.

Then $D : D' = L : X$

$$X = \frac{D' \times L}{D}$$

This test determines the capacity between either wire and the earth and is only an approximate location test, since the voltmeter is damped by the springs used to make it dead beat.

SECTION V.

PROCEDURE IN TESTING FOR AN UNKNOWN FAULT.

Paragraph.	21
Line out of order.....	

21. *Line out of order.*—In testing for an unknown fault the original report of the trouble will, in most cases, centralize it under one of the headings given in Section IV (Detailed instructions for using the set). The most difficult case is the report of the line being "out of order." Assume that such a report has been made on a given telephone line, the procedure would be as follows:

- a. Make a voltmeter test to see if the line is closed.
- b. Test for grounds.
- c. Open line at central office protector frame and ring toward the switchboard to see that drop or signal functions.
- d. Ring toward stations and try to call subscriber. After ringing, set keys for "Continuity of a metallic circuit" test. Observe voltmeter and if a deflection is shown after ringing, immediately change keys for position "Talk to magneto station." If party does not answer when this test is made, wait a few moments, ring station again, observe voltmeter and if needle is again deflected the trouble is at the station instrument; the most likely place being in the transmitter circuit. If trouble shows on some of the other tests (see a, b, c, above), it is evident that line trouble exists. For efficient testing a very complete record of the cables, lines, and instrument equipment is necessary; and in addition, a general knowledge of outside conditions, foreign wire circuits, pole line layouts, and so forth.

SECTION VI.

CARE AND ADJUSTMENT OF THE SET.

Procedure-----	Paragraph. 22
----------------	------------------

22. *Procedure.*—Figs. 2 and 3 shows the set box open for removal of battery or adjustment of the buzzer. Adjustment of the set to determine that it is in condition for use should be made as follows:

- a. Inspect cords and terminals and see that all cords are securely held by their respective binding posts.
- b. Connect a 1,000-ohm bell, that is in adjustment, across the test leads L-1, L-2. Operate ringing key No. 1 and turn generator handle, observing action of buzzer. If buzzer and bell do not respond, release ringing key, operate key No. 3 down. This shows whether the test leads are open or closed. A reading of the voltmeter signifies that the trouble is in the ringing key circuit. Key adjustment would be the most likely cause. If the station bell responded and buzzer did not, adjust buzzer by means of the two lock nuts on the vertical supporting posts until buzzer operates satisfactorily.
- c. Operate key No. 4 down and read battery voltage. Voltage should be approximately 44 volts when battery is new. When voltage falls to 38 volts, new batteries should be installed. If new BA-2 batteries are not available a temporary external battery can be substituted by connecting 30 reserve dry cells in series and to the posts marked "EX BAT." Before connecting the external battery be sure that the old battery in the test set has been disconnected.
- d. Operate key No. 1 up and short circuit the test leads L-1, L-2. Place receiver to your ear, press transmitter button, and blow lightly

into transmitter. If sound is reproduced clearly the BA-1 transmitter battery is in satisfactory condition.

e. Connect three or four cells in series and to the L-1 and L-2 leads. Operate key No. 4 up and if voltmeter shows a reading, this part of the circuit is functioning properly.

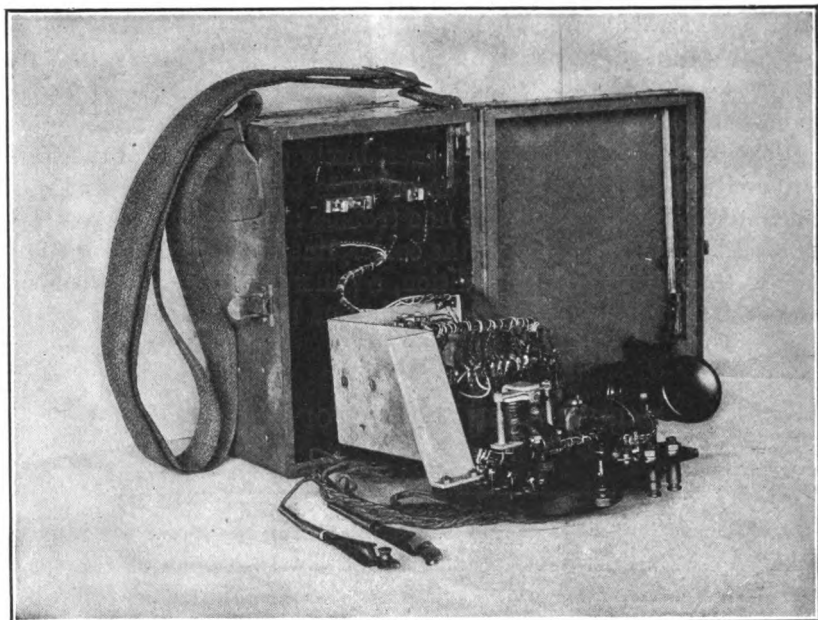


FIG. 2.—View of the interior of the test set.

f. Connect ground rod to L-1 test lead. Operate key No. 3 up. If circuit is working properly the needle should show a full scale reading on the voltmeter. This completes the check tests on the set and only occasional tests of this nature should be necessary. The most probable troubles that will develop in the set are battery and cord troubles. Care should be used to see that no strain is placed on the cord terminals, by using the reinforcement provided for this purpose.

SECTION VII.

TEST SET CIRCUITS.

Theory-----	Paragraph.
	23

23. *Theory.*—In figure 4 is shown the general wiring scheme of the set. These circuits will be discussed in detail in the following paragraphs. From the wiring diagram and the corresponding key designations the actual physical position of the equipment in the set and their electrical position in the various testing circuits can readily be seen.

a. Figure 5 shows the circuit when key No. 1 is in the down or ringing position. The trace of the circuit starts at L-1, through the long spring on L-1 side, through made spring (key No. 1 being operated), through automatic switch on generator shaft, generator, low-resistance buzzer, L-2 side made spring, long spring to L-2 post. This shows a series circuit, containing the magneto generator and buzzer, connected to the L-1, L-2 terminals.

b. Figure 6 shows the talking and listening circuits controlled by key No. 1 in the up position. Trace of circuit is from L-1 to long spring on "ringing" side of key, to inside of made spring, to long spring on "listen" side of key, to outside made spring, and to one

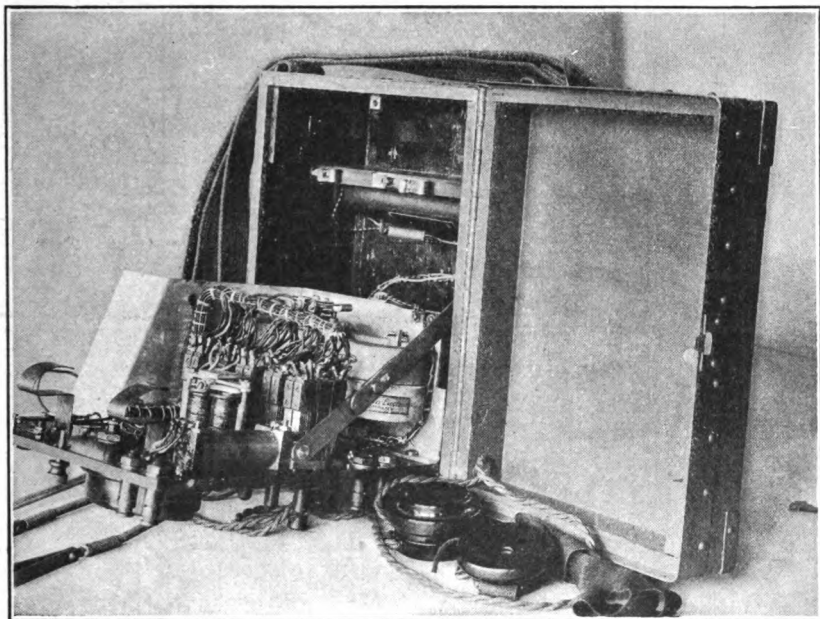


FIG. 3.—View of the interior of the test set.

side of receiver. From L-2 to long spring key No. 1 through made spring of key, to long spring, to outside made spring, to one side of secondary of induction coil, through coil to other side of receiver. The transmitter circuit starts at the positive side of 3-volt battery, through a pair of springs that are caused to make, whenever the key No. 1 is in the "listen" position, to "primary" of induction coil, to transmitter and the cut-out button (not shown), through transmitter to the negative side of the transmitter battery. The varying currents, set up by the transmitter, are impressed on the secondary side, through the action of the induction coil.

c. In figure 7 the circuit for measuring the potential or voltage of the testing battery is shown. Key No. 4 (down) opens the circuit

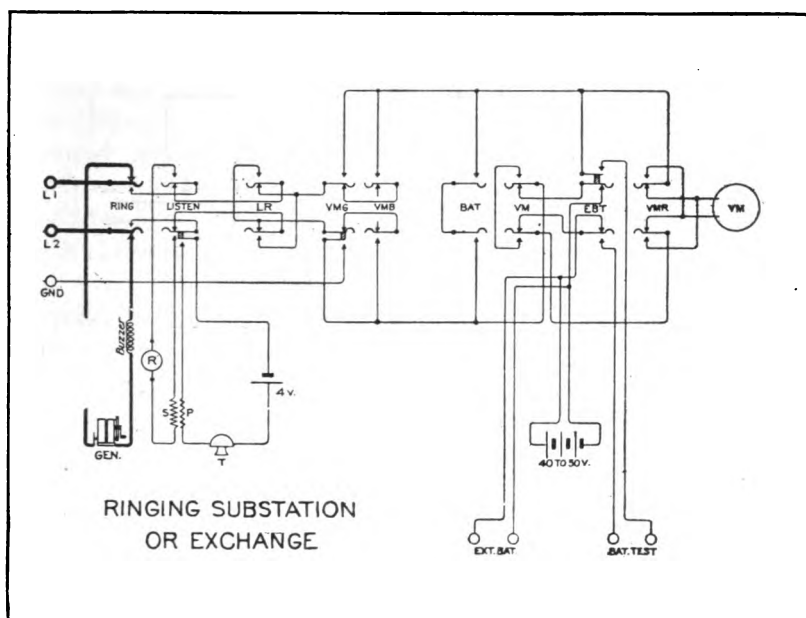


FIG. 5.

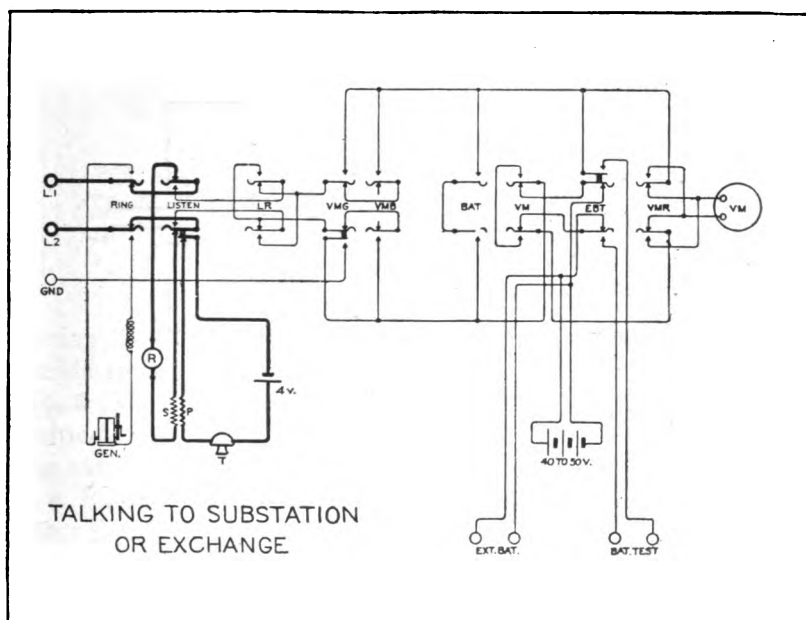


FIG. 6.

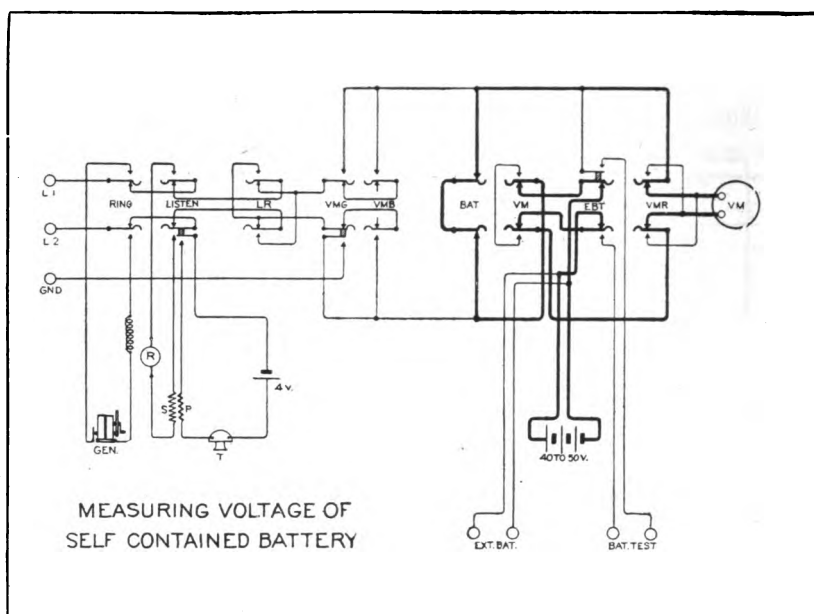


FIG. 7.

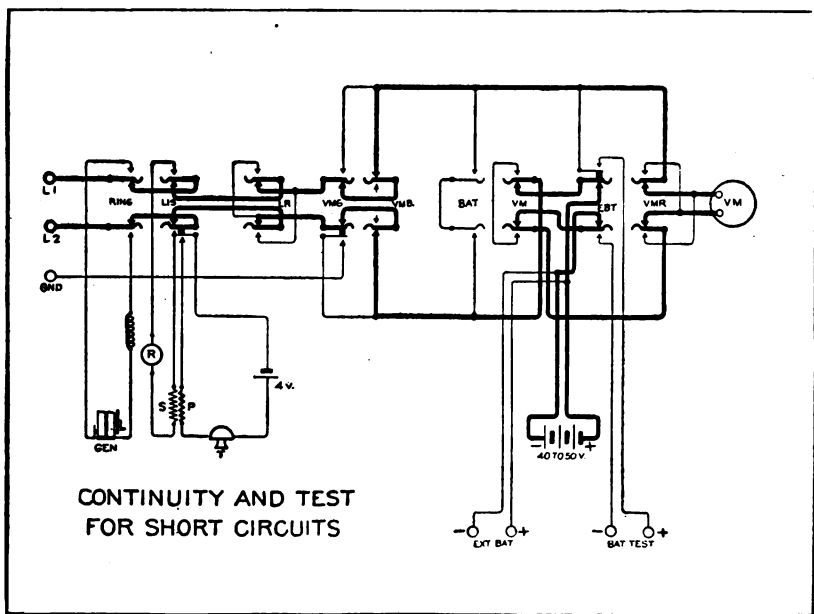


FIG. 8.

spring, to long spring, same key operated to down position (VMB), to outside made spring, to long spring, key No. 5 (VMR), through inside made spring, to one side of the voltmeter. From L-2 to long spring, key No. 1 (ring), to inside made spring, to long spring, same key (listen), to inside made spring, to long spring, key No. 2 (LR), through made spring to long spring, key No. 3 (VMG), to inside made spring, to long spring, same key (VMB) operated to down position, through outside made spring, to long spring, key No. 4 (VM), through inside made spring, to long spring, to L-1 side key No. 5 (EX BAT), through inside made spring, to positive side of 40-volt battery. From the negative side of battery to inside made

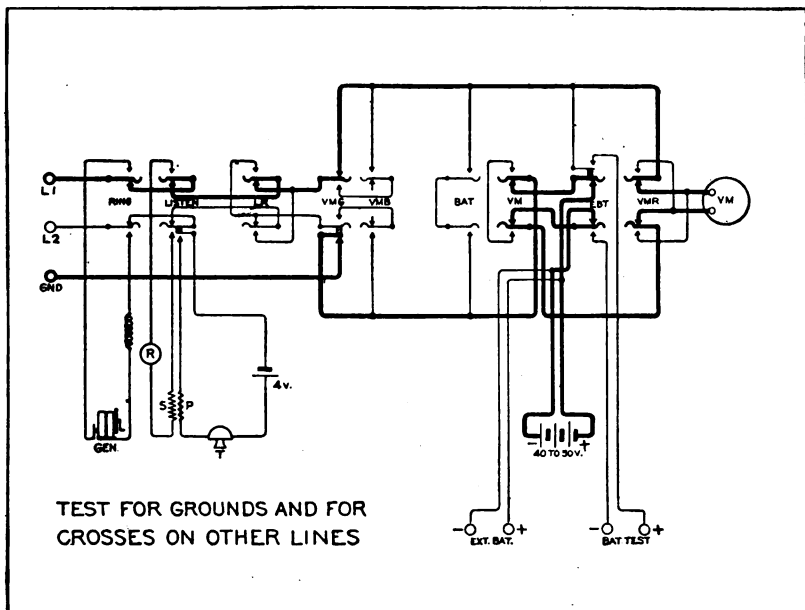


FIG. 9.

spring, key No. 5 (EX BAT), through long spring, same key, to inside spring key No. 4 (VM), to long spring, to long spring key No. 5 (VMR), through inside made spring, same key, to remaining voltmeter terminals. This circuit as previously explained connects the battery and voltmeter in series and across the L-1, L-2 leads.

e. Figure 9 shows the circuit for testing for grounds or crosses with other lines. The trace of the circuit starts at the L-1 terminal, to long spring of key No. 1 (ring), through inside made spring, to long spring, same key (listen), through the inside made spring, to long spring, key No. 2 (LR), through the inside made spring, same key, to the long spring, key No. 3 (VMG), to the outside made spring (the key being operated in the up position), to the long spring, key No. 5 (VMR), through inside made spring, to one terminal of the voltmeter. The trace of the other side of the circuit starts at the "GND"

post, through the outside made spring, key No. 3 (VMG) (the key being operated), through the insulated spring, to the long spring, key No. 4 (VM), through the inside made spring, through the long spring, same key (EX BAT), through the inside made spring, to the positive terminal of the battery. From the negative terminal of the battery the circuit is continued to the inside made spring, key No. 4 (EX BAT), through the long spring, to the inside made spring, same key (VM), through the long spring, to the long spring, key No. 5 (VMR), through the inside made spring, to the other terminal of the voltmeter. The circuit connects the testing battery in

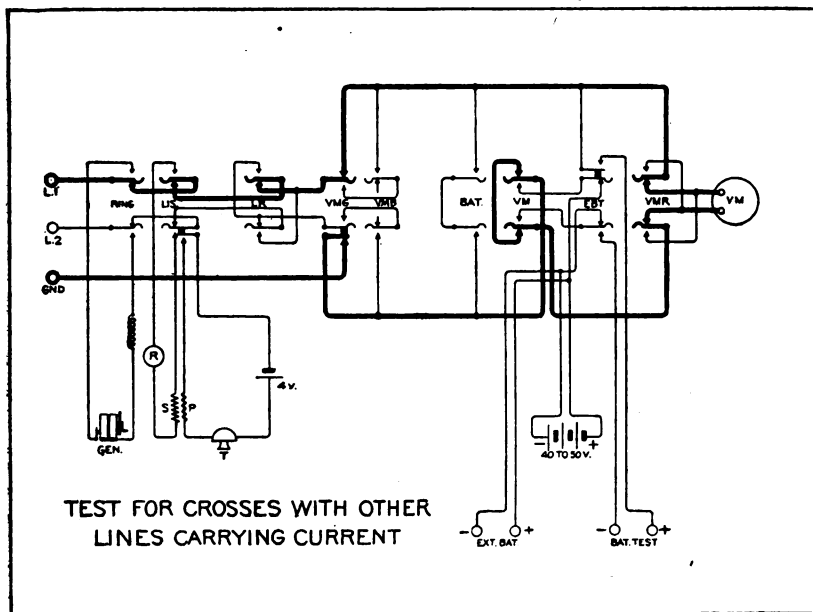


FIG. 10.

series with the voltmeter and across the L-1 and "GND" terminals. It is similar to the circuit shown for resistance tests.

f. Figure 10 shows the circuit for crosses with lines carrying current. The trace of the circuit is similar to the circuit in *e* above, except that key No. 4 has been operated to the up position (VM), in addition to key No. 3 given in *e*. This change cuts off the test battery and closes the voltmeter circuit directly across the L-1 and "GND" terminals. Therefore a foreign potential can be measured by the voltmeter.

g. Figure 11 shows the circuit for measuring the voltage of any source of current that may be connected across the "BAT TEST" posts. The trace of the circuit is from the left hand "BAT TEST" post (positive) to the L-1 side of outside made spring, key No. 5 (EX BAT TEST) (the key being operated in the down position),

through the insulated made spring to the long spring, same key (VMR), through the inside made spring to one terminal of the voltmeter. From the negative "BAT TEST" post to the outside made spring, key No. 5 (EX BAT TEST), through the long spring to the inside made spring, key No. 4 (VM), through the long spring to the long L-2 side spring, key No. 5 (VMR), through the inside made spring, to the other voltmeter terminal. This circuit connects the voltmeter across the "BAT TEST" posts and, at the same time,

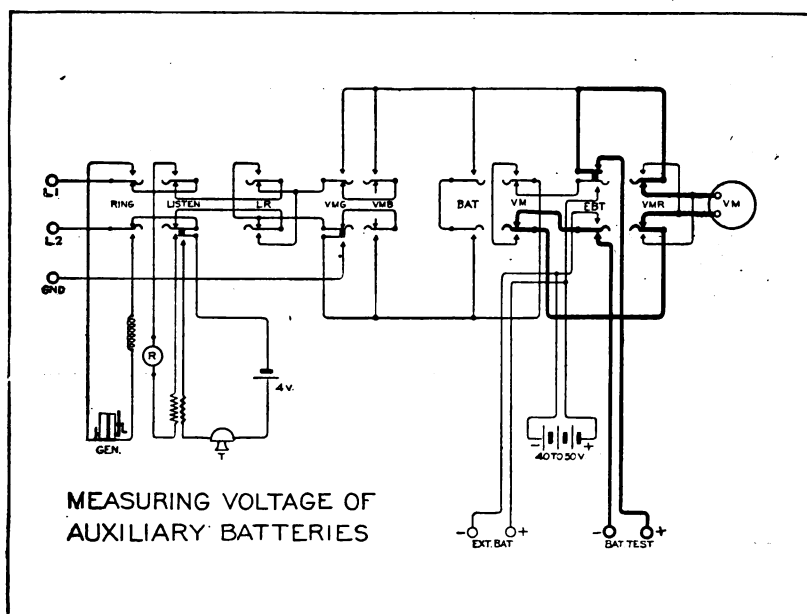


FIG. 11.

disconnects it from the test terminals and the testing battery. Care should be used to keep the potentials, whose values are to be determined, within the range of the voltmeter. Also see that the positive terminal of the desired battery is connected to the positive terminal of the set. Excessive battery voltages may injure the voltmeter and a reversed battery may bend the needle, thus causing it to become inaccurate.

SECTION VIII.

USEFUL TABLES.

	Paragraph.
Wire.....	24
Insulation resistance.....	25

24. Wire.—Resistance and weights of wires and cables most commonly used by the Signal Corps for communication purposes.

[The resistance given in this table is correct for a temperature of 68 degrees F. (20 degrees C.), and will be greater for a higher temperature and less for a lower temperature.]

	Weight per mille.	Resistance per mile of single wire, in ohms.
Hard-drawn bare copper wire:	Pounds.	Ohms.
No. 8, B. & S.....	264.0	3.310
No. 9, B. & S.....	209.3	4.173
No. 10, B. & S.....	166.0	5.264
No. 12, B. & S.....	104.5	8.370
No. 14, N. B. S.....	104.5	8.370
Galvanized-iron wire of B. B. grade:		
No. 9, B. W. G.....	320	17.19
No. 10, B. W. G.....	260	21.15
No. 12, B. W. G.....	165	33.33
No. 14, B. W. G.....	96	57.29
Bronze, phosper, No. 17, B. & S.....	33	42.0
Outside distributing, twisted pair, copper clad, No. 17, B. & S.....	240	95.1
Field, 11 strand:		
Single.....	90	51.0
Twisted pair.....	183	52.0
Outpost, 7-strand (3-steel, 4-bronze):		
Single.....	64	140.0
Twisted pair.....	130	142.0
Buzzer (2-steel, 1-copper).....	7	32.0
Cable, paper insulated and lead covered:		
No. 19, B. & S., 10 pair.....	5,610	44.0
No. 22, B. & S., 10 pair.....	3,000	88.0

Average number of feet per ohm in No. 22 gauge lead-covered cable, allowance being made for spiraling:

Number of pairs.	At 60 degrees F.	At 80 degrees F.
10 to 50 pairs.....	62.76	60.19
100 pairs.....	62.58	60.00
200 pairs.....	62.14	59.58

25. *Insulation resistance.*—Value of V' with corresponding values of X (resistance) with test battery at 40 volts. (See par. 10.) The resistance of the volt meter is *assumed* to be 3,000 ohms.

When V' equals 1, then X equals 117,000 ohms.

When V' equals 2, then X equals 57,000 ohms.

When V' equals 3, then X equals 37,000 ohms.

When V' equals 4, then X equals 36,000 ohms.

When V' equals 5, then X equals 21,000 ohms.

When V' equals 6, then X equals 17,000 ohms.

When V' equals 7, then X equals 14,140 ohms.

When V' equals 8, then X equals 12,000 ohms.

When V' equals 9, then X equals 10,330 ohms.

When V' equals 10, then X equals 9,000 ohms.

When V' equals 11, then X equals 7,900 ohms.

When V' equals 12, then X equals 7,000 ohms.

When V' equals 13, then X equals 6,230 ohms.

When V' equals 14, then X equals 5,570 ohms.
 When V' equals 15, then X equals 5,000 ohms.
 When V' equals 16, then X equals 4,500 ohms.
 When V' equals 17, then X equals 4,050 ohms.
 When V' equals 18, then X equals 3,660 ohms.
 When V' equals 19, then X equals 3,320 ohms.
 When V' equals 20, then X equals 3,000 ohms.
 When V' equals 25, then X equals 1,500 ohms.
 When V' equals 30, then X equals 1,000 ohms.
 When V' equals 35, then X equals 428 ohms.
 When V' equals 40, then X equals 0 ohm.

SECTION IX.

PARTS LIST.

Parts list-----	Paragraph.
	26

26. Parts list—

- 1 battery, type BA-1, for transmitter.
- 2 batteries, type BA-2, for test set.
- 1 buzzer, alternating current, 80 ohms.
- 1 case, carrying, 6 inches deep by $8\frac{1}{4}$ inches wide by $10\frac{1}{4}$ inches high; weight, complete, 14 pounds.
- 2 clips, test, with cord and terminals.
- 1 generator, hand, with handle.
- 1 ground rod, with cord and terminals.
- 1 induction coil, local battery.
- 5 keys, test, with red rubber handles.
- 1 receiver, hand, with head strap, cords, and terminals, No. 84-B.
- 1 strap, carrying.
- 1 transmitter, complete with cut-out button; cords, and terminals, local battery.
- 1 voltmeter, Weston, Model 280, 0-50 volts, D. C., back connected.

SIGNAL CORPS PAMPHLETS.

(Corrected to Feb. 1, 1921.)

SIGNAL CORPS PAMPHLETS.

(Formerly designated radio pamphlets.)

- No.
1. Elementary Principles of Radio Telegraphy and Telephony (edition of 4-28-21) (WDD 1064).
 2. Antenna Systems.
 3. Radio Receiving Sets (SCR-54 and SCR-54-A) and Vacuum Tube Detector Equipment (Type DT-3-A).
 5. Airplane Radio Telegraph Transmitting Sets (Types SCR-65 and 65-A).
 9. Amplifiers and Heterodynes (WDD No. 1092).
 11. Radio Telegraph Transmitting Sets (SCR-74; SCR-74-A).
 13. Airplane Radio Telegraph Transmitting Set (Type SCR-73).
 14. Radio Telegraph Transmitting Set (Type SCR-69).
 17. Sets, U. W. Radio Telegraph (Types SCR-79-A and SCR-99) (WDD No. 1084).
 20. Airplane Radio Telephone Sets (Types SCR-68; SCR-68-A; SCR-114; SCR-116; SCR-59; SCR-59-A; SCR-75; SCR-115).
 22. Ground Radio Telephone Sets (Types SCR-67; SCR-67-A) (WDD No. 1091).
 23. U. W. Airplane Radio Telegraph Set (Type SCR-80).
 24. Tank Radio Telegraph Set (Type SCR-78-A).
 25. Set, Radio Telegraph, Type SCR-105 (WDD No. 1077).
 26. Sets, U. W. Radio Telegraph, Types SCR-127 and SCR-130 (WDD No. 1056).
 28. Wavemeters and Decremeters (WDD No. 1094).
 30. The Radio Mechanic and the Airplane.
 40. The Principles Underlying Radio Communication (edition of May, 1921) (WDD No. 1069).

WIRE COMMUNICATION PAMPHLETS.

(Formerly designated electrical engineering pamphlets.)

1. The Buzzerphone (Type EE-1).
2. Monocord Switchboards of Units Type EE-2 and Type EE-2-A and Monocord Switchboard Operator's Set Type EE-64 (WDD No. 1081).
3. Field Telephones (Types EE-3; EE-4; EE-5).
4. Laying Cable in the Forward Area (formerly designated Training Pamphlet No. 3).
6. Trench Line Construction (formerly designated Training Pamphlet No. 6-a).
7. Signal Corps Universal Test Set, Type EE-65 (WDD No. 1020) (2d edition).
10. Wire Axis Installation and Maintenance Within the Division (WDD No. 1068).

TRAINING PAMPHLETS.

1. Elementary Electricity (edition of 1-1-21) (WDD No. 1055).
4. Visual Signaling.
7. Primary Batteries (formerly designated Radio Pamphlet No. 7).
8. Storage Batteries (formerly designated Radio Pamphlet No. 8).

FIELD PAMPHLETS.

1. Directions for Using the 24-CM Signal Lamp (Type EE-7).
2. Directions for Using the 14-CM Signal Lamp (Type EE-6).

ELEMENTS OF THE AUTOMATIC TELEPHONE SYSTEM

Wire Communication Pamphlet No. 11

PREPARED FOR THE OFFICE OF THE
CHIEF SIGNAL OFFICER

February, 1922



WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

CERTIFICATE: By direction of the Secretary of War, the matter contained herein is published as administrative information and is required for the proper transaction of the public business.

WAR DEPARTMENT
Document No. 1096
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WAR DEPARTMENT,
WASHINGTON, *February 28, 1922.*

The following publication, entitled "Elements of the Automatic Telephone System," Wire Communication Pamphlet No. 11, is published for the information and guidance of all concerned.

[A. G. 062.1 (2-16-22)].

BY ORDER OF THE SECRETARY OF WAR:

JOHN J. PERSHING,
*General of the Armies,
Chief of Staff.*

OFFICIAL:

P. C. HARRIS,
The Adjutant General.

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ELEMENTS OF THE AUTOMATIC TELEPHONE SYSTEM.

SCOPE OF PAMPHLET.

The studies of the automatic system are divided into two parts. Part I is an elementary discussion of the system based on an article prepared for the Chief Signal Officer of the Army by the Automatic Electric Co. Part II was prepared by the telephone section of the Bureau of Standards for the Chief Signal Officer. Part II gives functionalized circuit drawings of the automatic system.

PART I.

ELEMENTARY DISCUSSION OF AUTOMATIC TELEPHONE SYSTEM.

SECTION I.

INTRODUCTION.

	Paragraph.
Definition and advantages.....	1
Purpose of switchboard mechanisms.....	2
Method of calling a number.....	3
Equipment of a 100-line system.....	4
Purpose of connector switch.....	5
Purpose of line switch.....	6

1. *Definition and advantages.*—An automatic telephone system is one in which connections between subscribers' substations are set up and released, not by central-office operators, but by machines which are controlled by the subscriber at the calling station. The advantages claimed for the automatic system described here (Strowger type) are briefly: Saving of operators' salaries, training expenses, and accommodations; positive and rapid sending of call number; positive and accurate busy or ringing signals; long life and immunity from faults; uniform speed of connection and disconnection which tends to reduce peak-load conditions.

2. *Purpose of switchboard mechanisms.*—The central-office mechanisms, or automatic switches, are grouped together and mounted in frames to form switchboards. Their purpose is essentially the same as that of an operator in a manual system, namely, to connect the calling station with the one desired, to test the called line and return

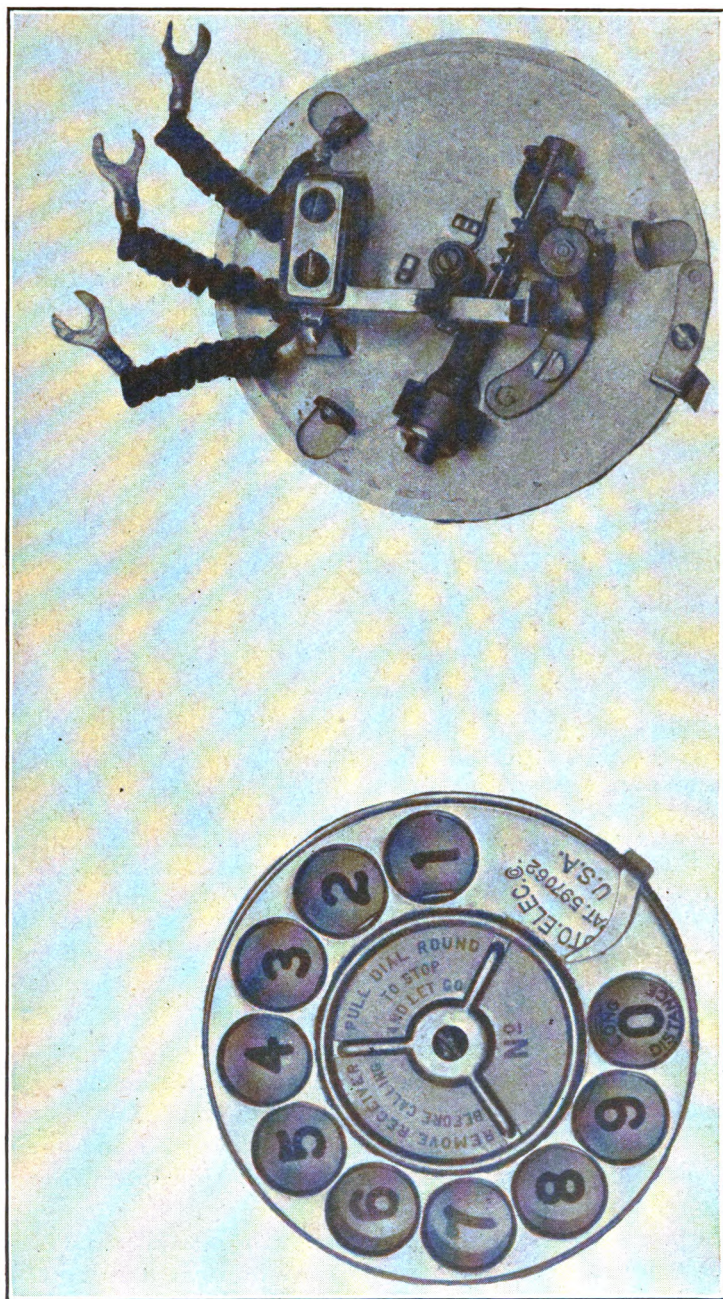


FIG. 1.—Dial calling device.

a definite signal if the line is busy, to ring the called bell if idle, to provide for the transmission of the voice, and to release the connection when conversation is finished.

3. *Method of calling a number.*—To enable the calling subscriber to control the central-office equipment so that it will connect his telephone with the proper station, his telephone is fitted with what is known as a dial calling device. (Fig. 1.) Besides this, there is of course the customary transmitter and receiver and bell box of the ordinary common battery telephone. To call a number on the automatic system the calling subscriber places his finger in a certain one of the holes in the dial and turns the dial until his finger strikes a stop. Upon releasing the dial it returns to normal and, in doing so, generates, by making and breaking a circuit having its battery at the central office, a number of electrical impulses which are transmitted to the central-office equipment. The operation is repeated for each figure of the call number.

4. *Equipment of a 100-line system.*—To facilitate the study of this system it is better at first to consider an exchange of only 100 lines. Such an exchange consists of 100 telephones and their lines (two wires each) leading to the central office, each line terminating in a line switch; 100-line switches (fig. 2), one attached to each line; a number of connector switches (fig. 3) sufficient to carry the traffic; and power equipment for supplying battery and ringing currents.

5. *Purpose of connector switch.*—The purpose of the connector switch is to do the work that is ordinarily done by an operator in a manual system. It must first search out the called line under the control of the calling subscribers' calling device, then test the line to see if it is busy or idle. If busy, the connector denies the connection and returns an audible busy signal on the calling line. If the line is idle, the connector rings the bell of the called station until the call is answered, or until the calling subscriber releases. When conversation is finished and both receivers are replaced, the connector switch is released ready for further use. (Sometimes the equipment is arranged so that the disconnection is made either by the calling or called party or both.) The number of connectors supplied for a 100-line board varies from 8 to 20. One connector switch is in use during one conversation. It will be convenient for our purpose to consider a 10-connector switchboard.

6. *Purpose of line switch.*—When the receiver is removed from the hook at the calling telephone, the line switch operates to connect the calling line with an idle connector. The line switch takes no further part in the connection, but releases when conversation is finished.

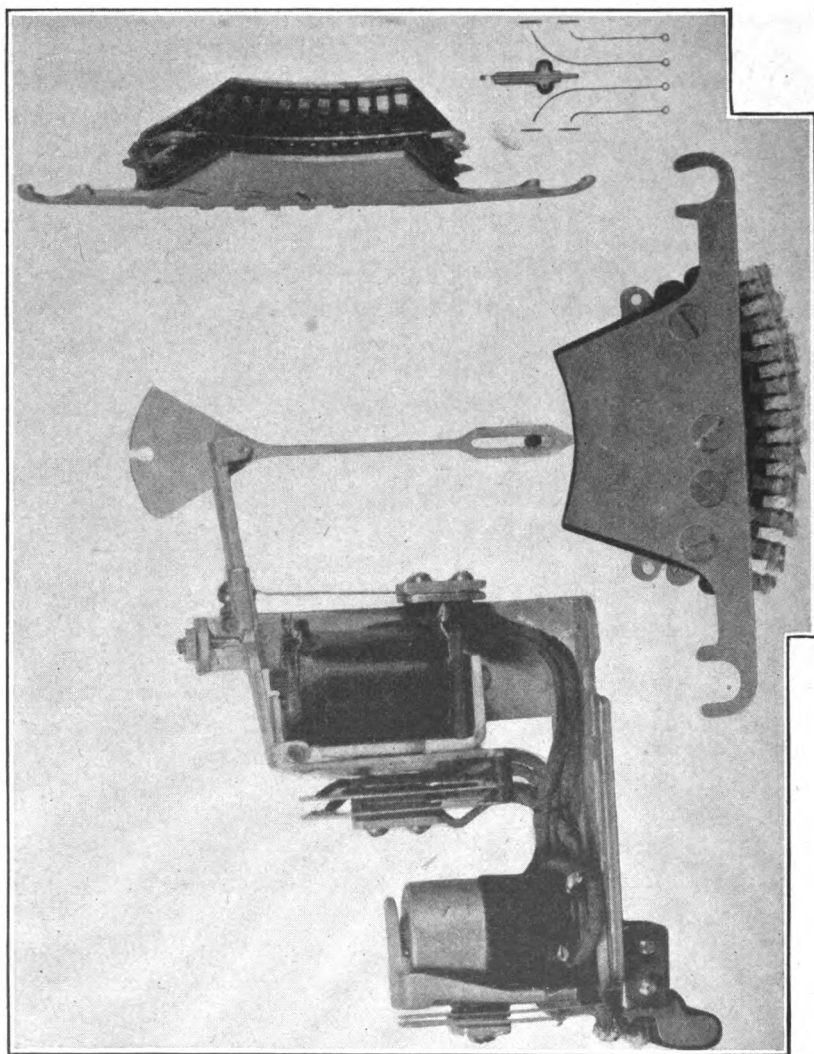


FIG. 2.—Plunger line switch with bank.

SECTION II.

DESCRIPTION OF CONNECTOR SWITCH.

	Paragraph.
Parts of connector switch.....	7
Arrangement of wiper springs and contact banks.....	8
Connections between different connectors.....	9

7. *Parts of connector switch.*—The connector switch (fig. 3) consists essentially of the following parts:

(a) A vertical shaft (A) carrying on its lower end three wiper springs (W).

(b) Vertical magnet and ratchet (B) by means of which the shaft may be lifted a step at a time from 1 to 10 steps.

(c) Rotary magnet and ratchet (C) by means of which the shaft may be rotated a step at a time from 1 to 10 steps, beginning after any number of vertical steps. This rotary motion takes place against the action of a spring (D) at the top of the shaft.

(d) Release magnet which, when operated, serves to release the ratchet detent and permit the shaft to drop to its normal position.

(e) A group of relays for transmitting the selective impulse to the vertical and rotary magnets and for controlling the other operations of the connector.

(f) The line bank (E) consisting of 100 pairs of brass contacts arranged in 10 semicircular rows containing 10 pairs of contacts per row. These contacts are the terminals of the 100 telephone lines.

(g) Private bank (F) of 100 single contacts arranged in a similar manner and placed above the line bank. These contacts are for the purpose of guarding the called line for interior off-normal springs.

(h) A set of contact springs (G) which are arranged to operate at the first upward step of the shaft and to remain operated until the shaft returns to its normal position.

8. *Arrangement of wiper springs and contact banks.*—The relation between the wiper springs and the contact banks is such that when the shaft is given a certain number of vertical and rotary steps the private (upper) wiper spring and the two line (lower) wiper springs will rest on the line and private contact corresponding to the number of vertical and rotary steps made. If, for instance, the number 25 is called on the calling device, the vertical magnet is first operated twice, stepping the shaft up until the wipers are resting *in line with* the second row of contacts. Then the rotary magnet is operated five times, stepping the shaft around until the wipers are resting on the fifth set of contacts in the second row, which contacts are the terminals of (circuit) No. 25.

9. *Connections between different connectors.*—To make it possible for any connector switch to call any one of the 100 lines the corresponding contacts of all line and private banks are connected in multiple. That

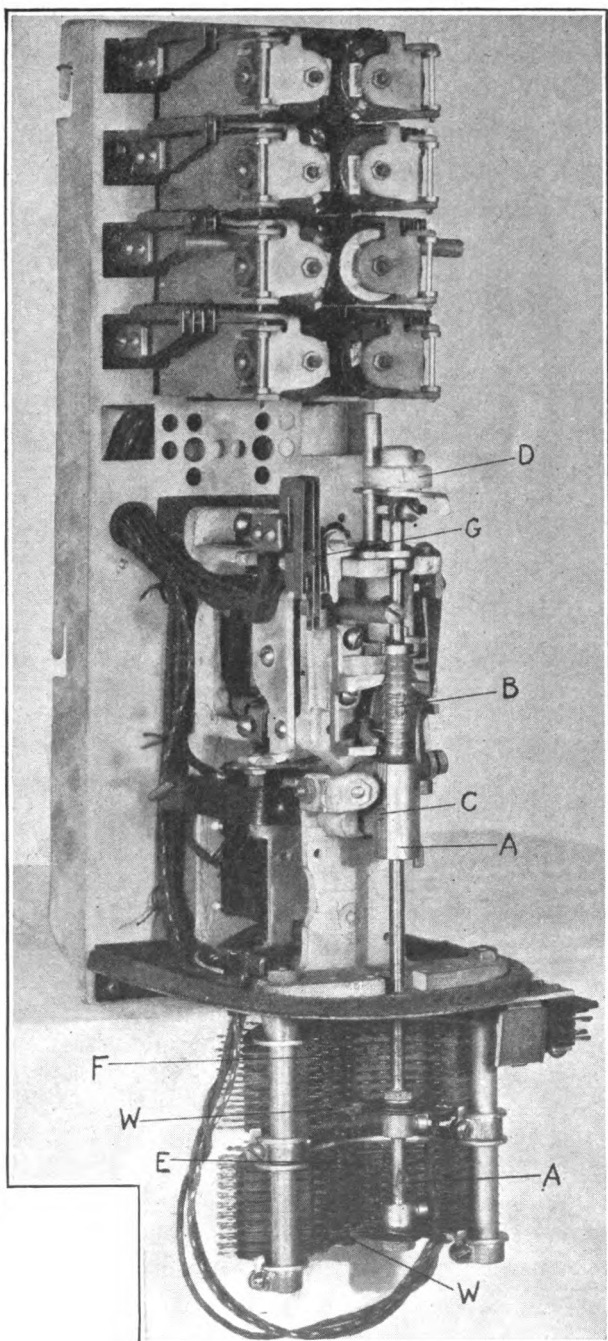


FIG. 3.—Connector with links.

is, contacts No. 11 of the first switch are connected to contacts No. 11 of all other switches, and so on. It is to be remembered that there are 10 connector switches in the system here discussed.

SECTION III.

ACTION OF CIRCUIT FROM TELEPHONE TO CONNECTOR SWITCH.

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Details of the telephone instrument circuit.....	11
How the action of the dial is transferred to the connector switch.....	12

10. *Condition of circuit.*—To facilitate further study of the system it is to be assumed at first that the receiver has already been lifted and that the telephone line has already been extended by means of the line switch to the connector switch. The action of the line switch will be described later.

11. *Details of the telephone instrument circuit.*—In its simplest form the telephone circuit consists of a bell and condenser in the signaling branch, a transmitter and receiver in the talking branch, a dial calling device, and a hook switch. With the exception of the dial, it is a simple common battery telephone. The dial calling device adds a pair of impulse springs (CD) for breaking and making the circuit so as to control the switches in the central office and a shunt spring which cuts out the talking apparatus during the time that the dial is in operation. These are shown in figure 4. This is done to reduce the noise in the receiver and to permit dialing to occur in a circuit of low resistance.

12. *How the action of the dial is transferred to the connector switch.*—In calling, say, the No. 56, the calling subscriber first places his finger in the hole of the dial through which the figure 5 appears. He then turns the dial in a clockwise direction until his finger strikes a stop. When the dial is released, it rotates back to normal, and in doing so causes the impulse springs to open and close a number of times corresponding to the figure dialed, in this case five. To call the second figure, 6, a similar operation is repeated.

The line circuit (fig. 4) includes at the central office a line relay (LR) and battery and at the telephone the impulse springs (CD) of the calling device. The dial by breaking and making the circuit causes the line relay to operate in groups of impulses, depending upon the number called. The line relay repeats these impulses through the release relay (Rel. Relay) and the series relay to the magnets (MAG) which operate the connector switch. It is to be noted that, in figure 4, the circuits and functions of the line switch are not shown. This is done for the sake of simplicity. The location of the line switch in the circuit is shown by the broken lines.

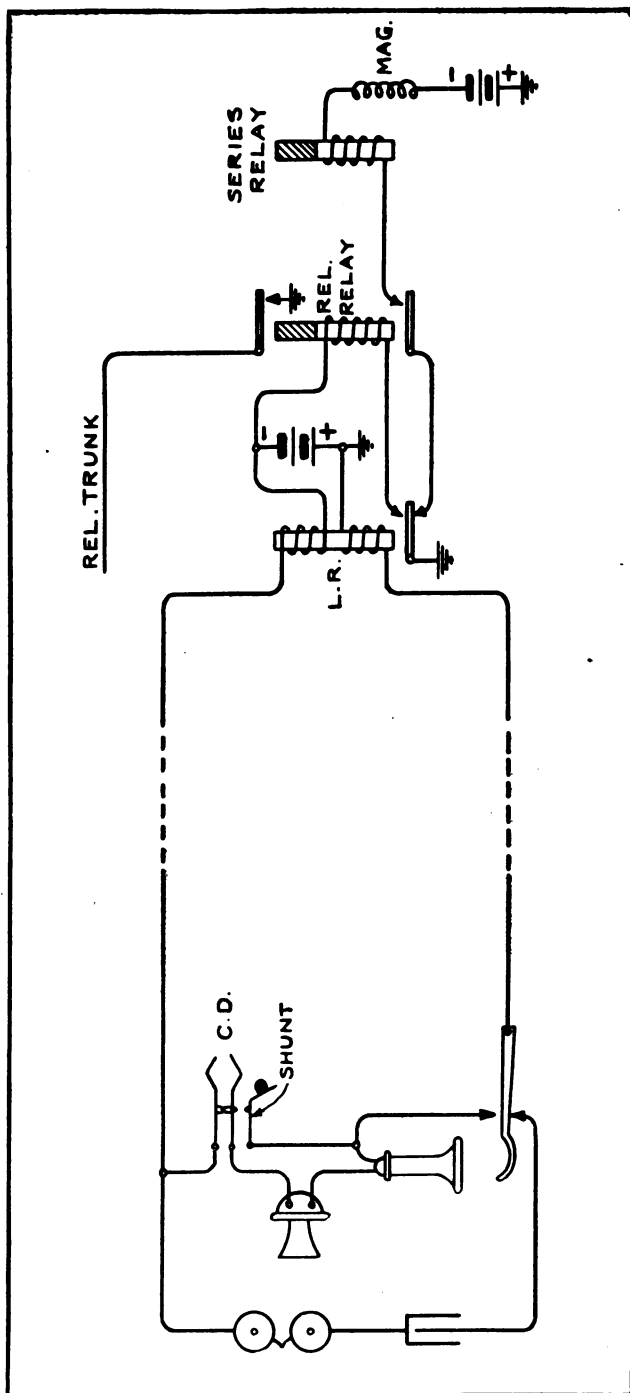


FIG. 4.—Simplified line circuit.

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CONNECTOR SWITCH CIRCUITS.

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Action of the first series of impulses.....	15
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Seizing the called circuit.....	18
The ringing circuit.....	19
The talking circuit.....	20
Effect of hanging up receivers.....	21

13. *Function of connector switch.*—The functions of the connector switch are as follows: (1) To protect the calling line; (2) to lift and rotate the wipers to the desired pair of contacts under the control of the calling device; (3) to keep the wipers clear until the called line has been prepared for connection; (4) to test the called line to see if it is busy, preventing connection thereto and notifying the calling subscriber by a busy tone; (5) to seize the called line if it is free, sending ringing current to called telephone and cutting it off when the subscriber answers; (6) to furnish connections to battery for battery transmission of the voice; (7) to release connections when both subscribers hang up their receivers.

14. *Action of the release relay.*—When the subscriber takes his receiver from the hook, the line relay pulls up. It must be remembered throughout the following discussion that the line relay is always energized when the receiver is off the hook except when the connections are broken by the dial rotating. The line relay in turn energizes the release relay, which places a ground upon the wire marked "release trunk." (Fig. 4.) The release relay also connects through the series magnet the impulsing circuit to the vertical magnet of the connection (MAG). The release relay is of the slow release type. It will remain energized during a series of impulses made by the line relay and will fall back if the line relay is deenergized much longer than one impulse period. Part of the circuit shown in figure 4 is also shown in figure 5, A being the line relay; B, the release relay; C, the series relay; and "VERT," the vertical magnet.

15. *Action of the first series of impulses.*—Some provision must be made so that the first series of impulses generated by the line relay will operate the vertical magnet (VERT) and after a brief pause, a second group of impulses will operate the rotary magnet (ROT). This shifting is caused by the joint action of the series relay (C) and the off-normal springs (ONS). The line relay (A) contact moves in response to the calling device. The impulses which it generates pass through the off-normal springs (ONS), (as noted above, the release relay remains energized), the windings of the series relay (C),

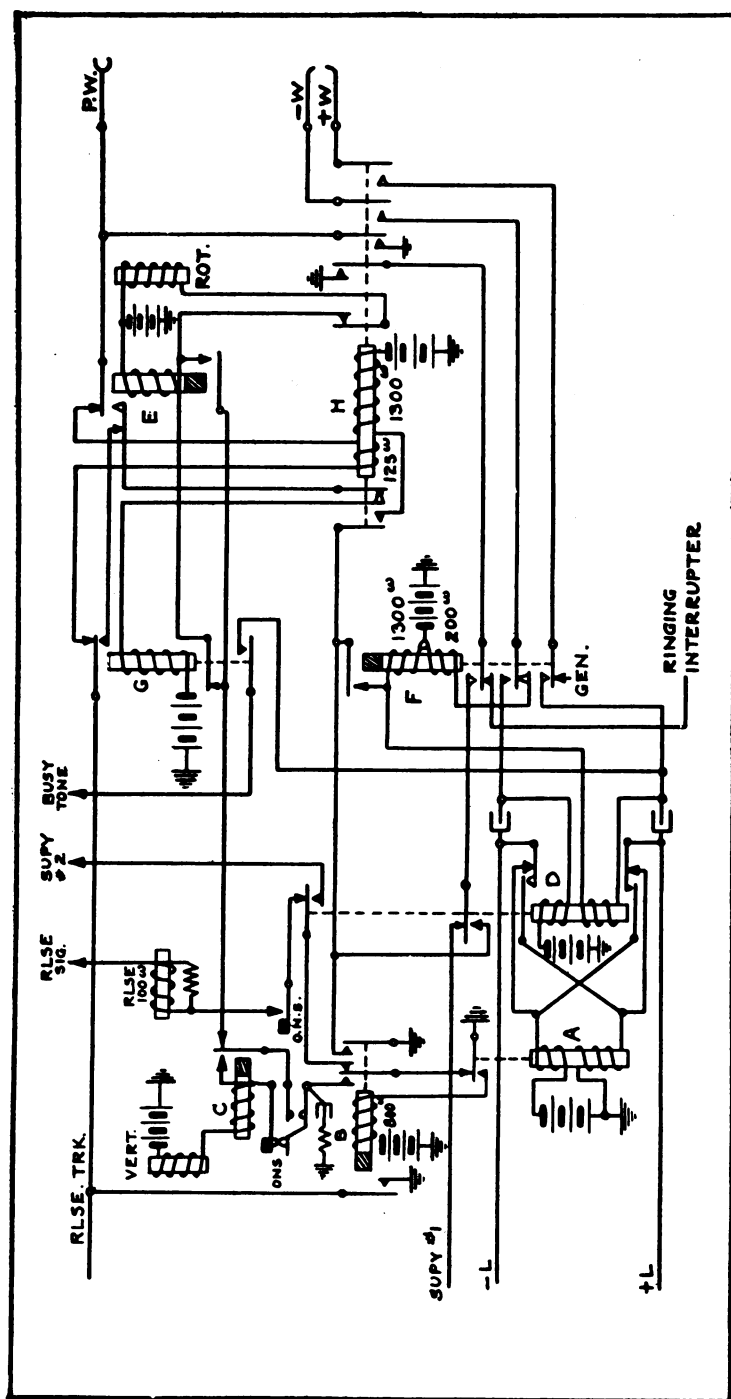


Fig. 5.—Simplified circuits of the connector switch.

and the windings of the vertical magnet. The first pulsation through this circuit energizes both devices. The series relay (C) pulls up ahead of the vertical magnet. When the vertical magnet lifts the shaft, the off-normal springs are operated by the shaft and remain operated until the shaft drops back to normal position. The off-normal springs cut off the direct connection to the series relay coil and establish it by way of the front contact of the same. The series relay is slow releasing. Consequently, as long as the pulsations continue to come, this circuit will be maintained. If, however, the line relay stops sending pulsations for a short time, the series relay (C) will fall back and divert the circuit from the vertical magnet to the rotary magnet and its associated slow release relay (E).

16. *Action of the second series of impulses.*—The second series of impulses generated by the line relay under the control of the calling device pass through the off-normal springs, back contact of series relay, back contact of relay (G), to the rotary magnet and relay (E) in parallel. The first impulse causes both of them to act together, relay (E) closing another contact, which permits pulsations to come regardless of the condition of contact of relay (G). Relay (E) is also slow releasing so that as long as the impulses come from the line relay (A) at the customary frequency, the circuit will be maintained. If contact of (G) should be open at the time that the line relay ceases giving impulses, relay (E) will fall back, thus breaking the circuit and rendering any further rotary motion impossible.

17. *Testing of a called line.*—The testing of a called line is the duty of relay (G). During the time that rotary impulses are being sent, relay (E) was energized. When rotary impulses stop coming, the line wipers ($-W, +W$) are resting upon the called line and the private wiper (PW) is resting upon the private contact which belongs to the same line, these connections having been made by the successive movements of the vertical and rotary magnets. If the called line is busy, there will be a positive battery or *ground* connection upon this private contact. This is the signal or indication that the line is occupied. If this is the case, current will immediately flow from this ground through the private wiper, front contact of relay (E)—which is energized—winding of relay (G) to negative battery. Relay (G) will therefore energize and make the busy-tone contact, placing a busy tone upon the positive line leading to the calling subscriber's telephone. Relay (E) will fall back because rotary pulsations have ceased, and therefore relay (G) will remain locked in an energized position through one of its own contacts to the ground at the release relay (B). The only thing the calling subscriber can do is to hang up his receiver. This breaks all connections and the apparatus returns to normal.

18. *Seizing the called circuit.*—If the called line is not busy, there will be no ground upon the private contact and relay (G) will not pull up. This permits the establishment of the seizing circuit. This seizing circuit passes from ground at the release relay (B), through the back contact on relay (G), the 125-ohm winding on relay (H), the back contact of relay (E), the private wiper (PW), the private bank contact (not in drawing) through a coil associated with the called line to negative battery. Relay (H) pulls up by its 125-ohm winding (there are seven makes or breaks) and locks itself by its 1,300-ohm winding, which obtains its ground at release relay (B). Relay (H) also places a dead ground upon the private wiper so as to prevent the called line from being seized by any other connector. The same relay (H) connects the ringing relay (F) to the line wipers so that ringing current will be sent to the called telephone.

19. *The ringing circuit.*—The ringing circuit comes through a grounded generator, through positive line wiper, through the called telephone bell, back to the negative line wiper, and through a 200-ohm winding on the ringing relay (F) to negative battery to ground. Relay (F) is made in such a form as to prevent its operation by the alternating current used for ringing. It will, however, operate with direct current which flows from the battery at (F) when the called subscriber lifts his receiver, thus substituting the talking apparatus for the *condenser* and bells. The ring-off relay (F) on pulling up by its 200-ohm winding locks itself through its 1,300-ohm winding, cuts off the ringing current, and switches the lines to the talking apparatus. The battery associated with relay (F) finds its ground near relay (B).

20. *The talking circuit.*—Conversation is carried on through the connector switch by means of relay impedances and condensers. The back bridge relay (D) supplies current to the called telephone. The line relay (A) performs the same function for the calling telephone. It is customary to arrange it so that the back bridge relay (D) reverses the connections of the line relay (A) as shown. This also permits the use of message registers on the line. The talking circuit, as well as other circuits, is shown separately in figure 6. These circuits are parts of the complete circuit shown in figure 5.

21. *Effect of hanging up receivers.*—When both subscribers hang up their receivers, line relay (A) and back bridge relay (D) both fall back and establish the release circuit. This release circuit also passes through the off-normal springs (ONS) which are closed as long as the shaft and wipers are away from normal. The operation of the release magnet causes the shaft and wipers to rotate and drop to normal, which opens the off-normal springs (ONS), cutting off the current.

SECTION V.

THE ROTARY LINE SWITCH.

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Function of rotary line switch.....	22
Description of rotary line switch.....	23
Action of line switch on calling line—private wipers on idle contact.....	24
Action of line switch on calling line—private wipers on busy contact.....	25
Action of line switch on called line.....	26

22. *Function of rotary line switch.*—There are two kinds of line switches, the rotary and plunger types. The functions of the rotary line switch are as follows: When a subscriber initiates a call, the switch must extend the line to an idle connector; it must protect the calling subscriber by placing a ground upon the private normal so that the connector switch will find the line busy; it must clear the talking circuit of the apparatus at the line switch. When a call is sent from a connector to the line to which the line switch belongs, its only function is to clear the talking circuit of the apparatus at the line switch.

23. *Description of rotary line switch.*—The rotary switch consists of three semicircular rows of contacts and three wiper springs driven by a single magnet through a ratchet. The wipers have no normal position, but rest where they were last used. Each rotary line switch has also its line and cut-off relays. Those relays are so arranged mechanically that unless the line relay is first energized, the cut-off relay can pull up only far enough to break its break contacts, but not make its make contacts. It is to be noted that the line relay of the switch is not identical with the line relay of the connector.

24. *Action of line switch on calling line—Private wipers on idle contact.*—The electrical circuits of the rotary line switch (fig. 7) involve a line relay (LR), a cut-off relay (COR), and a rotary magnet (ROT). The circuit from the telephone passes normally directly to ground on the positive side and through a 630-ohm slow release line relay on the negative side. When the subscriber initiates a call, the line relay closes two contacts, one of which places a dead ground on the private normal (PN) to protect the calling line from intrusion. In addition, they set up the trunk-hunting circuit, shown schematically in figure 7. There is a complete circuit extending from the ground at the line relay contact through the cut-off relay and the rotary magnet. There is a by-pass extending from a point between the rotary magnet and cut-off relay to the private wiper. If the private wiper is resting upon an idle *ungrounded* contact, the cut-off relay will immediately pull up, moving its contacts all the way up, switching the line to the connector and grounding the private wiper at the line relay contact. Since the line relay is now cut off, it must depend upon its slow releasing property to hold it energized until the connector line relay and connector release relay can place a ground

upon the release trunk which is connected to the bank contact upon which the private wiper is resting. After this the line relay of the line switch may fall back. There is ample time overlap to prevent any trouble. The cut-off relay now remains energized over the release trunk to the connector. The rotary magnet can not pull up through the resistance of the cut-off relay.

25. *Action of line switch on calling line—Private wipers on busy contact.*—If, when the subscriber initiates a call, the trunk upon which the wipers are resting is busy, there will be a ground on the private contact which the private wiper is touching. Hence, in the trunk-hunting circuit there will be a dead short circuit by-pass from ground to the point between the rotary and cut-off relay. The cut-off relay

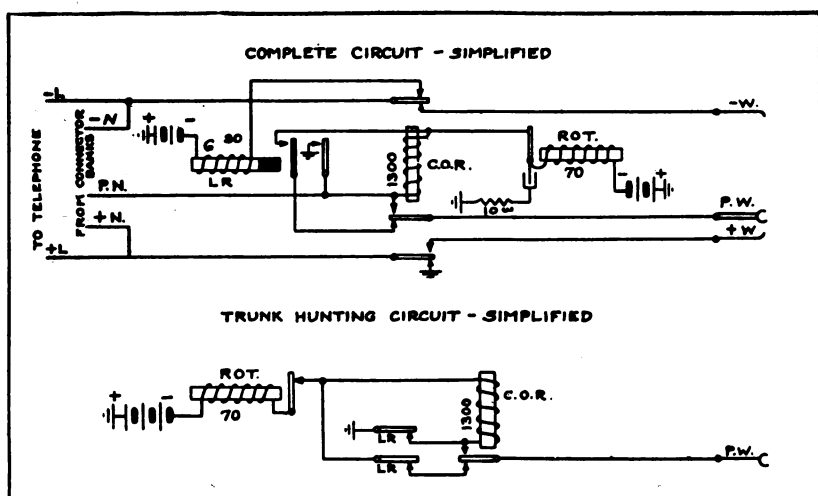


FIG. 7.—Rotary line switch circuit.

is, therefore, short circuited, and the armature of the rotary magnet will begin to vibrate like the armature of a door bell, driving the wipers off the busy contact and continuing to vibrate until the private wiper strikes an ungrounded contact. Then the cut-off relay will be able to pull up and switch the lines through as above described.

26. *Action of line switch on called line.*—When a call comes through a connector to the line whose line switch is being studied, it will arrive over the normal wires. The two line wires are marked "+N" and "-N" and the third wire is marked "PN." The connector switch first places a ground upon the private normal (PN), which energizes the cut-off relay. As has been previously stated, there is an interlocking device associated with the line relay and the cut-off relay which is so arranged that the cut-off relay can move its armature only half way up when the line relay is not energized. Since the line relay is not energized on an incoming call, the cut-off relay is therefore

able to move its armature only halfway, breaking all back contacts but not closing any front contact. This accomplishes the desired clearing of the line so that ringing and talking may proceed

SECTION VI.

THE PLUNGER LINE SWITCH.

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Functions of the plunger line switch.....	27
Principle of the plunger line switch.....	28
Description of the plunger line switch.....	29
Circuits of the line switch proper.....	30
Action of the line switch on calling line.....	31
Action of the master switch.....	32
Action of line switch on called line.....	33

27. *Functions of the plunger line switch.*—The functions of the line switch, together with its master switch, are briefly, as follows: When a subscriber initiates a call, the line switch must extend the line to an idle connector; it must protect the calling subscriber by placing a ground upon the private normal (PN), so that connector switches will find this line busy; it must inform the master switch that the trunk seized is now busy. This is done by placing a ground upon one of the master-switch bank contacts. The line switch must also clear the talking circuit of apparatus at the line switch, which it does by cutting off the line relay, battery, and ground. When a call is sent from a connector to the line to which this line switch belongs, it is only necessary to cut off the line relay and ground. There is one master switch to a group of line switches. The master switch directs all idle plungers of line switches to idle trunks.

28. *Principle of the plunger line switch.*—The plunger line switch is built upon radically different lines from the rotary type. Imagine 100 telephone lines running horizontally, of which only 8 are shown in the figure. (Fig. 8-A.) Imagine 10 trunks running vertically, of which only 4 are shown. Any telephone line could be connected to any trunk line by pinching two wires together at the point of intersection, as is shown by the heavy dots connecting line No. 1 to trunk No. 3, line No. 2 to trunk No. 1, etc. A little switch can be placed at each of the intersections. (Fig. 8-B.) Each little switch consists of a stationary plate attached to the trunk and a flexible spring attached to the subscriber's line. By pressing any flexible spring, we can connect a line to a trunk at will. The handle by means of which any switch is operated is called the plunger. It is mounted on a plunger arm which may be moved by a pull-down coil. The pull-down coil is under the control of the calling subscriber. The position of all the idle plungers is controlled by the master switch, which is so arranged as to direct all the idle plungers to idle trunks. (Fig. 8-C.)

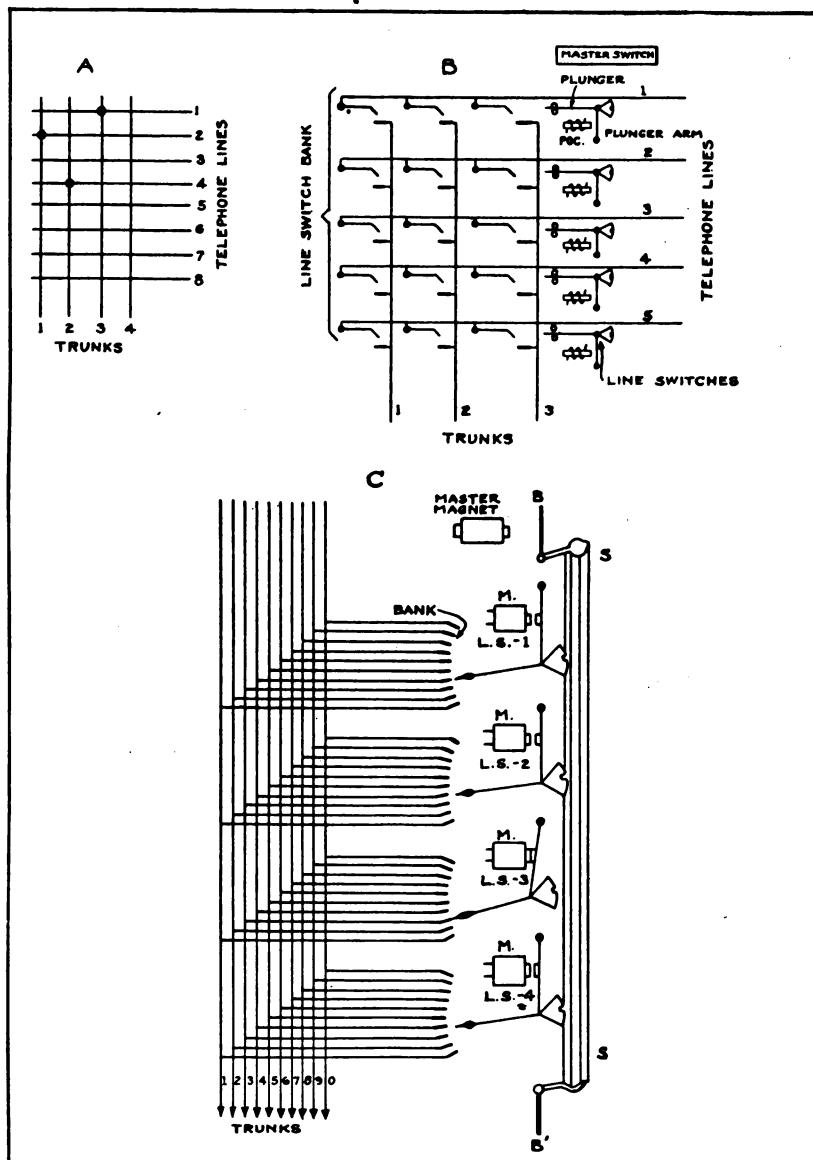


FIG. 8.—Scheme of the plunger line switch.

29. *Description of the plunger line switch.*—The plunger line switch (shown in fig. 9) consists of a slow-acting line relay (LR); a double wound combination pull-down coil (PDC) and cut-off relay (BCO); a cut-off armature (controlling contacts 11, 12, 13, and 14 in the figure); a plunger arm (PA) carrying the pivoted plunger; and a bank of contacts consisting of 10 sets of contacts of 8 in each set. Normally the plungers of idle line switches are kept in alignment opposite the same idle trunk by the master switch. When a call comes in to the switchboard, the pull-down coil pulls the plunger into the bank, and in doing so closes four pairs of contacts (1 to 8), thus connecting the calling line direct with a trunk leading to an idle connector. At the same time the master switch operates to move the plungers of the remaining idle line switch until they are resting opposite the contacts of the next idle trunk.

30. *Circuits of the line switch proper.*—The circuits of the plunger line switch are naturally divided into two parts—the line switch proper and the master switch. (Fig. 9.) The line switch proper has the line circuit containing the line relay and battery; the pull-down coil circuit, which derives its negative battery connection from the master switch; the bridge cut-off relay circuit, whose winding is on the pull-down coil core and extends through the private normal (PN) to the connector banks (not shown in figure) and through the line switch bank (2-6) to the release trunk.

31. *Action of line switch on calling line.*—The reader will imagine a subscriber's telephone instrument across the two-line wires, +line and -line. He will also imagine the line relay of a connector bridged across the trunk wires, +trunk and -trunk, and supplying battery to them. When the subscriber takes his receiver from the hook, the line relay (LR) pulls up and closes the circuit of the pull-down coil (PDC). Immediately, the pull-down coil attracts both the plunger arm (PA) and the cut-off armature. The plunger arm pulls the plunger away from the guide shaft and into the bank, operating all of the contacts numbered from 1 to 8. Springs No. 1 and No. 4 extend the connection to the connector switch so that immediately the line relay of the latter pulls up, energizes the release relay, and places a ground upon the release trunk. This sends current back through spring No. 2 on the line switch bank to the bridge cut-off coil (BCO). This coil is strong enough to hold both armatures even after the pull-down coil current has died away (circuit broken by action of the cut-off armature breaking the line relay circuit). The line relay is slow acting so that the pull-down coil circuit will not be broken at the line relay armature until after the connector switch has grounded the release trunk so that the bridge cut-off coil can hold the plunger in the bank. The same ground on the release trunk also furnishes protection by way of the

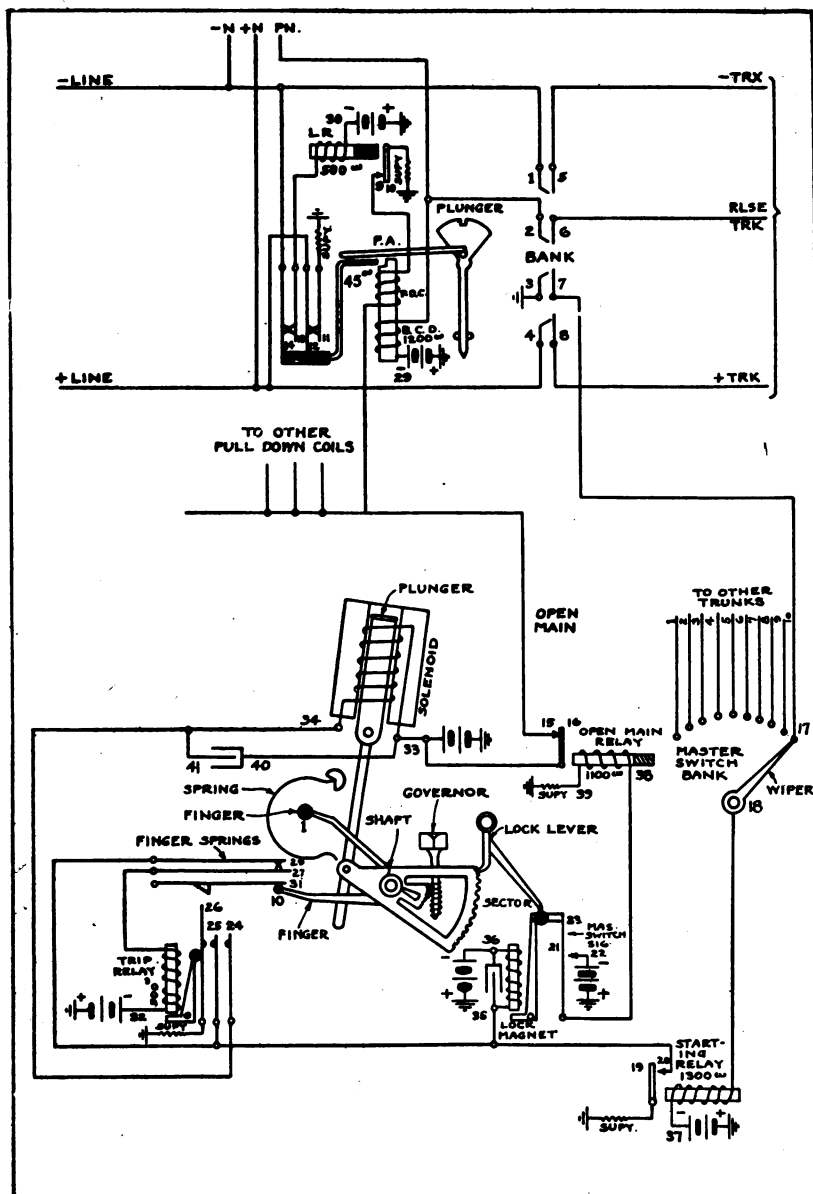


FIG. 9.—Plunger line and master switch circuits.

private normal (PN) to the connector banks. Bank spring No. 3 furnishes a ground to the master switch bank to indicate that the trunk is now busy. When the line relay of the connector is energized, it pulls up the release relay and the latter places a ground upon the release trunk. This action will be remembered as having been described for the connector switch.

32. *Action of the master switch.*—The master switch circuits consist of the starting relay, the lock magnet, the open main relay, the trip relay and solenoid magnet, all of which are shown in figure 9. When a trunk has become busy, the fact is indicated by a ground on the master-switch bank contact. This energizes the starting relay, which in turn pulls up the lock magnet. The lock magnet energizes the open main relay, thus disconnecting the battery supply of the pull-down coil of all line relays in this master switch group. This makes it impossible for any subscriber to operate his line switch while the master switch is hunting an idle trunk. The lock magnet also releases the escapement so that the spring may rotate the guide shaft, carrying the idle plungers toward other trunks. When the master switch wiper reaches an ungrounded contact, the starting relay falls back, the lock magnet lets go, and the escapement stops the guide shaft with all the plungers pointing toward this idle trunk. The open main relay now restores negative battery to the open main wire.

When the guide shaft reaches trunk No. 1, having passed over all the other trunks, the shaft finger No. 1 presses together the finger springs (27-28), closing one break in the circuit of the trip relay. Now, when trunk No. 1 is seized, the starting relay, in addition to pulling up the lock magnet, will also pull up the trip relay, which is mechanically locked in the operated position by the end of spring No. 26 catching on a lug on finger spring No. 31.

This action of the trip relay closes simultaneously the circuit of the lock magnet and of the solenoid magnet. The former releases the escapement, while the latter pulls the guide shaft back to trunk No. 10. During this motion, the guide shaft picks up any idle plungers which have been released from the bank. When the guide shaft arrives at trunk No. 10, shaft finger No. 10 presses spring No. 31 and releases the springs of the trip relay, cutting off the current from the solenoid and from the lock magnet. What follows depends upon the condition of trunk No. 10. If it is not busy, the shaft will stay there. If it is busy, the starting relay will cause the master switch to hunt the first idle trunk.

The lock magnet also controls contact No. 23, which leads to a master switch signal (not shown in figure). The adjustment is such that if the lock lever is not engaging the sector, current will be sent through the master-switch signal to indicate that something is wrong.

In series with the open main relay winding, is a supervisory relay (supy. 39, not shown in detail in figure) which operates after a certain time has elapsed. If all trunks should be busy, the master switch will vainly hunt an idle trunk. This means that the open main relay will be continuously energized. Supervisory No. 39 will indicate this fact, but will not respond to momentary action.

33. *Action of line switch on called line.*—When a call comes from a connector switch to the telephone to which this line switch belongs (through + N, - N, PN), the connector first grounds the private normal (PN) which results in energizing the bridge cut-off coil (BCO). As the magnet is not strong enough to move the plunger without the aid of the pull-down coil, only the cut-off armature responds, breaking the contacts No. 11, 12, 13, and 14, so as to clear the line of attachments. After this the connector sends out ringing current and later on conversation takes place.

SECTION VII.

SYSTEMS OF MORE THAN 100 LINES.

	Paragraph.
1,000-line system.....	34
Systems larger than 1,000 lines.....	35

34. *1,000-line system.*—To build up a system of more than 100 lines, two or more such 100-line units must be provided, and provision made for the selection of the 100-line group containing the list desired. The trunking scheme of a 1,000-line system is indicated in figure 10. Upon the removal of the receiver the line switch extends the connection, not to a connector, but to a selector. Mechanically the selector is identical with the connector. Electrically it is much simpler, having but two signal functions, namely, to select the desired 100-line group, under the control of the calling device, and to select automatically a trunk leading to an idle connector serving that 100-line group.

Each level of contacts on a selector bank contains the terminal of 10 trunks leading to the 10 connectors of the corresponding 100-line group. If No. 261 (fig. 10) calls No. 805, for instance, he first dials the figure 8, which steps the shaft of the selector up until the wipers rest opposite the contacts of the eighth level. Immediately, and regardless of the calling device, the shaft rotates until the wipers are resting on the contact of a trunk leading to an idle connector. Dialing the two final digits operates the connector in the usual way.

35. *Systems larger than 1,000 lines.*—Systems larger than 1,000 lines are built up by grouping a number of 1,000-line systems in a similar way and providing another group of selectors, to choose the 1,000-line group desired. These two groups of selectors are known as second and first selectors, respectively.

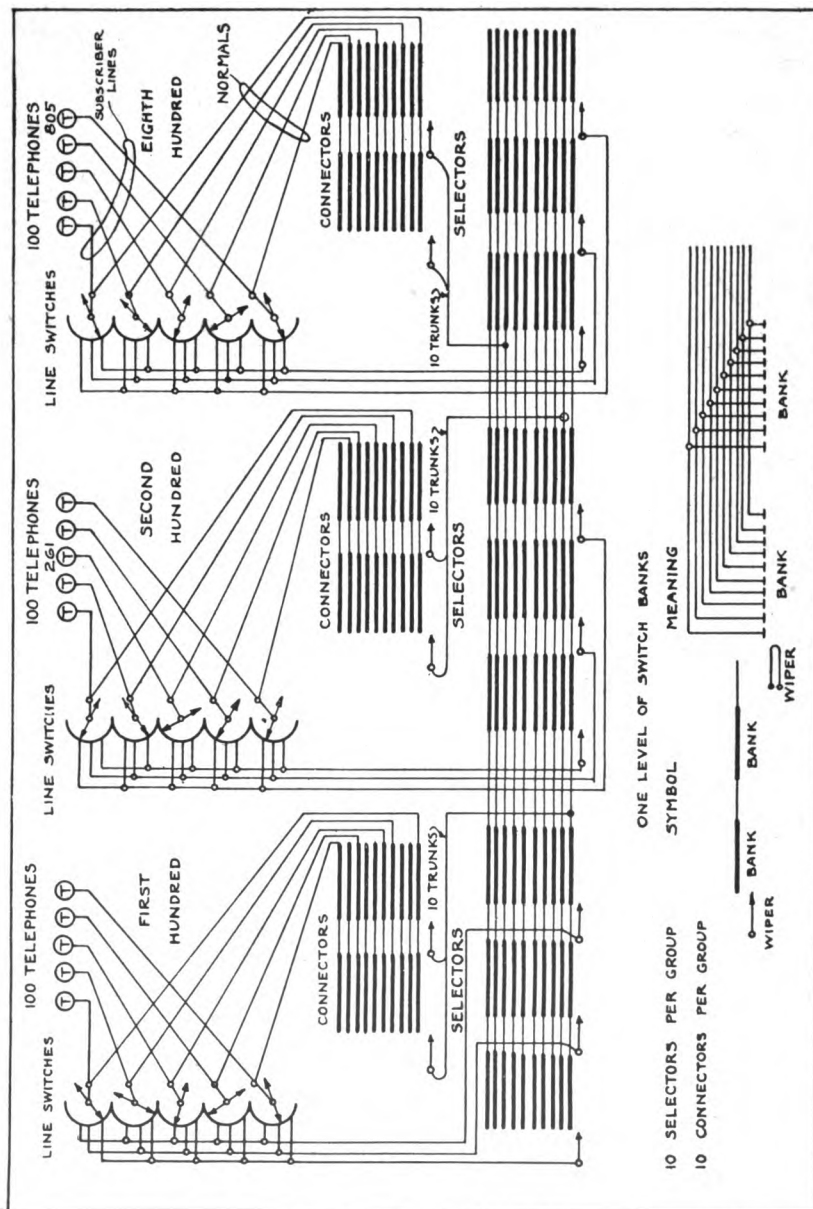


FIG. 10.—Trunk scheme—1,000 line automatic exchange using rotary line switch.

PART II.

CIRCUIT OPERATION OF THE PRIVATE AUTOMATIC TELEPHONE SYSTEM OF THE AUTOMATIC ELECTRIC CO.

SECTION I.

THE SYSTEM.

	Paragraph.
Equipment described.....	1
How a telephone line is selected automatically.....	2
Calling device.....	3
Purpose of line switches.....	4
Purpose of master switch.....	5
Special services on automatic system.....	6

1. *Equipment described.*—The equipment covered by this description includes that which is required in the smaller so-called connector systems. Such systems require two types of switches, the fundamental selecting switch or connector and the line and master switch. These are arranged in units to serve either 50 or 100 lines.

2. *How a telephone line is selected automatically.*—The number of a line is the basis of its automatic selection. Lines are terminated on the multiple banks of the connectors and given a line number corresponding with the number of vertical and rotary steps the connector wipers (brushes) have to make to reach the called line terminals. Thus, when a connector lifts its wipers four vertical steps and rotates them eight steps the terminals of line 48 are engaged.

3. *Calling device.*—The calling device at the telephone is designed to open and then close the line circuit once or any number of times up to 10 at a uniform rate, the number of interruptions in a series being under control of the calling party. In a connector system there must be two of these series of interruptions, one to cause the vertical motion and one to cause the rotary motion.

4. *Purpose of line switches.*—If connectors were the only switches used, each line would have to be terminated on a connector switch for calling purposes as well as on the bank multiple. This would require as many connectors as there were lines and this would make the cost very high. To offset this is the purpose of the line and master switch. (The rotary line switch, as described in Part I, performs the same functions as both the line and master switches. Only the action of the latter is described, however, in Part II.) Each line is terminated on a line switch for calling purposes and on the connector multiple for incoming calls. These line switches are mounted in groups of 25

in two vertical rows, one row being mounted on each side of a spring assembly known as a trunk bank. Two of such groups of 25-line switches are required for a 50-line private automatic exchange and four for a 100-line private automatic exchange. The lines are multiple-wired horizontally to 10 sets of springs in the trunk bank. Ten trunks are multiple-wired vertically through the springs of the trunk bank. Thus each line has the possibility of being connected to any one of the 10 trunks.

5. *Purpose of master switch.*—The master switch determines the order of trunk selection. This it accomplishes by aligning the plungers of the associated idle line switches before an idle trunk after each call, in order that the next line switch will be also connected to an idle trunk. The distant end of the trunks terminate on connectors.

6. *Special services on automatic system.*—Most private automatic exchange installations are wired for special services such as watchman's recorder service, code call, etc., but the following description will not include their operation.

SECTION II.

THE LINE AND MASTER SWITCH.

	Paragraph.
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Detailed functions of line switch.....	8
Detailed functions of the master switch.....	9

7. *General functions.*—The line switch and the master switch, although separate mechanisms, are so interrelated that they will be considered jointly in the following description. Briefly stated, the purpose of the line and master switch is to connect any *calling line* in a relatively large group to one of a smaller number of selecting mechanisms, and later to disconnect the line from the selecting mechanism when the calling party hangs up the receiver. For instance, a private automatic exchange could have 45 working lines which would require 45 line switches. Supposing that 8 connectors (selecting mechanisms) were supplied, then it is the function of the line and master switch to connect any one of the 45 lines that may originate a call to an idle connector. The mechanics of the line and master switch will not be described here, as that can best be studied directly from the apparatus.

8. *Detailed functions of line switch.*—Taken alone, the detailed functions of the line switch are as follows:

When *calling*—(a) To disassociate itself from the master switch control, which determines the trunk selection, and to connect the calling line via an idle trunk to a connector.

(b) To clear the calling line of attachments—that is, the line relay and ground.

(c) To connect with the selecting device (connector) at far end of trunk in such a manner that that device will hold the calling line switch operated.

(d) To protect the calling line from intrusions—that is, make it test busy.

(e) To close the master switch circuit, which controls the trunk selection, so that when another line switch subsequently operates it will connect with another trunk.

(f) On release, to release the trunk, reconnect the line relay and ground to its line, and reassociate itself with the master switch control.

When the line is called—(g) To clear the called line of attachments—that is, the line relay and ground—without other operation.

9. *Detailed functions of the master switch.*—The functions of the master switch, considered alone, are as follows:

(a) After each connection of a calling line to an idle trunk, to so align the idle line switch plungers with respect to the trunk bank that the next connection will be made to an idle trunk.

(b) To prevent the operation of *any* line switch plunger during the process of realignment—that is, while those plungers still attached to the master shaft are in rotary motion.

SECTION III.

DETAIL OPERATION OF LINE AND MASTER SWITCH CIRCUIT.

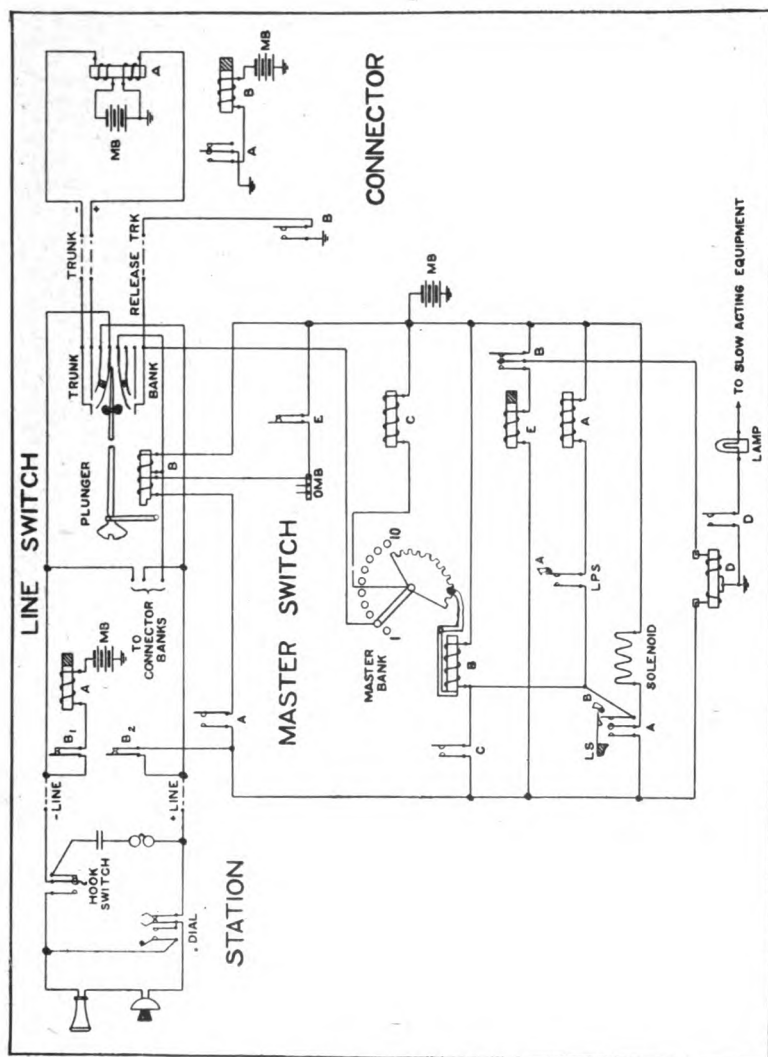
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Conventions employed in diagrams.....	10
Line calling—seizure of a trunk.....	11
Operation of the master switch.....	12
Reverse motion of master shaft.....	13
Release of line switch after an originating call.....	14
Line being called—operation of line switch.....	15
Functions of supervisory ground relay D.....	16

10. *Conventions employed in diagrams.*

The following diagrams give a description of the functions and detailed circuit operation of the private automatic exchange type of line switch and master switch. Drawing I shows the line and master switch circuit in the normal or unoperated condition.

The following conventions are employed in the diagrams:

- (a) To facilitate the tracing of the circuit, relay and magnet springs are shown separated from their coils.
- (b) Energized relays and magnets are surrounded by magnetic fields.
- (c) Conductors carrying current are shown by heavy lines.
- (d) Component circuit elements are arranged as far as possible in order of first operation.
- (e) Springs of contact sets are shown in parallel when in the normal or unoperated position.



DRAWING I.—Showing circuit in the unoperated condition.

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SEQUENCE OF OPERATIONS.

11. *Line calling—seizure of a trunk.*

(1) Subscriber lifts receiver from hook, operating hook switch. Disconnects bell and condenser from line and closes line circuit through line relay A, at the same time closing circuit of supervisory ground relay D.

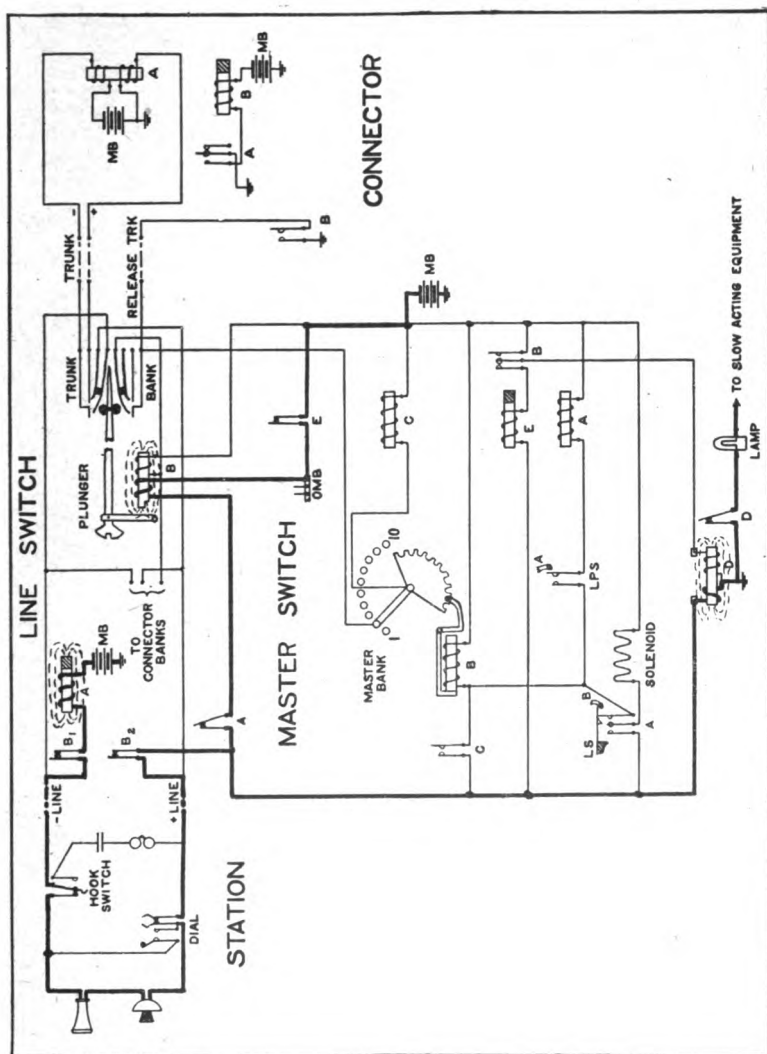
(2) Line relay A of line switch and supervisory ground relay D operate.

Contact relay A closes a circuit through one winding of the cut-off and plunger relay B of line switch. (Provided the master switch is not in motion. If this condition exists, then this circuit will be open at contacts E until master switch stops.)

Contact relay D closes circuit of supervisory lamp through the slow acting equipment. The lamp, however, does not light if the apparatus functions properly.

NOTE.—Conditions which cause the operation of the supervisory lamp will be discussed later.

Drawing II shows the circuit condition at this stage. The energization of the winding of the cut-off and plunger relay B of line switch causes the operation of the plunger and of the contact springs B_1 and B_2 , but for convenience in the drawing these are considered as about to operate.



DRAWING II.—Showing circuit conditions as plunger is about to enter trunk bank.

11. *Line calling—seizure of a trunk*—Continued.

(3) Cut-off and plunger relay B of line switch operates.

Contacts B_1 and B_2 cut off the line relay A of the line switch. This relay is slow on release (delayed release) and holds its contacts operated for a brief interval. Plunger is driven into trunk bank.

(4) Trunk bank functions.

Closes line circuit through line relay of next switch. Closes a contact in the holding, guarding, and releasing circuit (release trunk circuit).

(5) Line relay A of connector operates.

Contacts A close circuit of release relay B of connector.

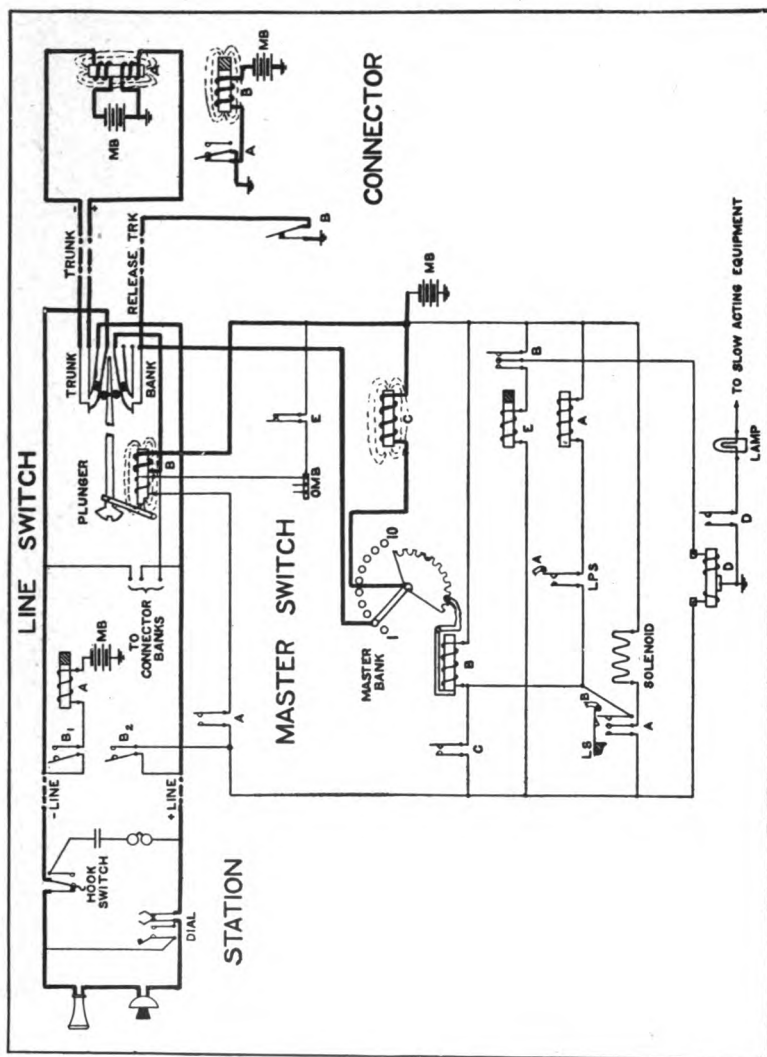
(6) Release relay B of connector operates.

Contact B closes release trunk circuit, energizing the second winding of the cut-off and plunger relay B of line switch in order to hold the line switch operated. It also grounds the master bank contact corresponding to the trunk seized to start the master switch and, further, ground is placed on the third wire of the connector multiple to guard the connection and make the calling line test busy.

(7) Line relay A of line switch releases its armature (slow release).

Contact A opens circuit of operating winding of cut-off and plunger relay B.

Drawing III shows circuit conditions with line cut through and master switch about to function to align idle plungers before an idle trunk. Relay C, shown energized, is considered as about to operate.



DRAWING III.—Showing line connected through and master switch about to function.

12. *Operation of the master switch.*

(8) Start relay C of master switch operates (closed to ground on master bank).

Contacts C close circuit of lock magnet B of master switch. This circuit includes one winding of supervisory relay D.

(9) Lock magnet B of master switch operates.

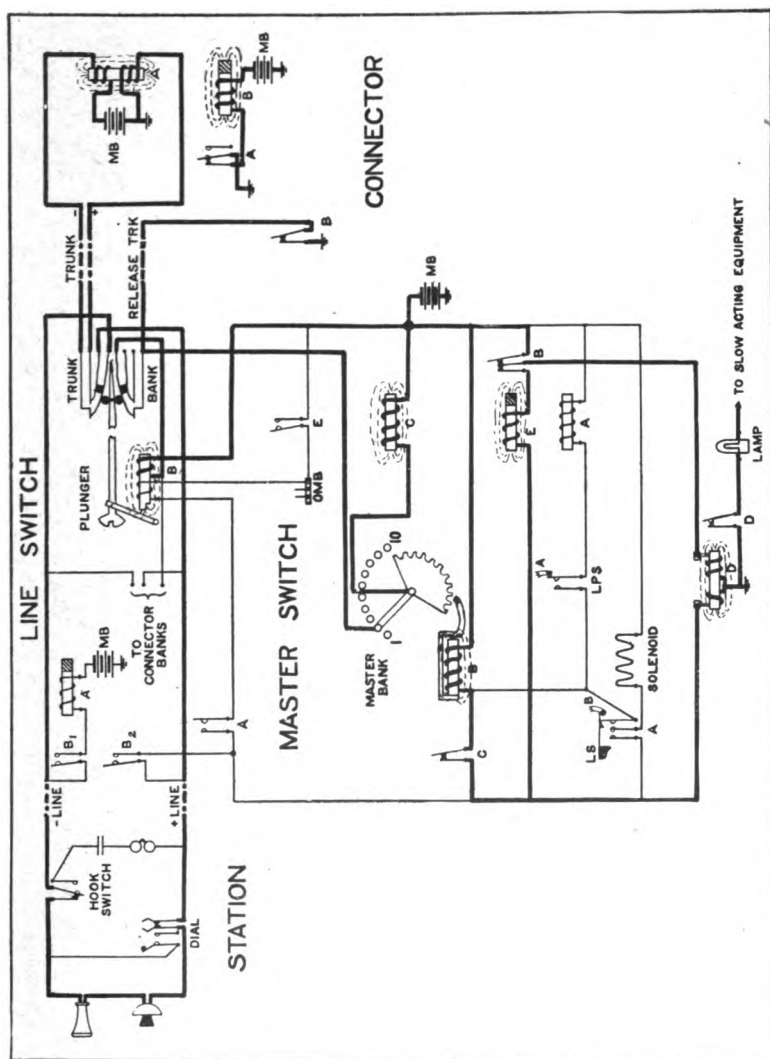
Contacts B close circuit of open main relay E, as well as the circuit of the second winding of the supervisory relay D.

Arm unlocks the sector on the master shaft.

(10) Open main relay E operates.

Contacts E open the common (main) battery feed to line switches, thus preventing operation of plungers while the master shaft is in motion.

Drawing IV shows the circuit condition as the master shaft is about to move under influence of a spring from position 2 to position 1 in the process of aligning idle plungers before an idle trunk.



DRAWING IV.—Showing circuit conditions as master shaft is about to move to position 1.

12. *Operation of the master switch*—Continued.

(11) Master shaft moves by spring from position 2 to position 1. (Trunk No. 1 assumed idle.)

Breaks circuit of start relay C on leaving position 2.

Arm "A" closes locking plate springs (LPS) when shaft reaches position 1 (extreme); the trip relay A of master switch, however, will not operate as contacts C open before this time.

(12) Start relay C released at beginning of motion of shaft.

Contacts C opened lock magnet B circuit, and also open circuit of one winding of supervisory relay D.

(13) Lock magnet B releases.

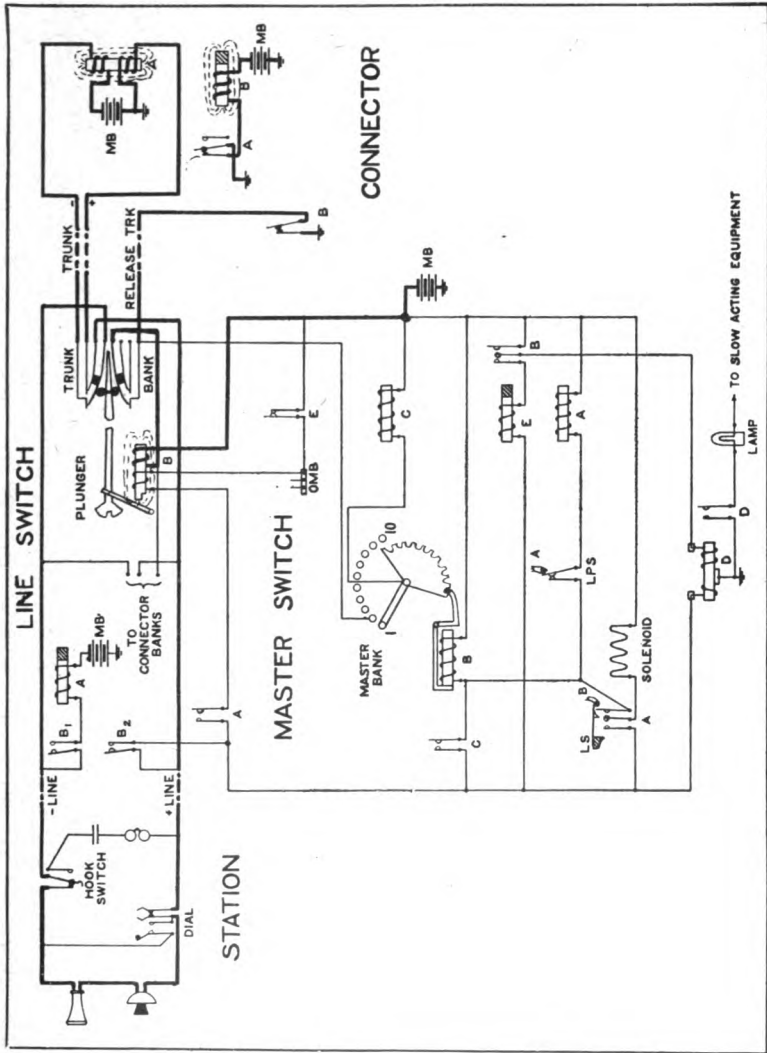
Contacts B open circuits of open main relay E and second winding of supervisory relay D.

Its arm locks sector when position 1 is reached.

(14) Open main relay E releases.

Contacts E close common (main) battery feed to line switches so that trunk No. 1 may now be seized.

Drawing V shows circuit conditions with idle plungers aligned before trunk No. 1, while trunk No. 2 is engaged by a calling line.



DRAWING V.—Showing circuit conditions when master shaft reaches position 1.

13. *Reverse motion of master shaft.*

If, now, a plunger is detached from the master shaft and driven into a terminal bank of trunk No. 1 by another originating call in this group, then the master switch will function to align all idle plungers before trunk No. 10 (assumed idle).

(15) A station calls, seizing trunk No. 1, grounding master bank contact No. 1.

Start relay C is energized.

(16) Start relay C operates.

Contacts C close circuits of lock magnet B and trip relay A, in series with one winding of supervisory relay D.

(17) Lock magnet B and trip relay A operate simultaneously.

Contacts B close open main relay E circuit and circuit of second winding of supervisory relay D

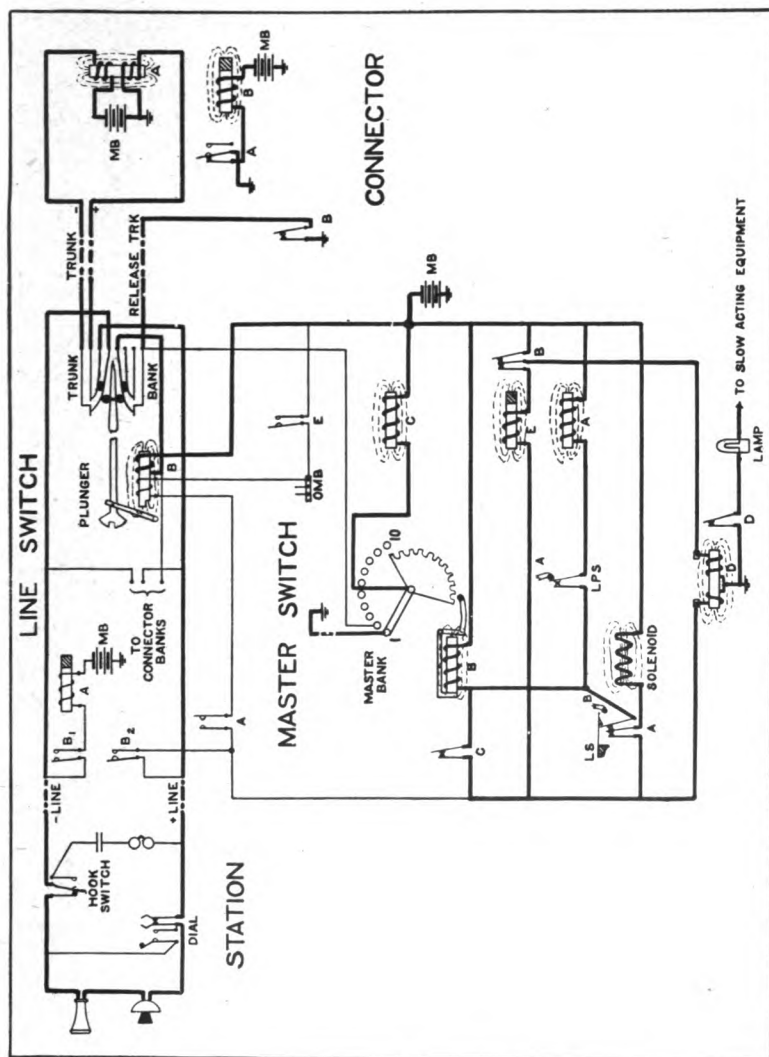
Lock magnet arm unlocks sector on the master shaft.

Contacts A close circuit of solenoid. Locking spring (LS) locks contacts A mechanically.

(18) Open main relay E operates.

Contacts E open common (main) battery feed to line switches. The solenoid will now cause the master shaft to move to position 10.

Drawing VI shows the circuit conditions just as the shaft carrying the plungers and contact arm is about to move under influence of the solenoid.



DRAWING VI.—Showing circuit conditions just as the reverse motion commences.

13. *Reverse motion of master shaft*—Continued.

- (19) Solenoid acts on its plunger, moving master shaft against spring to position 10.

As master shaft leaves position 1, the arm A moves away from the LPS.

NOTE.—Idle plungers, before the trunk bank, are reengaged with the master shaft as it moves from position 1 to 10.

- (20) Locking platé springs (LPS) return to normal (at beginning of motion).

Opens trip relay A circuit.

- (21) Trip relay A releases armature.

Contacts A held locked by locking spring (LS).

- (22) Locking spring (LS) deflected by arm A (when master shaft reaches position 10).

Contacts A return to normal position.

- (23) Lock magnet B and solenoid deenergize (provided trunk number 10 is idle).

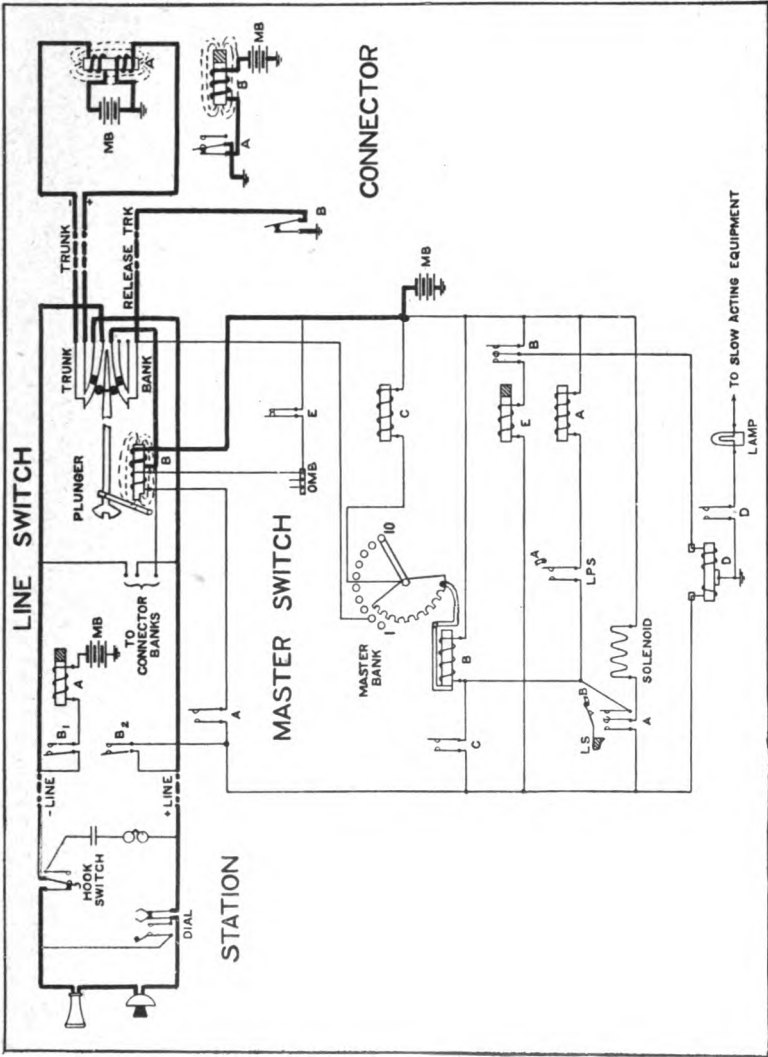
Contacts B open circuit of open main relay E and both windings of supervisory relay D.

Arm locks sector on master shaft.

- (24) Open main relay E releases.

Contacts E close common (main) battery feed to line switches.

Drawing VII illustrates the circuit condition just after the reverse motion, the plungers now being aligned before trunk number 10 which was assumed idle. As each trunk becomes busy the master shaft will progress step by step to position 1 in a manner similar to that previously described except that arm A functions only in position 1 and arm B functions only in position 10.



DRAWING VII.—Showing circuit conditions just after the reverse motion.

14. *Release of line switch after an originating call.*

When the receiver is replaced on the hook the line circuit is opened, causing ground to be removed from the release trunk at the connector. The line switch releases and restores to the normal condition.

(25) Calling party replaces receiver on hook.

(26) Hook switch is returned to normal.

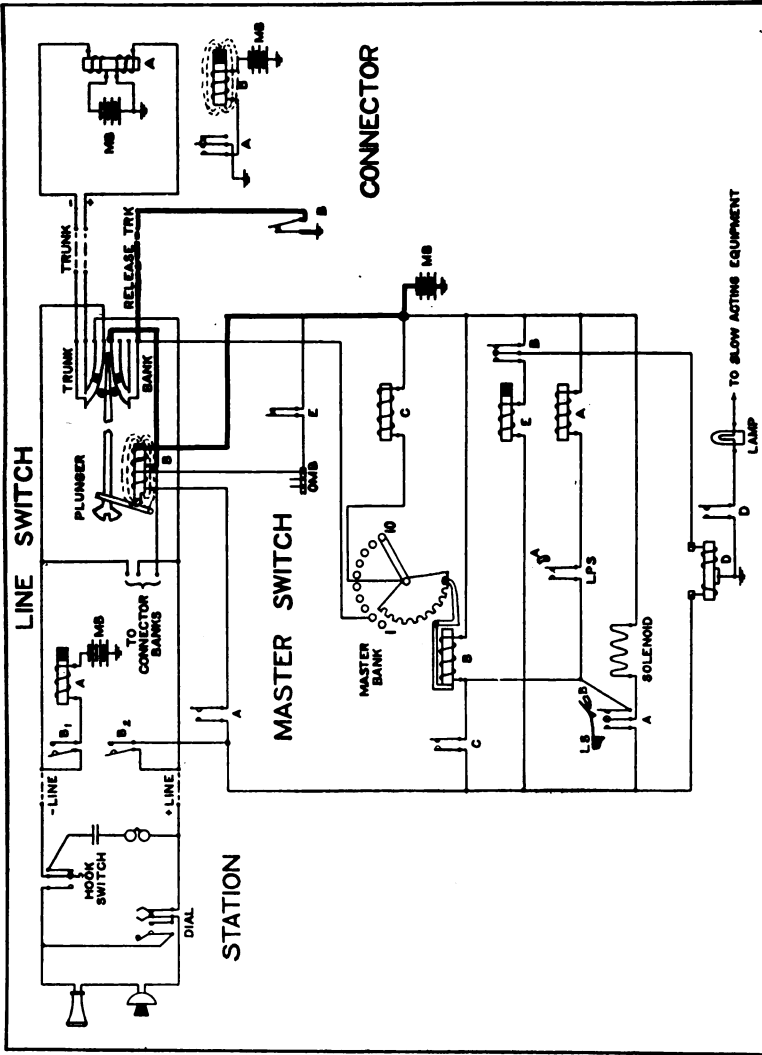
Opens line circuit.

Also reconnects bell and condenser to line.

(27) Line relay A of connector releases.

Opens circuit of release relay B of connector which is slow on release.

Drawing VIII shows this circuit condition. The release relay, which is about to release, will cause the restoration of the line switch.



DRAWING VIII.—Showing opening of line circuit at hook switch. Release relay about to release.

14. *Release of line switch after an originating call—Continued.*

(28) Release relay of connector releases.

Opens release trunk circuit.

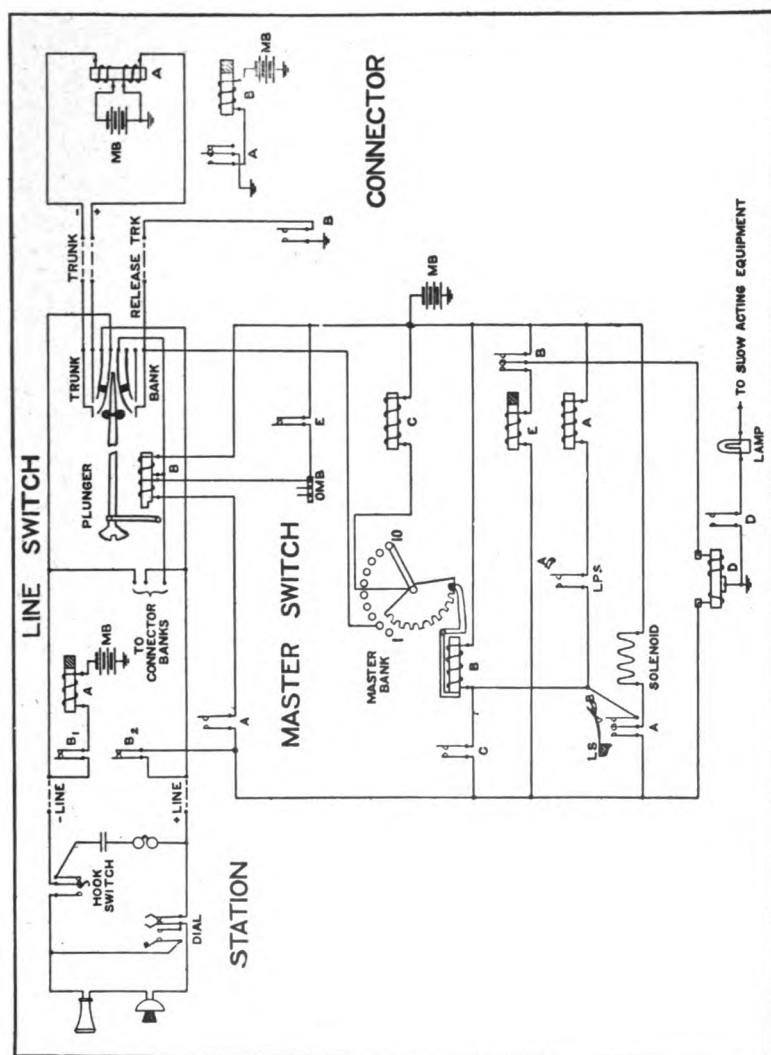
(29) Cut-off and plunger relay B of line switch releases.

Plunger is withdrawn from trunk bank by spring action and is free to reassociate itself with the master shaft.

Cut-off springs B_1 and B_2 reconnect line relay A of line switch to the line.

The line switch is now completely released and is ready for another call—either incoming or outgoing. The master switch is not directly affected by the release of the line switch.

Drawing IX illustrates the circuit conditions after the release of the switches.



DRAWING IX.—Showing circuit of switches completely released.

15. *Line being called—operation of line switch.*

When the line is called, the connector tests the line and, if idle, connects to it at the connector multiple. It next puts ringing current on the line, ringing the bell of the called station. If the line is busy, the connector does not connect, but places a busy tone on the calling line. The master switch has no function when a line is called.

(30) Wipers (brushes) of a connector engage terminals of the line at the connector multiple bank.
 (31) If idle, the holding coil of the cut-off and plunger relay B of line switch is energized, the circuit being completed in the connector.

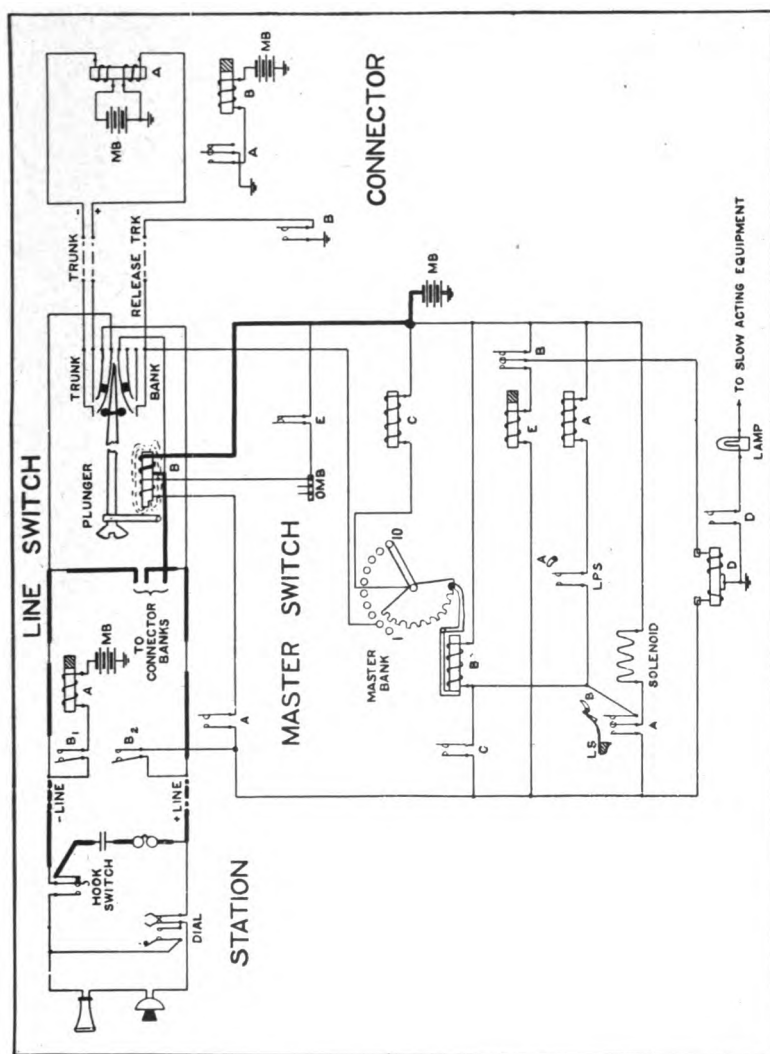
(32) Cut-off and plunger relay B of line switch operates its springs B_1 and B_2 , but does not thrust plunger into the trunk bank.

Contacts B_1 and B_2 cut off bridged line relay A.

(33) Connector puts ringing current on called line.

Called party's bell rings.

Drawing X shows circuit conditions while called party's bell is being rung. Heavy dashed line indicates ringing current.



DRAWING X.—Showing circuit conditions while called party's bell is being rung.

15. *Line being called—operation of line switch—Continued.*

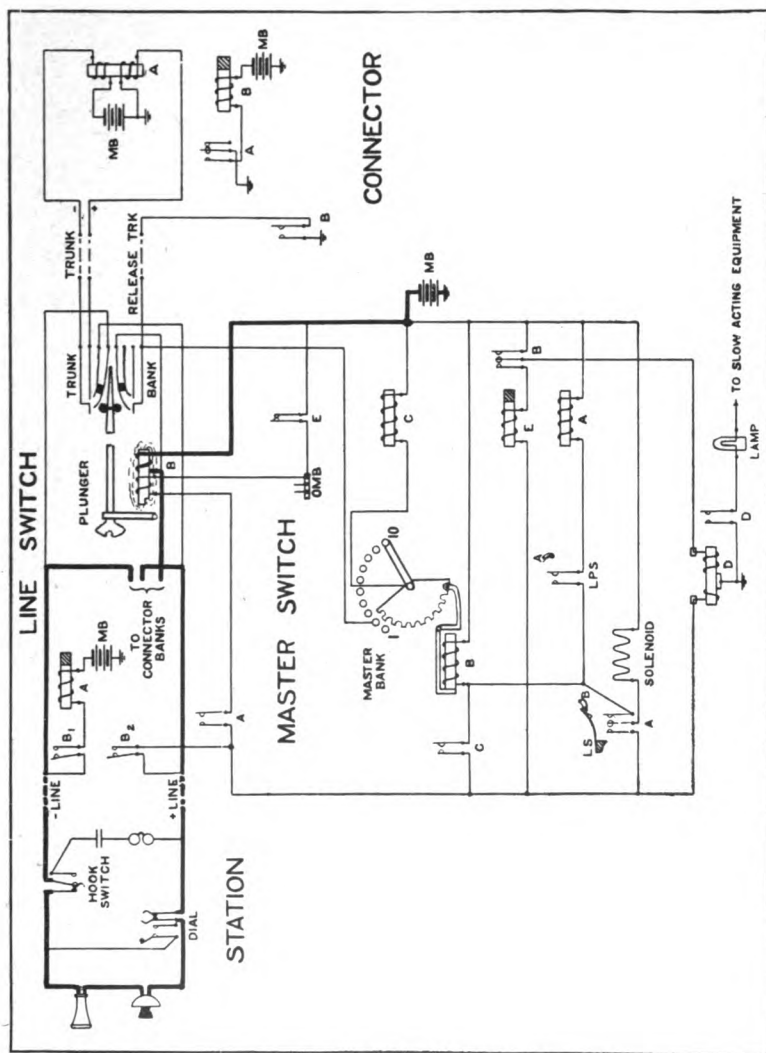
(34) Called party answers—lifts receiver from hook.

(35) Hook switch operates.

Disconnects bell and condenser from line and closes line circuit through the bank bridge relay of the connector.

(36) The two parties are now in communication.

Drawing XI shows the line switch in operated condition as resulting from an incoming call.



DRAWING X1.—Showing circuit conditions when called party lifts receiver from hook.

15. *Line being called—operation of line switch—Continued.*

(37) Both parties replace receivers on hooks.

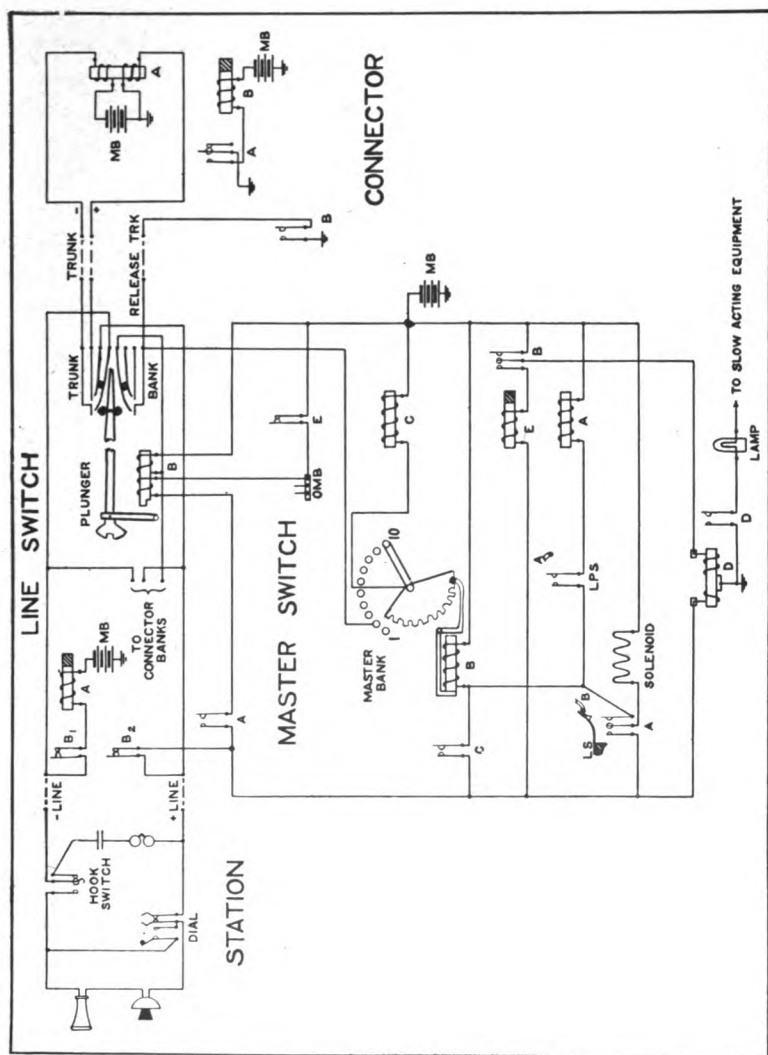
Connector is released. Bell and condenser are bridged across line by hook switch. Cut-off and plunger relay B of line switch is deenergized.

(38) Cut-off and plunger relay B of line switch releases.

Contacts B₁ and B₂ reconnect the line relay A. (Plunger was not operated.)

(39) The line switch is again in the unoperated condition.

Drawing XII shows the circuit conditions after both parties hang up.



DRAWING XII.—Showing unoperated circuit conditions after both parties have hung up.

16. *Functions of supervisory ground relay D.*—This relay controls a circuit which includes a lamp, an audible alarm, and slow-acting equipment. When the relay operates, nothing happens until after a time interval which is determined by the slow-acting device. Then the lamp shown on the drawing is lighted and an audible alarm is sounded.

With normal operation of the line and master switch the lamp and audible alarm are not operated, but any abnormal condition which causes the supervisory relay D to remain operated more than a few seconds will bring in the alarm.

Some of the more important abnormal conditions are:

(1) Line switch line relay permanently pulled up. This may be caused by the plunger failing to plunge into the bank for any one of a number of reasons or by the cut-off and plunger relay springs failing to break contact when that relay is energized.

(2) Line switch chattering because of having plunged in on an open trunk.

(3) Master switch rotating, resulting from all outgoing trunks being busy or trouble on the master switch.

(4) Master switch stuck. Any condition of the master switch wherein the starting relay is energized without break for an extended period will operate the alarm.

(5) Line crossed. If the positive side of line should get crossed with "foreign battery," the alarm will operate.

SECTION IV.

THE PRIVATE AUTOMATIC EXCHANGE CONNECTOR.

	Paragraph.
Functions	17

17. *Functions.*—As used in the smaller type of private automatic exchange, the general functions of the connector are to select the terminals of and to signal the called line under control of the calling party, and thereafter to complete a talking connection between the calling and called stations. To serve its purpose the connector must accomplish the following detailed functions:

(1) To feed battery to the calling line for selection, talking, and control of the release of the connector.

(2) To hold the calling line line switch operated during the connection.

(3) To execute the vertical movement of the shaft under control of the dial.

(4) To execute the rotary movement of the shaft under control of the dial.

(5) To test the called line for busy and if busy to prevent intrusion.

(6) To notify the calling party if the called line is busy. This is done by a distinctive "busy tone."

(7) To protect the called line from intrusion—that is, make it test busy.

(8) To clear the called line of attachments—its line switch.

(9) To ring the bell of the called station and to furnish a ring-back tone to the calling party.

(10) To cut off the ringing current upon answer of the called party and to connect the calling line to the called line.

(11) To supply battery to the called line in order that the called party may talk.

(12) To release the line switch under control of the calling party.

(13) To release without interfering with other lines and to release the called line.

SECTION V.

DETAIL OPERATION OF CONNECTOR CIRCUIT.

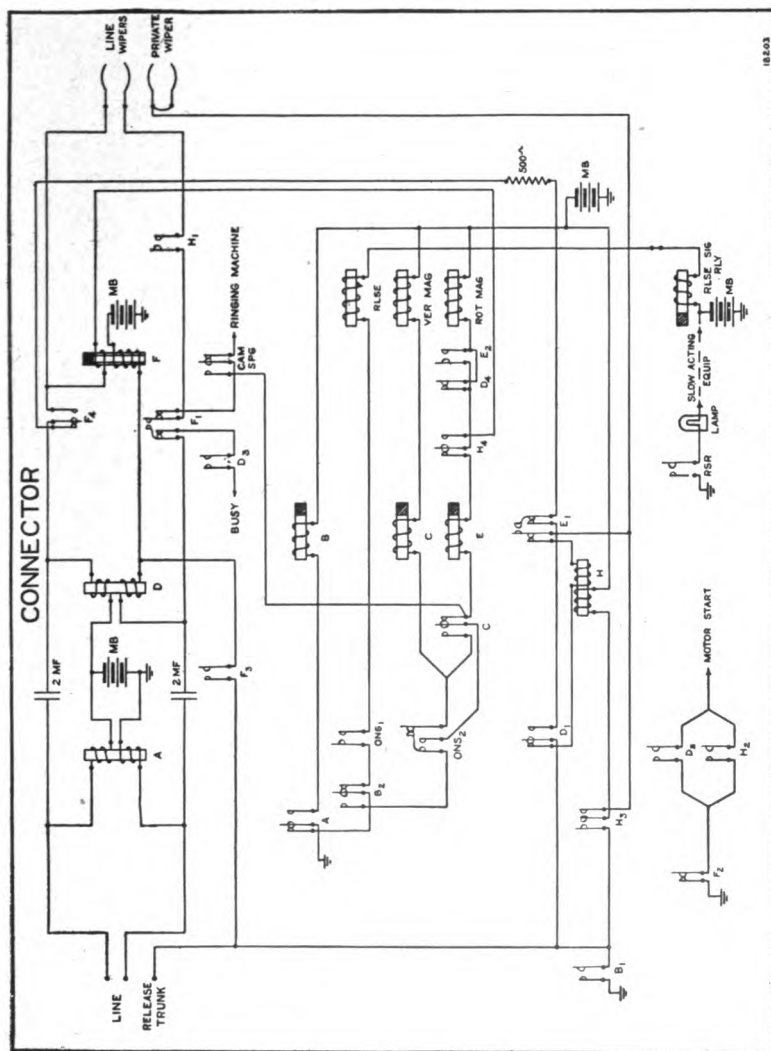
Conventions employed in diagrams.....	Paragraph.
The seizure of the switch.....	18
The vertical stepping.....	19
The rotary stepping.....	20
Disconnection on a busy call.....	21
The called line found idle.....	22
The called party answers.....	23
Release of the connector.....	24
Function of the release signal relay.....	25
	26

18. *Conventions employed in diagrams.*

The following diagrams give a description of the functions and detailed circuit operation of the private automatic exchange connector. Drawing I shows the connector circuit in the normal or unoperated condition.

The following conventions are employed in the diagrams:

- (a) To facilitate the tracing of the circuit, relay and magnet springs are shown separated from their coils.
- (b) Energized relays and magnets are surrounded by magnetic fields.
- (c) Conductors carrying current are shown by heavy lines.
- (d) Component circuit elements are arranged as far as possible in order of first operation.
- (e) Springs of contact sets are shown parallel when in the normal or unoperated position.

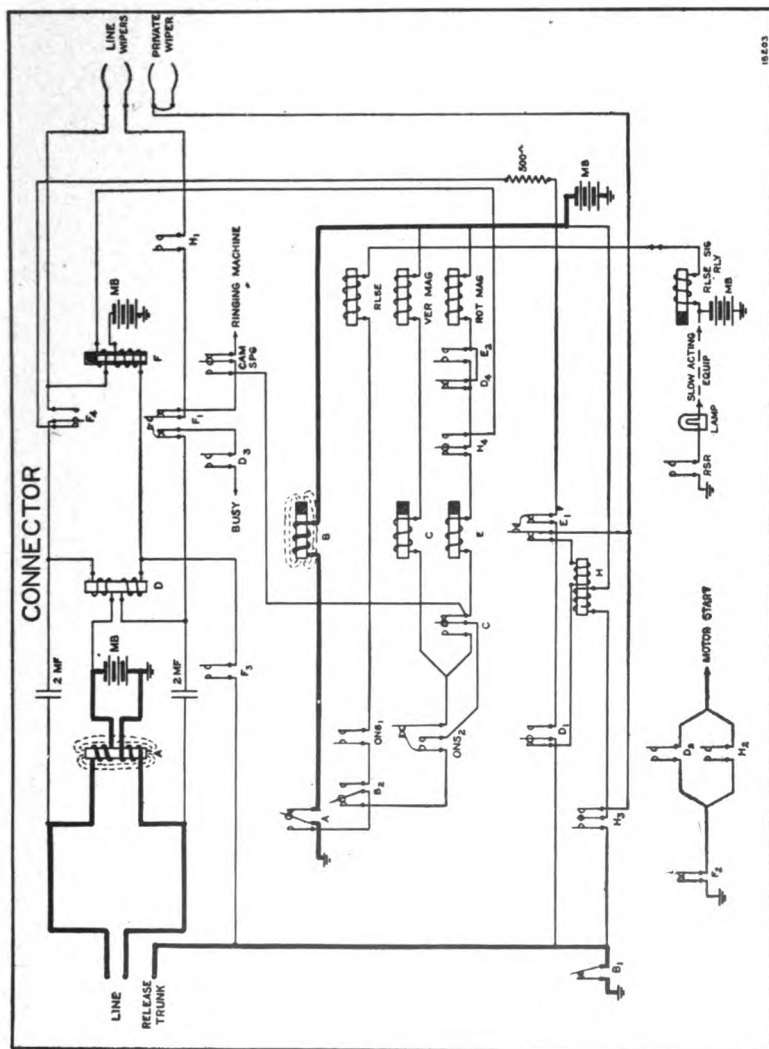


DRAWING 1.—Simplified diagram of connector circuit in normal or unoperated condition.

19. *The seizure of the switch.*

- (1) Line circuit switched over trunk to connector energizing line relay A.
Contacts A open contact in circuit of release magnet and close circuit of release relay B.
- (2) Release relay B operates.
Contacts B₁ ground release trunk to hold operated the line switch previously seized. This ground is common to other circuits which function later.
Contacts B₂ open a contact in the circuit of the release magnet and close a contact common to the vertical and rotary stepping circuits.

Drawing II shows the circuit conditions at this stage. The circuit remains thus until the dialing starts. When the calling party dials the first digit, his dial will interrupt the line current a number of times equal to the digit dialed.



DRAWING 11.—Circuit conditions resulting from seizure of switch.

20. *The vertical stepping.*

First stage—First break of line circuit by dial.

(3) The dial opens the line circuit.

(4) Line relay A releases.

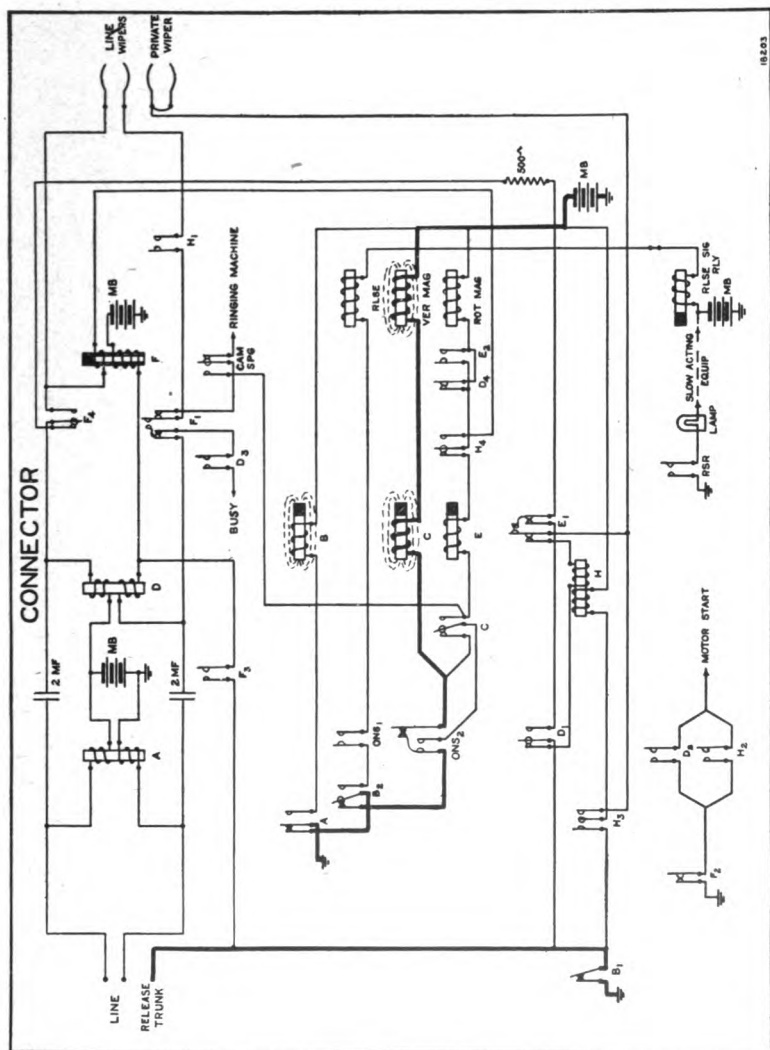
Contacts A open momentarily the circuit of the release relay B (which is slow on release and remains operated during the brief dial interruptions) and then close the vertical stepping circuit which includes the series relay C and the vertical magnet.

(5) Series relay C and vertical magnet operate.

Contacts C open a contact in the rotary stepping circuit and close a contact in the vertical stepping circuit for the second and succeeding current pulses.

The vertical magnet proceeds to lift the shaft carrying the wipers one vertical step.

Drawing III shows the circuit conditions at the stage of the first break of the line circuit by the dial, and the wipers about to be lifted one vertical step.



DRAWING III.—Circuit conditions resulting from first break of line circuit by dial showing first vertical stepping circuit.

20. *The vertical stepping*—Continued.

Second stage—Closure of line circuit after first dial interruption.

(6) Shaft and wipers lifted to first level by vertical magnet.

(7) Off normal switch (ONS) operates during first vertical step.

Contacts ONS₁ close a contact in the release magnet circuit.

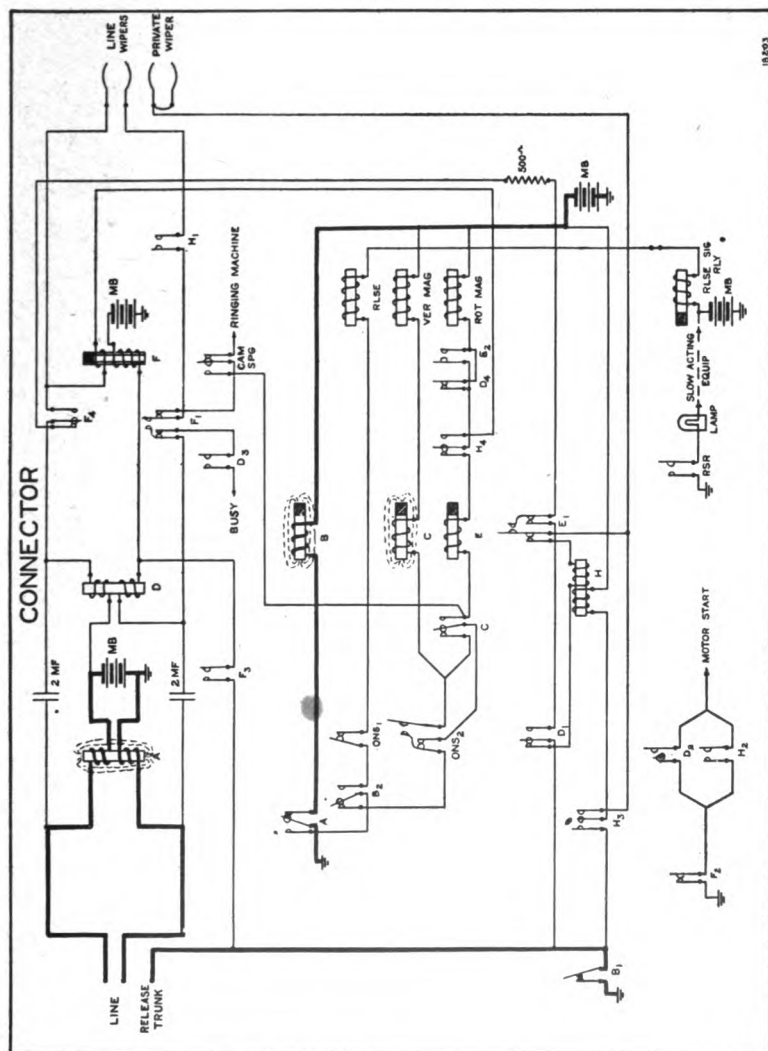
Contact ONS₂ switches the vertical stepping circuit, without opening it, so as to include contacts C of the series relay. This action is preparatory to the rotary stepping.

(8) Line circuit closed by dial after first interruption, energizing the line relay A.

Contacts A open the vertical stepping circuit (momentarily) and again close the circuit of the release relay B which remained operated during the brief interval its circuit was open by the dial.

NOTE.—The vertical magnet releases, but the series relay, being slow on release, holds until the next impulse (if any).

Drawing IV shows the circuit conditions at this instant.



DRAWING IV.—Circuit conditions between first and second vertical steps.

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20. *The vertical stepping—Continued.*

Third stage—Second and subsequent opening of the line circuit by the dial.

(9) Dial opens line circuit second time. Line relay A releases (momentarily).

Contacts A open circuit of release relay B (which is slow on release and remains operated) and close the circuit of the series relay C and vertical magnet. This circuit now includes the contacts C of the series relay.

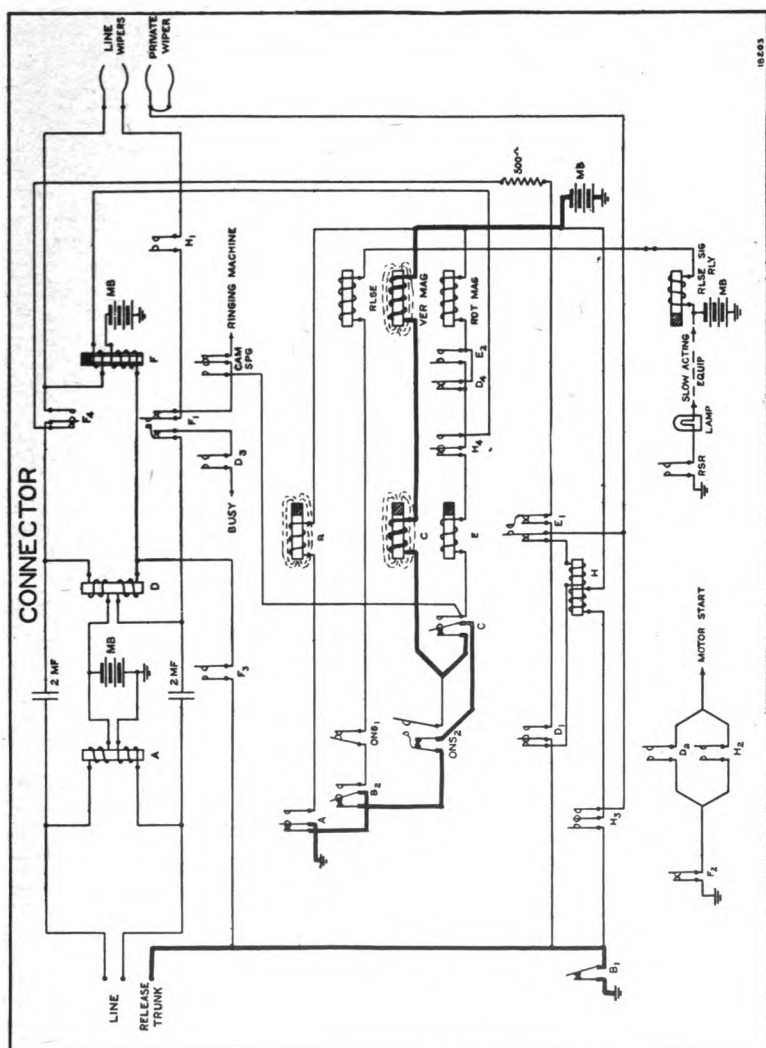
(10) Vertical magnet operates. (Series relay C operated.)

Lifts shaft and wipers one vertical step as before. (Second level.)

Drawing V shows the vertical stepping circuit for the second and succeeding vertical steps.

(11) Switching from vertical to rotary motion.

After the last interruption of the first series there is an interval during which the line relay A is energized. Its circuit being open over one-tenth second, the series relay C will release. Its contacts C will open the vertical stepping circuit and close a contact in the rotary stepping circuit preparatory to the next series of interruptions of the line circuit by the dial.



DRAWING V.—Showing vertical stepping circuit for second and succeeding vertical steps.

21. *The rotary stepping.*

First rotary step.

(12) The dial opens line circuit. Line relay A releases (momentarily).

Contacts A open circuit of release relay B (which holds) and close circuit of private relay E and rotary magnet in series.

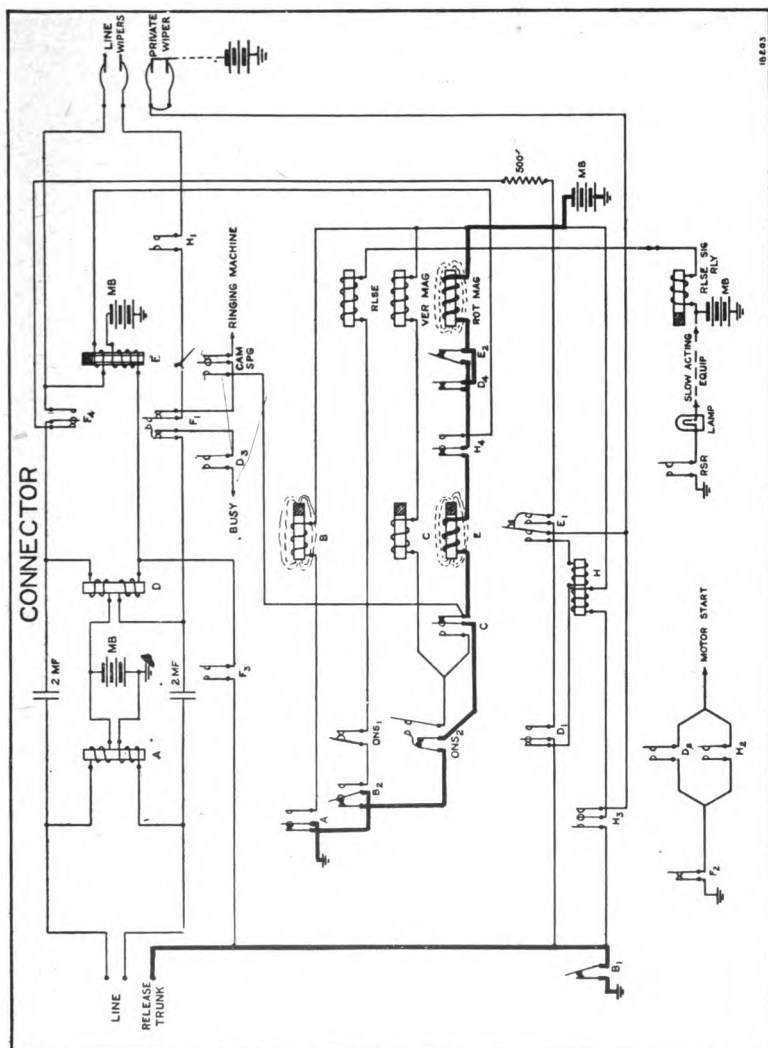
(13) Private relay E and rotary magnet operate.

Contacts E₁ prepare the busy test circuit to the private wiper for testing the called line. The back bridge and busy relay D serve to make the test.

Contacts E₂ short contacts D₄ to prevent opening of rotary stepping circuit when private wiper passes over busy lines.

Rotary magnet rotates shaft and wipers one step.

If we assume the first terminal on the level idle then the circuit condition at this instant is shown by Drawing VI.



DRAWING VI.—Circuit conditions for each rotary step. Private wiper passing over idle contact.

21. *The rotary stepping—Continued.*

Second and succeeding rotary steps.

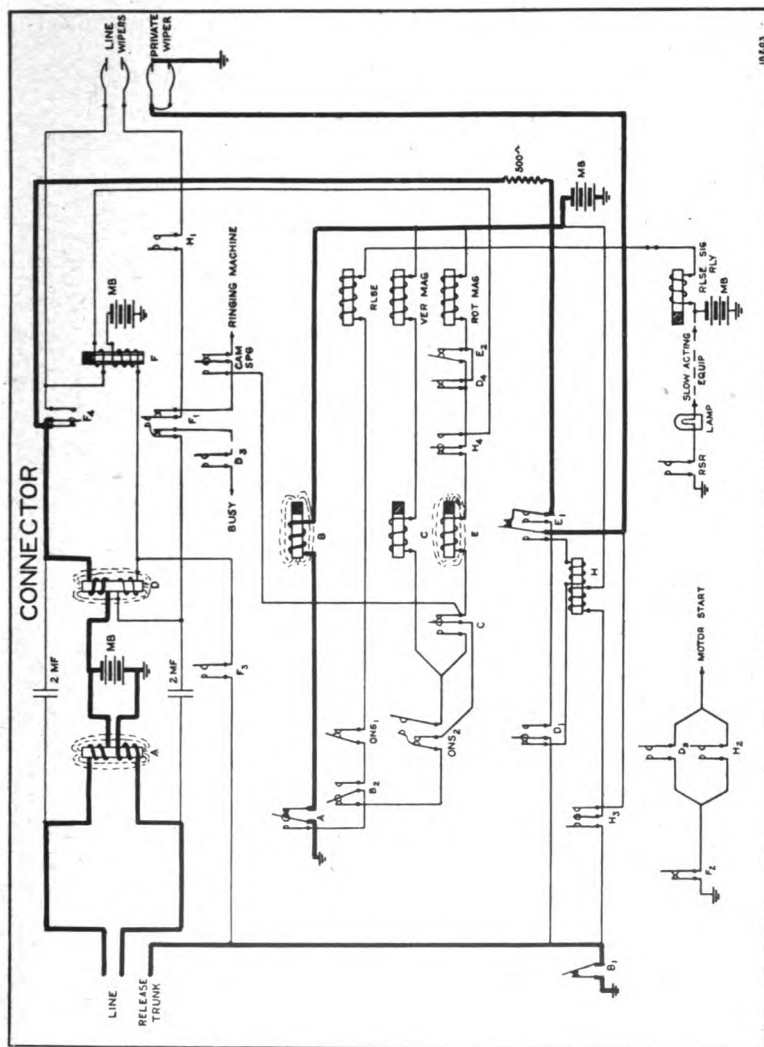
(14) The line circuit is again closed after first interruption by the dial, operating line relay A.

Contacts A open circuit of private relay E and rotary magnet and close circuit of release relay B.
(Private relay E holds over.)

Each succeeding interruption of the line circuit by the dial results in sending a pulse through the private relay E and rotary magnet. The rotary magnet steps the wipers to the terminals of the called line while the private relay E remains operated for an interval after these terminals have been reached.

If the called line is *busy*, then the private wiper will meet ground and the operating circuit of the busy and back bridge relay D will be closed.

Drawing VII shows the closure of the operating circuit of the busy and back bridge relay D. Private relay E is still holding, and relay D is considered as about to operate.



DRAWING VII.—Showing closure of busy and back bridge relay, D. Relay, D, about to operate.

21. *The rotary stepping*—Continued.

The busy test and notification.

(15) Busy and back bridge relay D is operated from ground at private wiper.

Contacts D_1 open operating circuit of line wiper relay H and partially close locking circuit of busy and back bridge relay D.

Contacts D_2 close circuit to start ringing machine which generates current for busy tone.

Contacts D_3 place busy tone on calling line to notify calling party that desired line is busy.

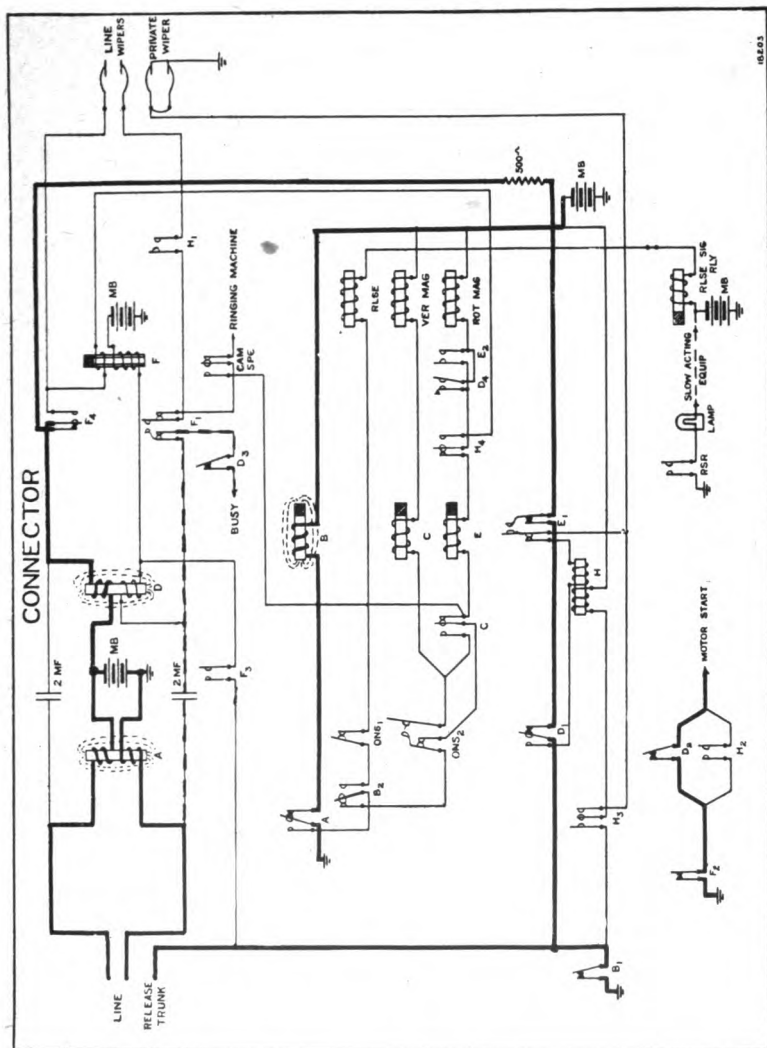
Contacts D_4 open contact in rotary magnet circuit.

(16) Private relay E releases (has been holding because of slow release feature).

Contacts E_1 close locking circuit of busy and back bridge relay D and open operating circuit of same relay.

Contacts E_2 open rotary stepping circuit at a second point to prevent any further stepping should the calling party again move the dial.

Drawing VIII shows the circuit conditions at this stage. The dashed line indicates the interrupted tone used to notify the calling party of the busy condition of the called line.



22. *Disconnection on a busy call.*

The calling party on hearing the busy tone hangs up his receiver.

(17) Line circuit is opened at calling station by action of hook switch.

(18) Line relay A releases.

Contacts A open circuit of release relay B and close ground contact in circuit of release magnet. The release-circuit is still open at contacts B₂.

(19) Release relay B restores (after short interval).

Contacts B₁ remove ground from release trunk, thus releasing the calling line switch and also open circuit of busy and back bridge relay D.

Contacts B₂ close circuit of release magnet (in series with release signal relay).

(20) Busy and back bridge relay D releases and release magnet operates.

Contacts D₁ restore to normal.

Contacts D₂ open circuit of busy and ringing machine.

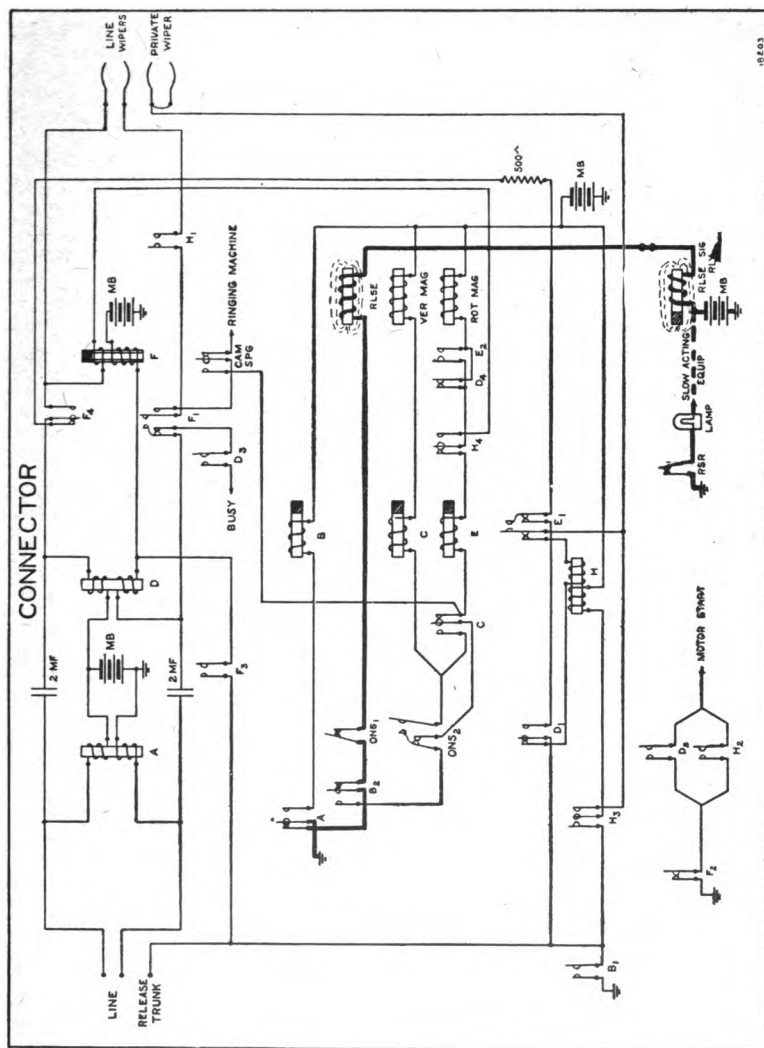
Contacts D₃ remove busy tone from line.

Contacts D₄ restore to normal.

Release magnet operates releasing mechanism.

NOTE.—The functions of the release signal relay will be described later.

Drawing IX shows the closure of the releasing circuit. The shaft and wipers now return to the normal position. The off-normal switch mechanically restores near end of downward motion of the shaft, at which time the circuit of the release magnet is opened and the entire circuit is restored to normal, as shown in Drawing I.



DRAWING IX.—Showing closure of release magnet circuit.

23. *The called line found idle.*

Ring the called station.

(21) The called line is assumed idle. The private wiper meets battery via the bridge cut-off coil of the called line switch. (Relay B.)

(22) The private relay E releases a brief interval after wipers reach bank terminals.
Contacts E₁ switch the private wiper from the busy circuit to the operating circuit of the line wiper relay H.

Contacts E₂ open a contact in the rotary stepping circuit.

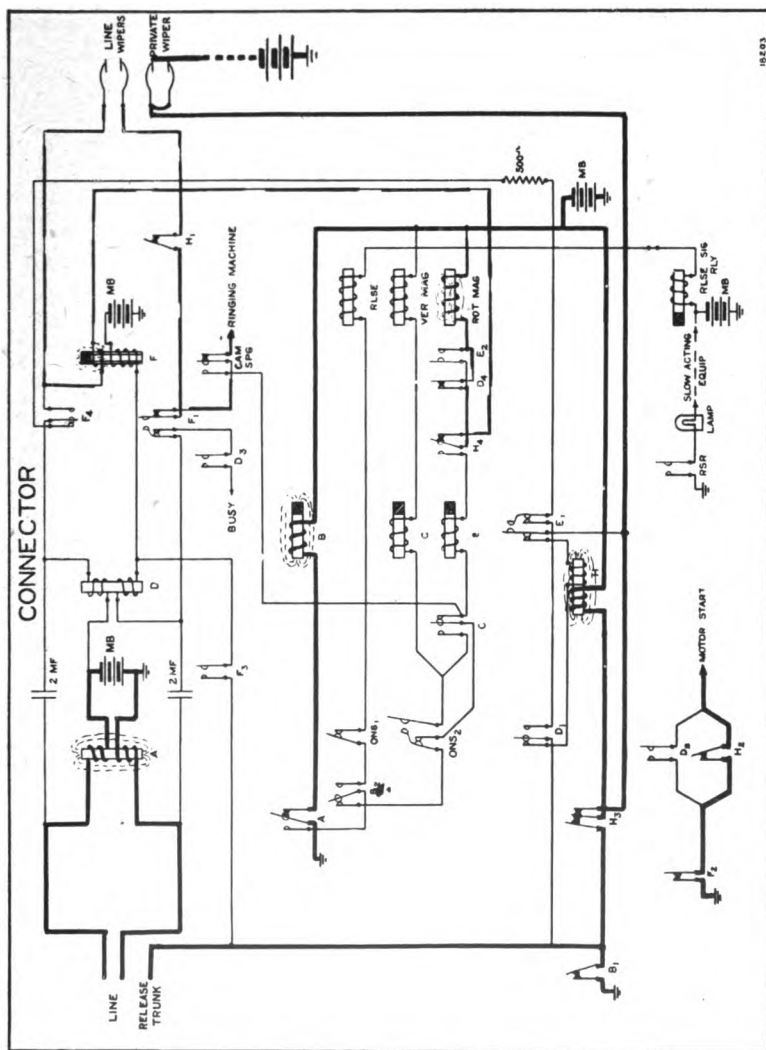
(23) The line wiper relay H operates (in series with the bridge cut-off coil of the called line switch).

Contacts H₁ and H₄ close the ringing circuit to the called line—indicated by the dashed line on drawing X.

Contacts H₂ close circuit of ringing machine to start ringing.

Contacts H₃ close holding winding of relay H, short-circuit operating winding relay H, and place a ground on the private bank contact to make the line test busy.

Drawing X shows circuit conditions at this stage. The called line has been seized and the bell is being rung. Note that the high resistance holding winding of relay F acts as a secondary winding of an induction coil to put a ring back tone on the calling line.



DRAWING X.—Circuit conditions when called line has been seized and is being rung.

24. *The called party answers.*

Cutting through of the calling line.

(24) Called party lifts receiver from hook, disconnects bell and condenser and closes line circuit through the transmitter and receiver.

(25) The ringing cut-off relay F operates. This relay remained unoperated on the ringing current, but now operates on direct current.

Contacts F_1 and F_4 open circuits used for busy test and ringing and close the called line circuit through the busy and back bridge relay D, thus putting the two parties in communication.

Contacts F_2 open the circuit of the busy and ringing machine since it is not needed.

Contacts F_3 close the locking circuit of the ringing cut-off relay and at same time furnish a ground to close circuit of relay D.

(26) The busy and back bridge relay D operates.

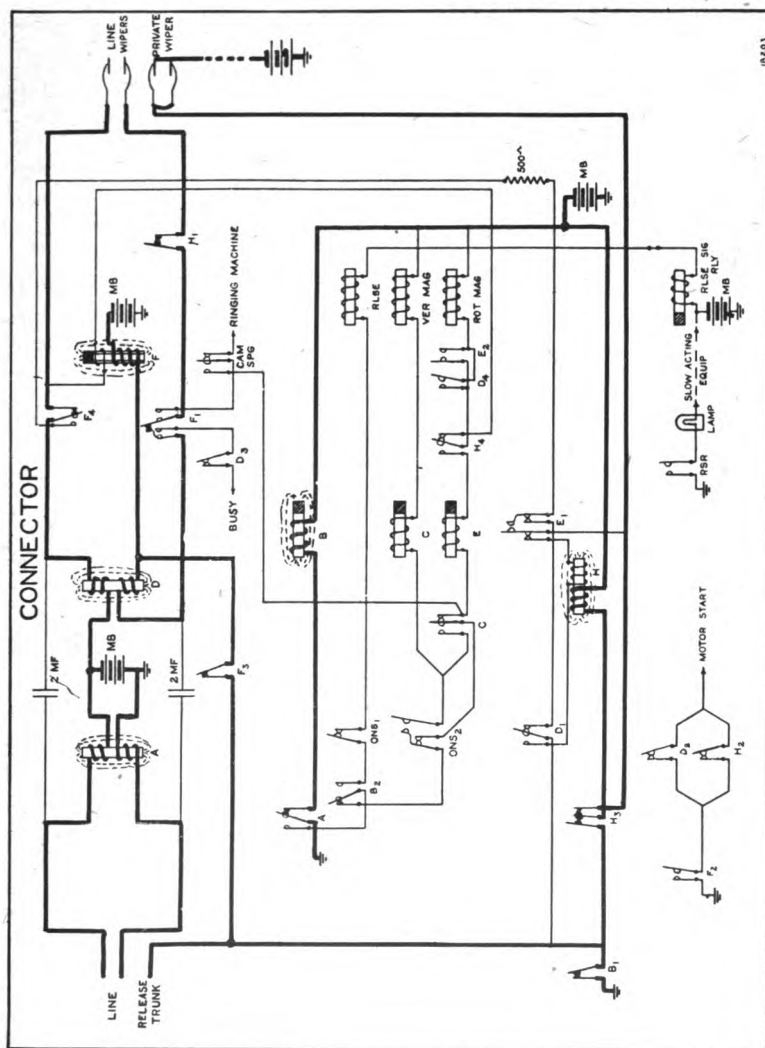
Contacts D_1 shift circuits.....

Contacts D_2 close contact in motor start circuit... } Not significant at this time.

Contacts D_3 close contact in busy circuit.....

Contact D_4 opens a contact in rotary magnet circuit as a precaution against further rotary stepping.

The circuits, now in their normal operated condition, are shown in Drawing XI.



DRAWING XI.—Condition of circuit when connector is in its normal operated condition.

25. *Release of the connector.*

The control of the release of this connector is given entirely to the calling party. If the called party hangs up first, the busy and back bridge relay D merely releases without causing any significant circuit changes.

(27) Calling party hangs up receiver and opens calling line.

(28) Line relay A releases.

Contacts A open circuit of release relay B and close contact in circuit of release magnet.

(29) Release relay B releases.

Contacts B₁ remove ground from release trunk, thus releasing the line switches of both the calling and called line and opening the circuits of line wiper relay H and ringing cut-off relay F. (Relay F holds over because of slow release.)

Contacts B₂ close circuit of release magnet (in series with release signal relay).

(30) Line wiper relay H releases while release magnet operates.

Contacts H₁ open called line circuit, which includes busy and back bridge relay D.

Contacts H₂ open contact in motor start circuit.

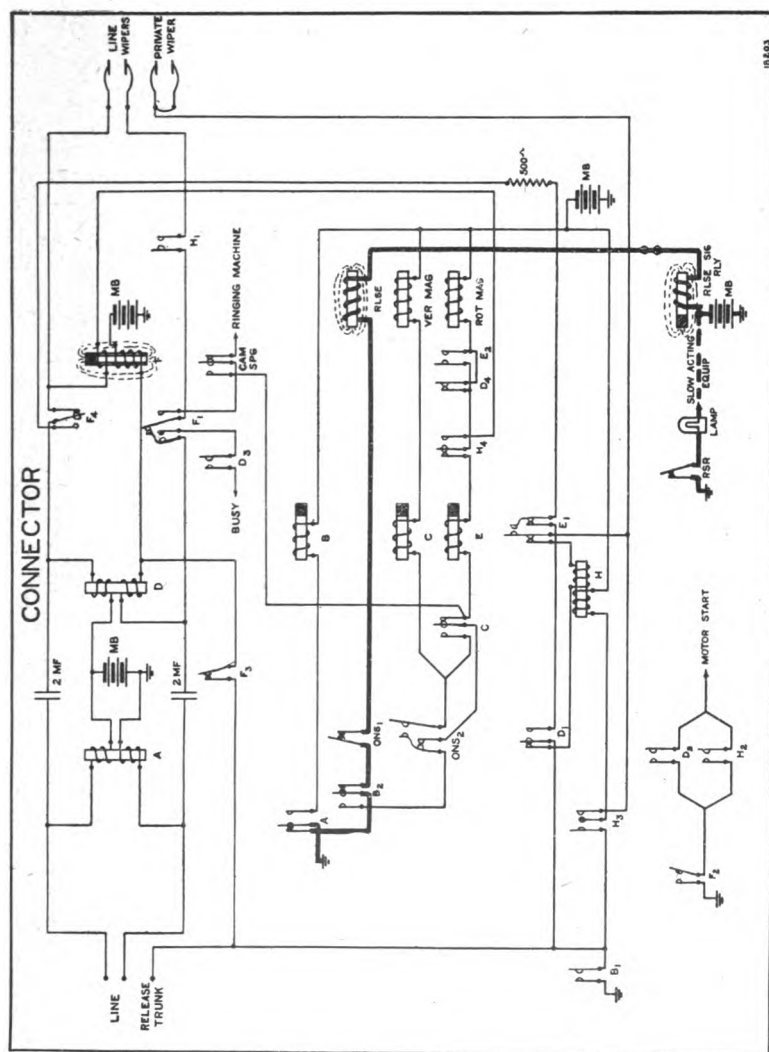
Contacts H₃ open contact in the locking circuit of relay H and disassociate the release trunk and private wiper.

Contacts H₄ restore, this action not being significant at this time.

(31) Busy and back bridge relay D releases.

Contacts D₁, D₂, D₃, and D₄ restore to normal preparatory to the release of the switch.

Drawing XII shows the circuit conditions at this instant, the release magnet circuit being about to release the mechanism. Ringing cut-off relay F is holding because of its slow release feature.



DRAWING XII.—Circuit condition causing release of connector and calling and called line switches, relay F holding for a brief interval.

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25. *Release of the connector*—Continued.

(32) Ringing cut-off relay F releases.

Contacts F_1 , F_2 , F_3 , and F_4 restore to normal preparatory to release.

(33) Release magnet operates releasing mechanism.

The shaft and wipers now return to the normal position. The off-normal switch is mechanically restored near the end of the downward motion of the shaft, at which time the release magnet is deenergized and the entire circuit is restored to normal, as shown in Drawing I.

26. *Function of the release signal relay.*

There is one release signal relay furnished to a connector board, and the release magnets of all the connectors on the board receive battery through this relay. Thus whenever a release magnet is energized the release signal relay is also energized. The relay has a pair of contact springs which close a circuit containing a lamp and slow acting equipment so arranged that if a release magnet is energized for a certain period the signal (including the lamps and an audible alarm) will be brought in. If a connector fails to release properly, the resulting alarm signal notifies the attendant of the trouble. The release signal relay may also be provided with an additional pair of contact springs which may be wired to a meter. This meter will then register the number of originating calls.

SIGNAL CORPS PAMPHLETS.

(Corrected to February, 1922.)

RADIO COMMUNICATION PAMPHLETS.

(Formerly designated Radio Pamphlets.)

No.

1. Elementary Principles of Radio Telegraphy and Telephony (edition of 4-28-21). W. D. D. 1064.
2. Antenna Systems.
3. Radio Receiving Sets (SCR-54 and SCR-54-A) and Vacuum Tube Detector Equipment (Type DT-3-A).
5. Airplane Radio Telegraph Transmitting Sets (Types SCR-65 and 65-A).
9. Amplifiers and Heterodynes. W. D. D. 1092.
11. Radio Telegraph Transmitting Sets (SCR-74; SCR-74-A).
13. Airplane Radio Telegraph Transmitting Set (Type SCR-73).
14. Radio Telegraph Transmitting Set (Type SCR-69).
17. Sets U. W. Radio Telegraph (Types SCR-79-A and SCR-99). W. D. D. 1084.
20. Airplane Radio Telephone Sets (Types SCR-68; SCR-68-A; SCR-114; SCR-116 SCR-59; SCR-59-A; SCR-75; SCR-115).
22. Ground Radio Telephone Sets (Types SCR-67; SCR-67-A). W. D. D. 1091.
23. U. W. Airplane Radio Telephone Set (Type SCR-80).
24. Tank Radio Telegraph Set (Type SCR-78-A).
25. Set, Radio Telegraph (Type SCR-105). W. D. D. 1077.
26. Sets, U. W. Radio Telegraph (Types SCR-127 and SCR-130). W. D. D. 1056 (edition of Nov., 1921).
28. Wavemeters and Decremeters. W. D. D. 1094.
30. The Radio Mechanic and the Airplane.
40. The Principles Underlying Radio Communication (edition of May, 1921). W. D. D. 1069.

WIRE COMMUNICATION PAMPHLETS.

(Formerly designated Electrical Engineering Pamphlets.)

1. The Buzzerphone (Type EE-1).
2. Monocord Switchboards of Units (Type EE-2 and EE-2-A) and Monocord Switchboard Operator's Set (Type EE-64). W. D. D. 1081.
3. Field Telephones (Types EE-3, EE-4, EE-5).
4. Laying Cable in the Forward Area (formerly designated Training Pamphlet No. 3).
6. Trench Line Construction (formerly designated Training Pamphlet No. 6-a).
7. Signal Corps Universal Test Set (Type EE-65) (edition of Dec., 1921). W. D. D. 1020.
10. Wire Axis Installation and Maintenance within the Division. W. D. D. 1068.
11. Elements of the Automatic Telephone System. W. D. D. 1096.

TRAINING PAMPHLETS.

1. Elementary Electricity (edition of 1-1-21). W. D. D. 1055.
2. Instructions for Using the Cipher Device, Type M-94. (W. D. D. 1097.) FOR OFFICIAL USE ONLY.
4. Visual Signaling.
5. The Homing Pigeon, Care and Training. W. D. D. 1000.
7. Primary Batteries (edition of 6-9-22).
8. Storage Batteries (formerly designated Radio Pamphlet No. 8).

FIELD PAMPHLETS.

1. Directions for Using the 24-CM. Signal Lamp (Type EE-7).
2. Directions for Using the 14-CM. Signal Lamp (Type EE-6).



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