CHAPTER 137

Telephones

In the electric telephone, *the vibrations of the diaphragm of the transmitter are transmitted to that of the receiver by means of electric currents sent out in the form of electric waves along the conducting wires connecting the two instruments.*

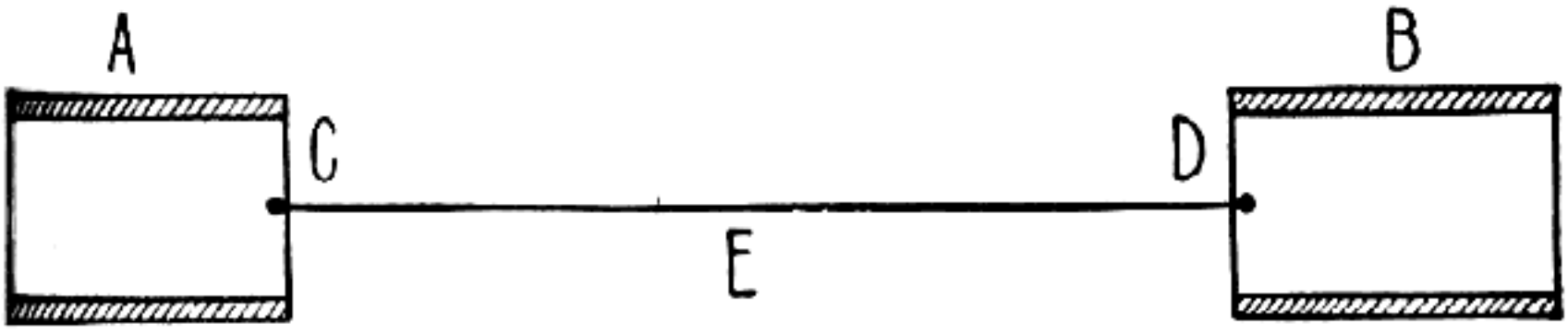


FIG. 8,382.—Simple toy telephone, whose working principle is similar to that of the electric telephone. ***In operation,*** when the open end of the tube A, is placed before the mouth, the vibrations of the membrane C, caused by the varying sound waves constituting articulate human speech, are transmitted with mechanical action by the string E, to the membrane D, and set up in the latter vibrations corresponding to those of C. The vibrations of C, cause sound waves in the air which are propagated according to the principles of acoustics, to the ear, placed at the open end of the cylinder B.

The current used for this purpose is of vibrating or alternating character and its strength at any instant has direct relation to the sound vibrations transmitted by the voice.

A telephone set usually comprises: 1, a *source of electric current supply;* 2, a *transmitter;* 3, a *receiver;* 4, an *induction coil* consisting of primary and secondary windings; 5, a *receiver hook* or automatic switch; 6, a *bell* or ringer consisting of two magnets and an armature and two bell gongs, and 7, a *condenser* with common battery sets.

Current Source.—This varies according to the system used at the exchanges.

The "common battery system" does away with the use of primary cells,

The *d.c.* required for the talking and for the switch board indicating signals is obtained from storage batteries charged from power driven dynamos and the *a.c.* for operating the subscriber's polarized bell or ringer is obtained from alternators.

Transmitter.—Fig. 8,383, shows a form of transmitter largely used.

The speaker talks into the mouth piece M, and the sound waves caused by his voice impinge on the metal diaphragm D, producing corresponding vibrations therein. Attached to the center of the diaphragm is a button and cup of hard carbon B, opposite to which and fastened to the frame is a second brass button E, and carbon cup A.

The space between the two cups is filled with coarse granules of carbon C. The buttons A and B, constitute the electrodes of the transmitter. The electric current from the battery passes from one to the other of the electrodes, through the carbon granules which form a conducting path consisting of an indefinite number of loose contacts. The resistance of the circuit, and consequently the strength of the current, can be regulated by varying the rate of vibration of the carbon granules. The button B, communicates the vibrations of the diaphragm D, to the carbon granules: therefore the voice of the speaker, characterized by the inflections and articulations of human speech, is reproduced in the varying strength of the electric current.

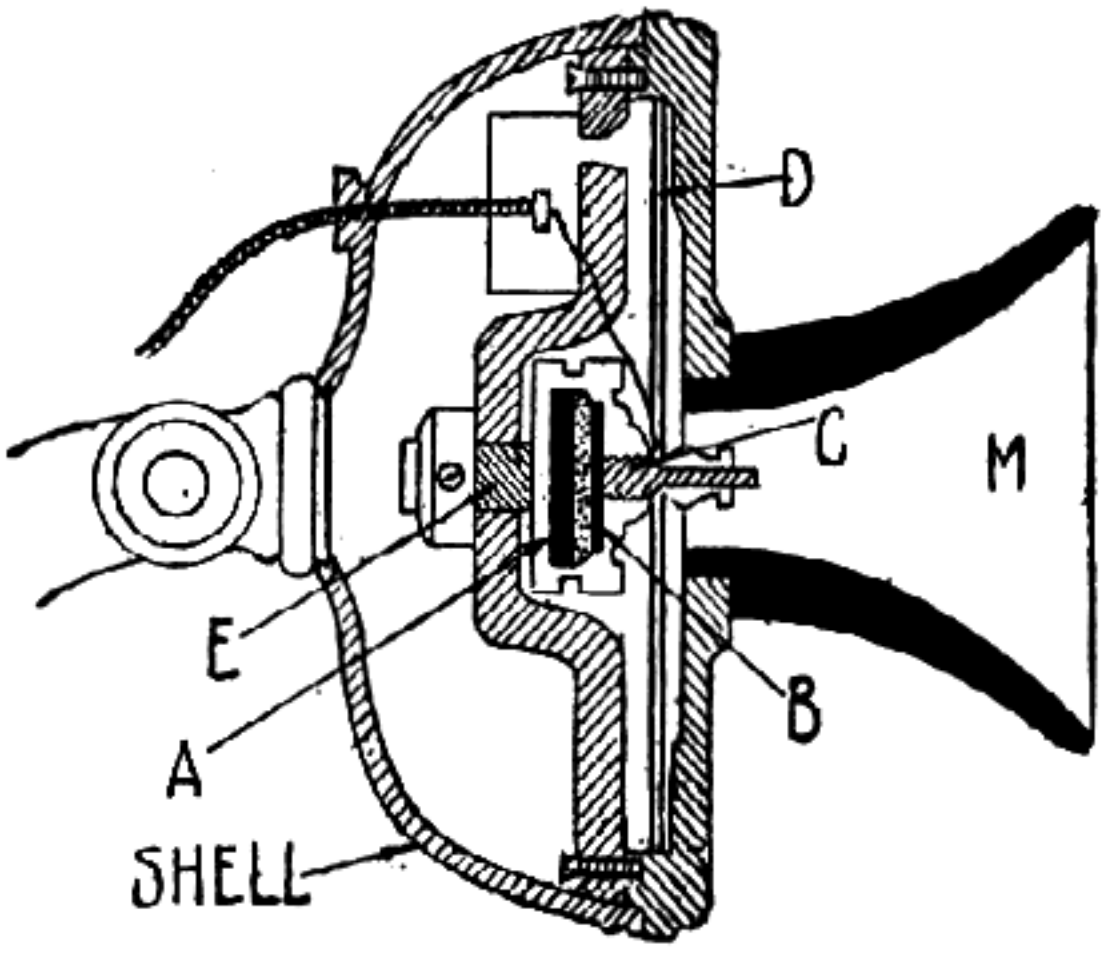


FIG. 8,383.—White solid back transmitter. ***In construction,*** the carbon chamber is formed by two mica diaphragms supporting the electrodes and brass ring collar. Each electrode is fastened to a brass disc. The use of two mica diaphragms provides for any vibration of the front electrode, which is transmitted through the granular carbon to the rear electrode. The whole chamber is caused to vibrate, which keeps the carbon granules alive and precludes their becoming packed.

Receiver. — There are numerous forms of receiver, the Bell receiver being the form now generally used, as in fig. 8,384.

In operation the varying strength of the electric current produced by the vibrations of the diaphragm of the transmitter causes corresponding variations in the magnetic state of the electromagnet D, making it act upon the diaphragm B, with different degrees of intensity, so that the listener's ear placed close to the receiver cap readily recognizes the characteristics of the speaker's voice.

Call Bells.—These devices, for attracting the attention of the party desired, usually consist of a *polarized bell operated by current from a magneto located in a box.*

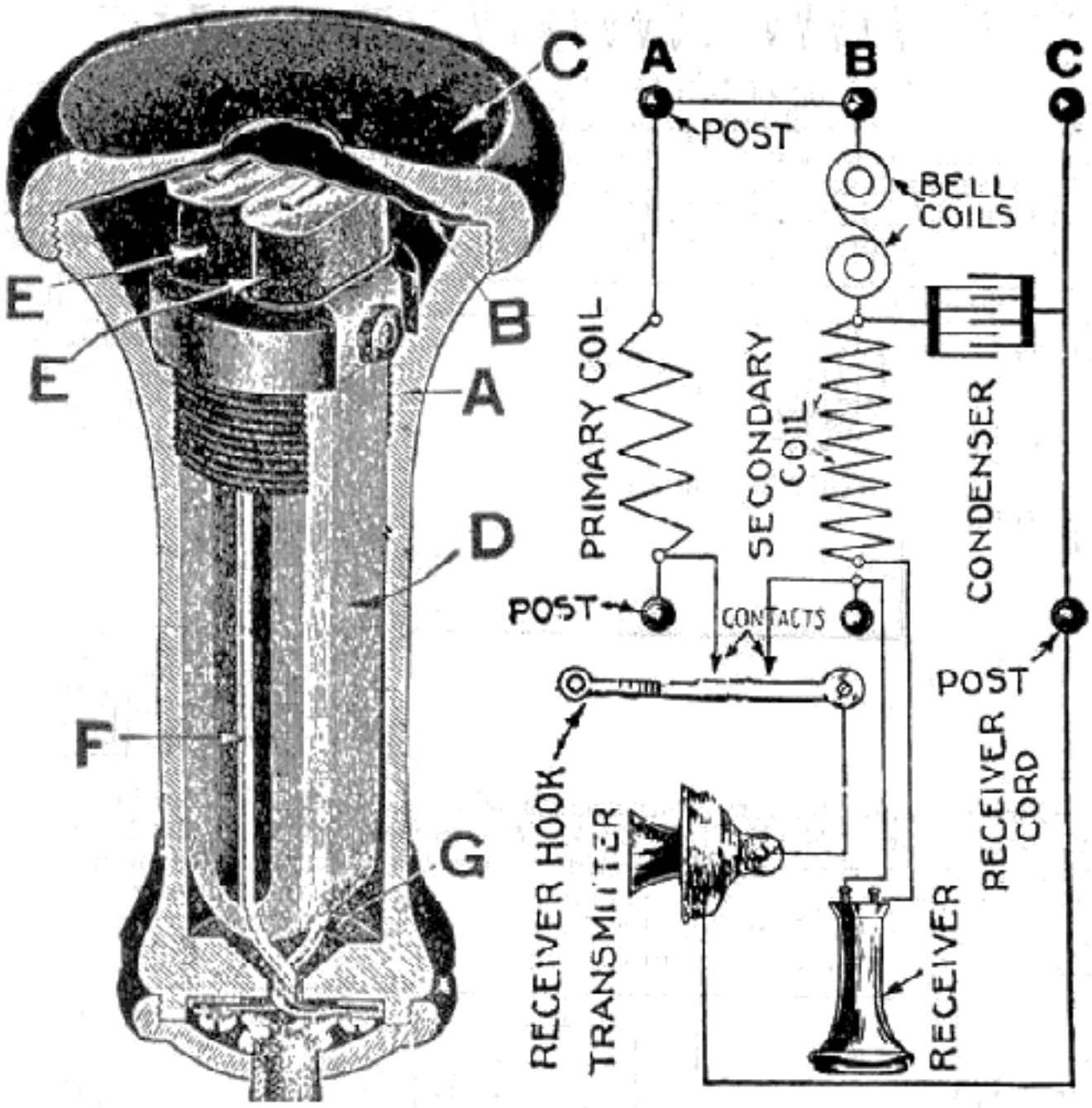


FIG. 8,384.—Bell Standard bi-polar receiver. ***It consists of*** a hard rubber case A, hollowed out at its upper extremity, and containing the thin, soft iron diaphragm B. Cap C, which screws on case A, is capable of vibrating freely. D, is a permanent magnet of the horse shoe type and E, E, an electromagnet located directly under the diaphragm B, which is in close proximity, but not in contact with, the poles of the magnet. These coils have soft iron cores screwed fast to the ends of the steel magnet so that when heavy alternating currents traverse through their windings the permanent magnetism of the horse shoe magnet is not disturbed. These coils are connected in series and terminate at the wires F and G.

FIG. 8,385.—Inside connections of telephone bell box. ***In operation,*** when the receiver is off the hook the contacts there are closed by the upward spring of the hook and the circuits are closed for operation. The line is always connected to the two outer posts A and C, the middle post B, often stamped G, is used for ground connection on party line instruments.

Inter-Communicating Switching Device.—For small systems such as those of hotels, the inter-communicating switching device is often combined with the telephone set.

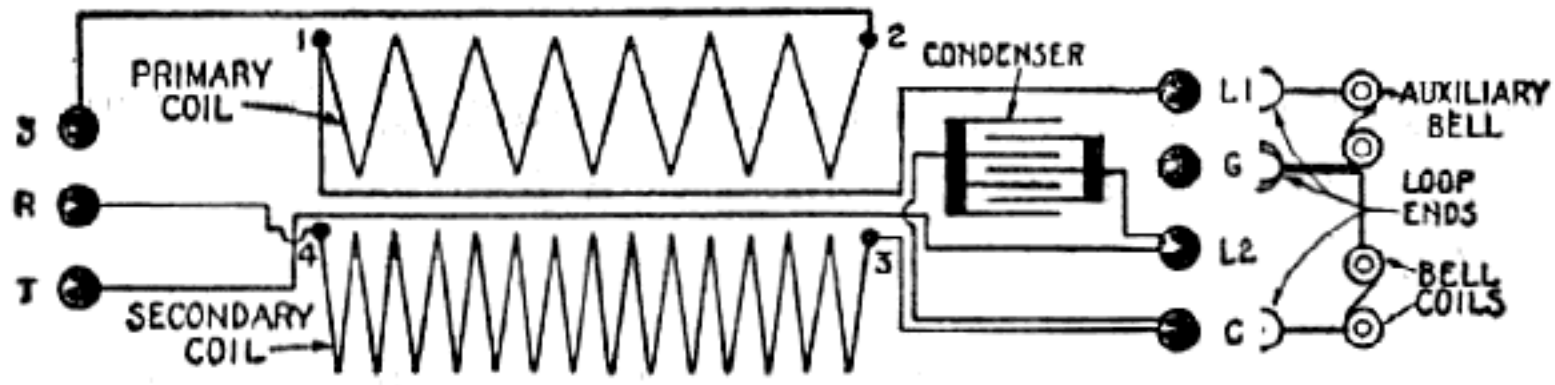


FIG. 8,386.—Improved wiring of bell box by N. Y. Telephone Co. If an auxiliary bell be wired in, the two sets of coil are connected in series and the post G, is used to connect the loops; otherwise the G, post is not used unless for ground connection in party wires. Post marked L1, corresponds to post A in fig. 8,385, post C, corresponds to post B, and post L2, corresponds to post C, in fig. 8,385, C referring to the condenser in each case. Post S, is connected to switch contact, post R, to receiver cord and post T, to transmitter.

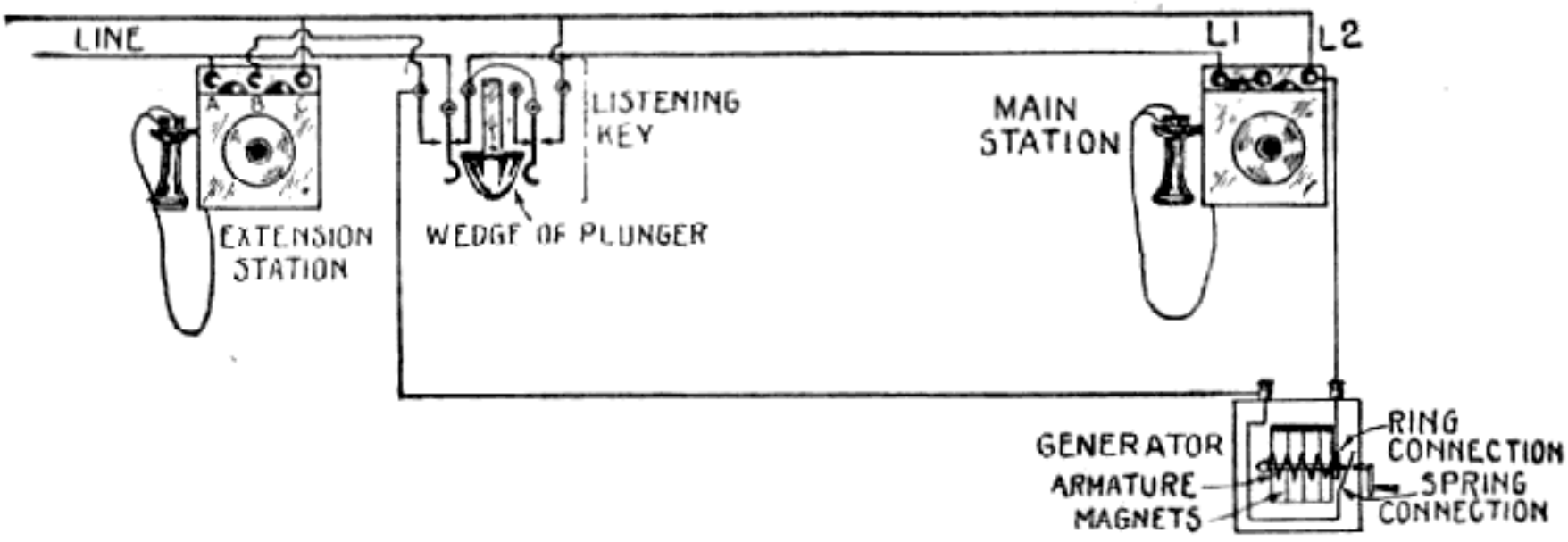


FIG. 8,387.—Two common battery instruments wired so that only one bell at a time can be rung by Central (plan 3 N. Y. Tel. Co.). ***In operation,*** with the listening key normal (as shown) central can ring only the main station bell but the extension can talk, and by throwing the listening key, the main is completely cut out and allows only the extension to ring and talk. The ringing key must be thrown to ring the extension station from the main, which makes the system intercommunicating.

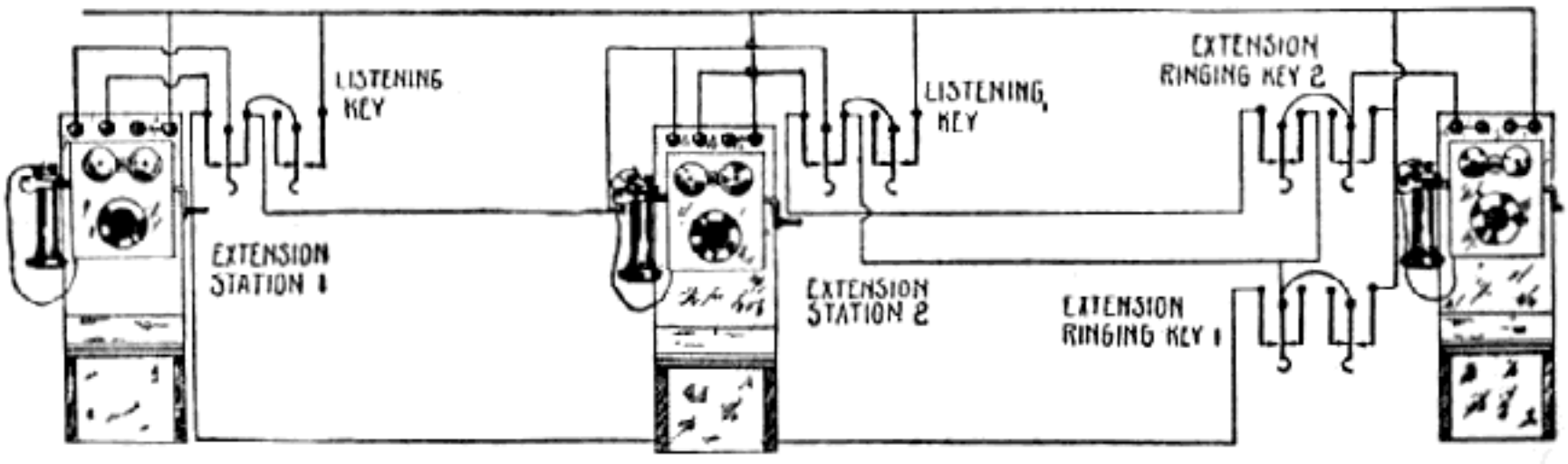
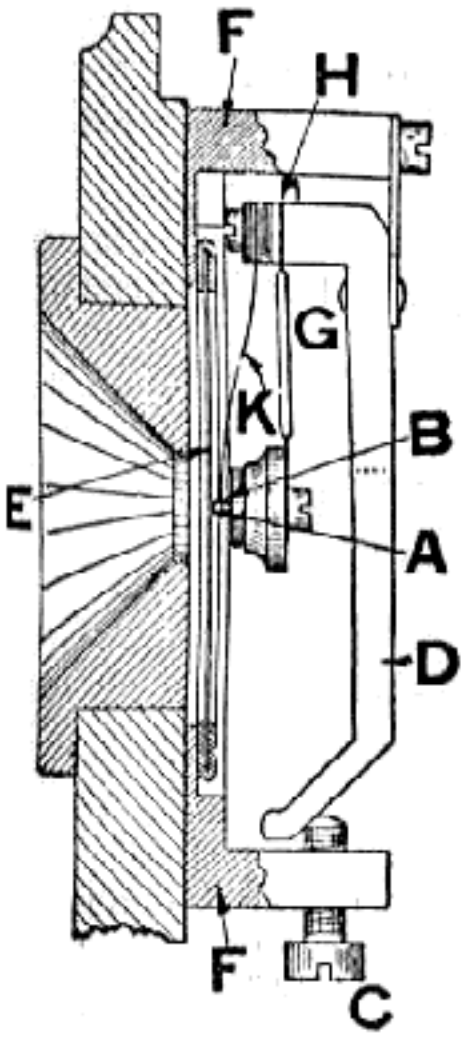


FIG. 8,388.—Three magnetos wired so that only one bell at a time can be rung by central (according to which listening key is thrown, permitting talk for any telephone with keys normal.



When there are a large number of subscribers, an exchange or central station is necessary, where the wires connecting the various subscribers or other small stations can be joined at will by the central operators.

Switch Boards.—These are made in sections, called *positions*, for central offices.

FIG. 8,389.—The Blake microphone transmitter. In this instrument a single contact is maintained between the platinum point A, and the polished carbon button B, by means of the adjusting screw C, acting against the strip of iron D, called the anvil. The vibrations of the diaphragm thus affecting the current which passes from the battery through the iron frame ring F, the anvil D, the connection G, the carbon button B, the platinum point A, and out again from the contact H, of the spring K. At one time the Blake transmitter formed a part of the standard equipment of almost every telephone in the United States and was also largely used abroad. No transmitter has ever exceeded it for clearness of articulation but it is decidedly deficient in power in comparison with the modern transmitters. The latter are composed of granulated carbon.

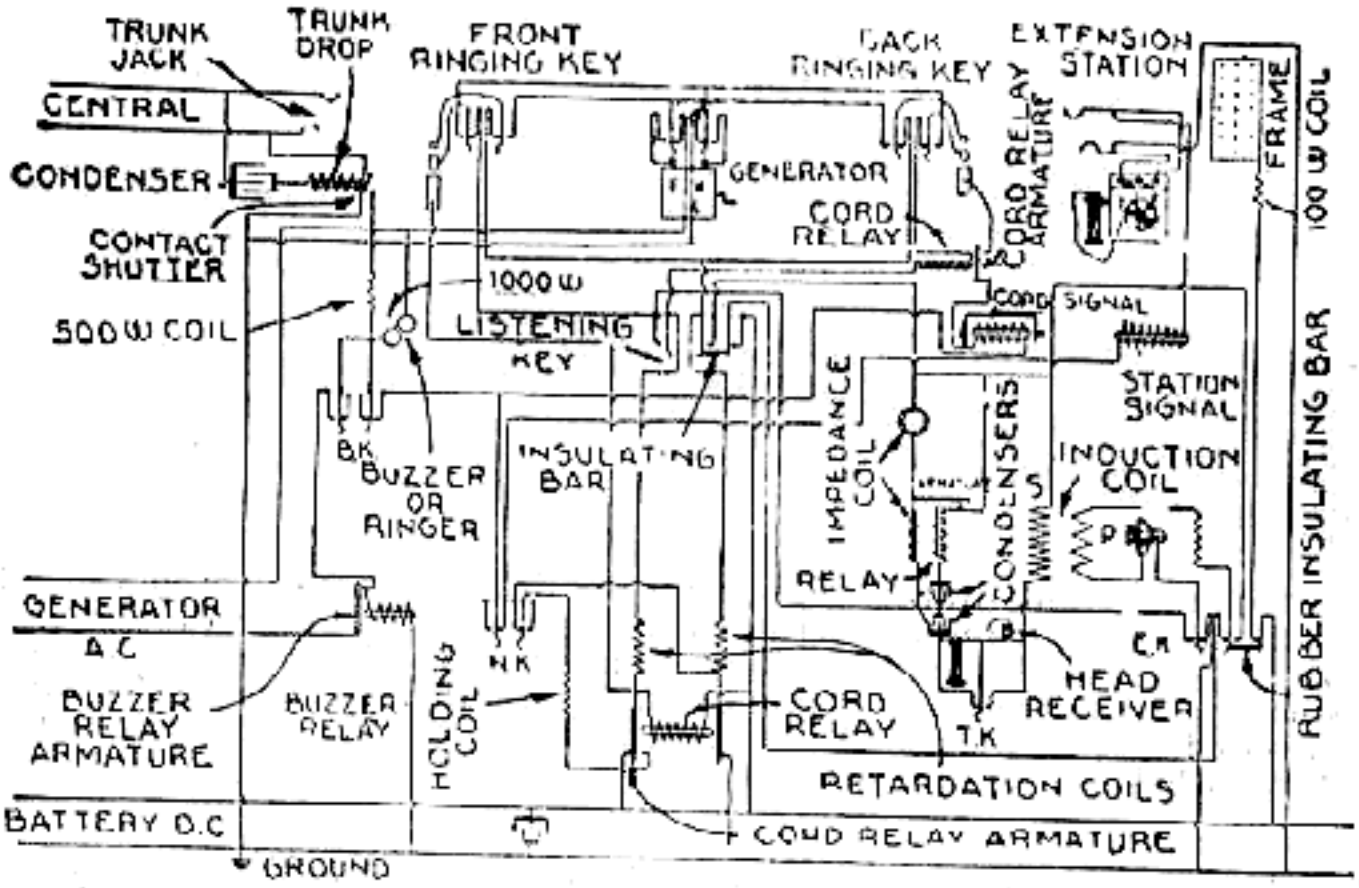


FIG. 8,390.—Positive supervision type of P.B.X. switch board adopted by N. Y. Telephone Co. ***With this type,*** each pair of cord is supervised by the positive supervision relay which controls the bull's eye cord signal. There are as many station jacks and station signals as there are extension stations and as many central jacks and drops as there are central (trunk) lines coming into switch board. There is only one buzzer key B.K., one night key N.K., one generator key G.K., one emergency key E.K., and one telephone receiver key T.K., mounted on each switch board.

The requirements of such exchanges are satisfactorily met by the use of various forms of multiple switch board in which each subscriber's line, instead of terminating in only one jack, connects with several, equal to the number of "positions."

This arrangement enables each operator to make any desired connection of the many thousands registered in the exchange, either by inserting

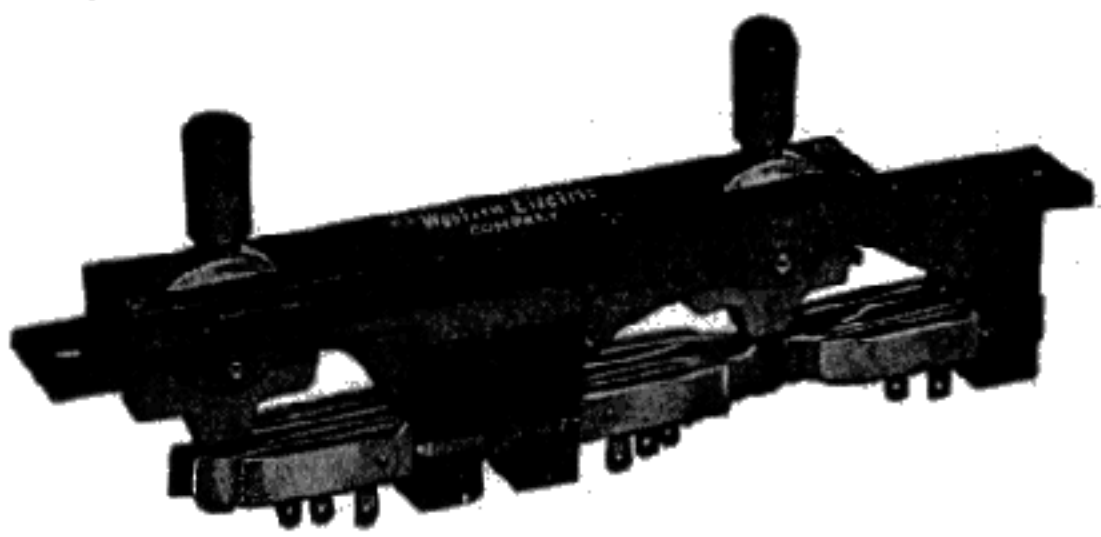


FIG. 8,391.—Modern ringing keys. In order to meet the needs of every calling subscriber, the operator must perform several different acts in shifting and changing circuits and to facilitate this work, devices to simplify it as much as possible have been developed. The modern ringing keys have greatly helped in the saving of the operators' time. By throwing the little levers a hard rubber bushing makes or breaks the contacts at the springs and throws alternating current ringing power into the line. When the finger pressure is released, the levers fly back again into normal position.

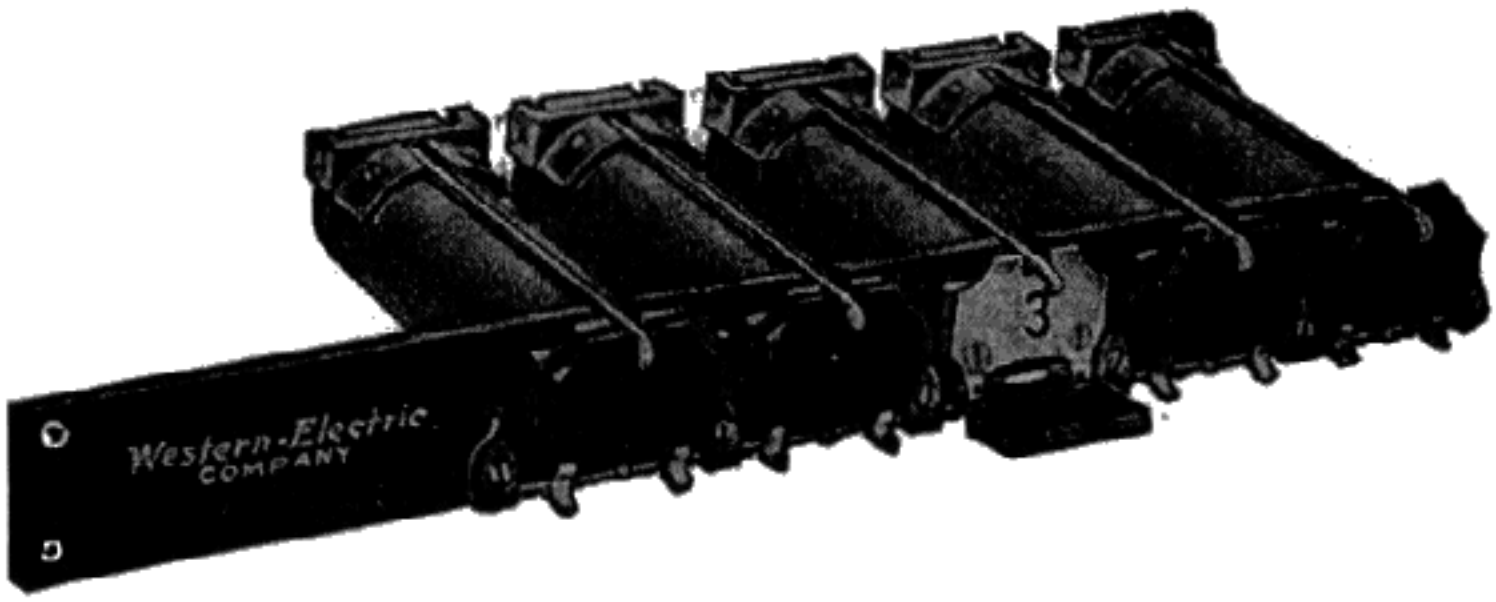


FIG. 8,392.—Mounted trunk drops. Tubular trunk drops are mounted on a metal strip each being held by two small screws underneath the drop shutter. The tubular casing of each drop is soft iron inside of which is the drop winding, the ends of the coil wires terminating at lugs which protrude from the casing and are insulated therefrom. The drop shutters are then screwed fast to the metal strip and adjusted so that they may fall easily when the armature is held up by the magnet.

the plug in the jack on her own panel or by reaching with the cord of her calling plug to the panel or position on either side of her.

The Common Battery Telephone System.—This is sometimes called a central energy arrangement. A dynamo at the

central office charges storage batteries over night with electricity which supplies current to all subscribers, thus affecting a cost saving.

A feature of this system is that the removal of the subscriber's receiver informs central of the subscriber's presence at the telephone.

The operator's equipment consists of a regular head or hand receiver

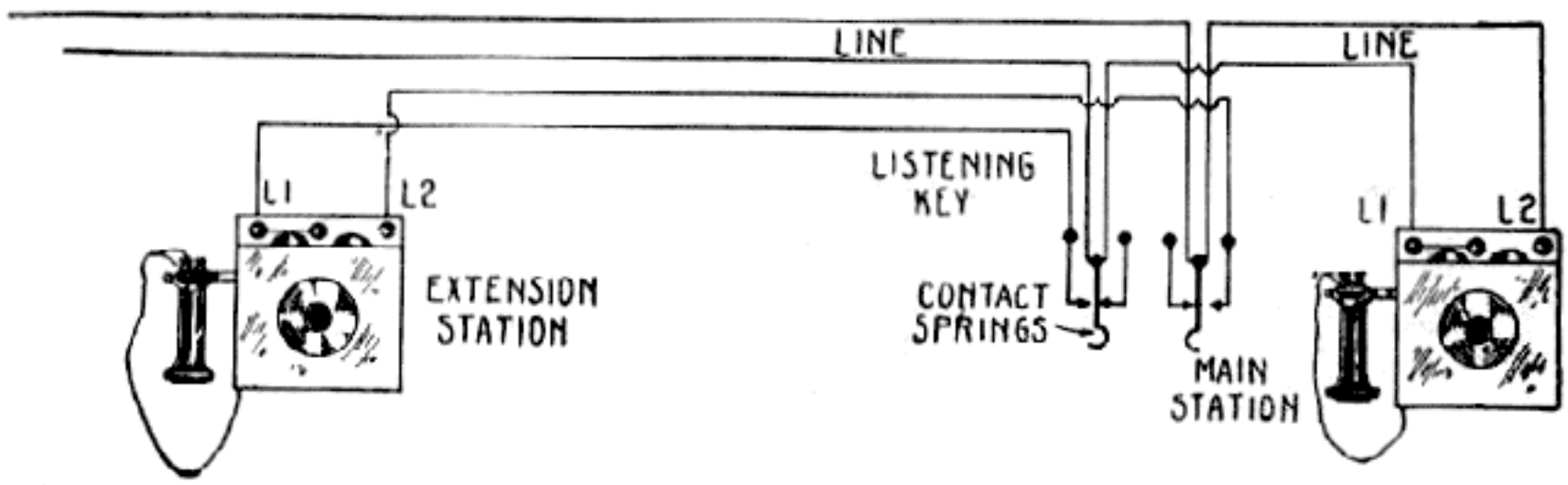


FIG .8,393.—Wiring diagram showing two telephones with a listening key at the main instrument to cut off the extension-station. This key can be placed at either instrument and the extension wired to either inner or outer contacts. As shown, the key is at the main station and the extension is on the outer contacts. This is called plan 10.

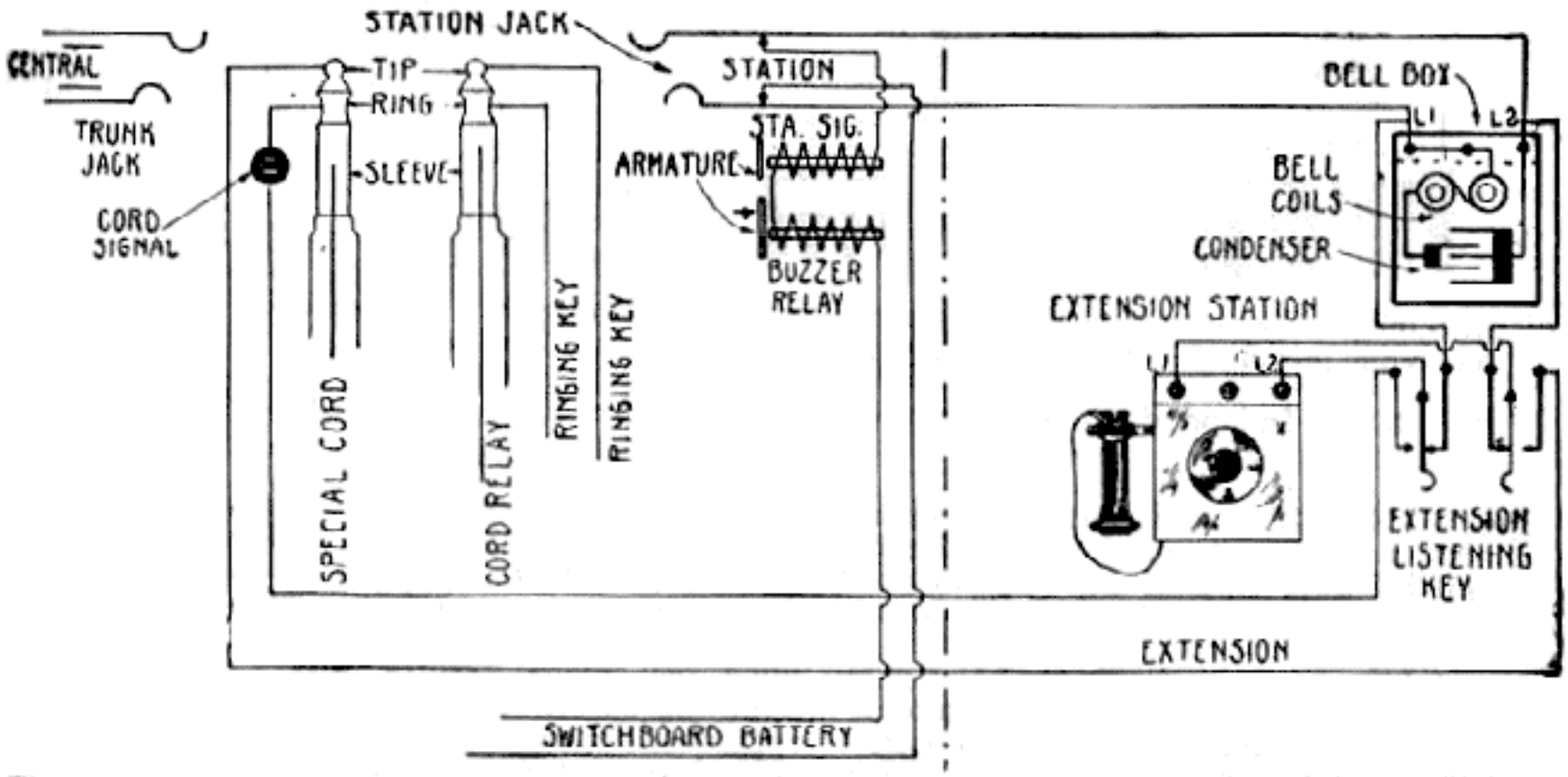


FIG. 8,394.—Private line extension station current from P.B.X. switch board, whereby absolute secrecy with outside exchanges is obtained. When extension listening key is normal, extension signals operator in same way as do all other extensions. After asking for private connection special cord, without listening key being plugged in central (trunk) jack by operator, subscriber throws extension listening key and conversation ensues. If P.B.X. operator's attention be again desired, listening key is thrown normal. Operator calls extension in usual way on any cord except special and rings extension special bell no matter how listening key be thrown. Since there is no listening key on special cord, operator must use any other cord for connection between P.B.X. and extension station.

and a switchboard transmitter supported on an adjustable transmitter arm with cords, or a breast plate transmitter and receiver with head band, cord, and cut in plug, also the necessary condensers, induction coils, and retardation coils, all of which are connected to the listening key circuits.

Central Office Exchange Equipment.—This consists of the necessary apparatus for transmission and signalling between private branch exchange (P.B.X.) switchboards and the exchange.

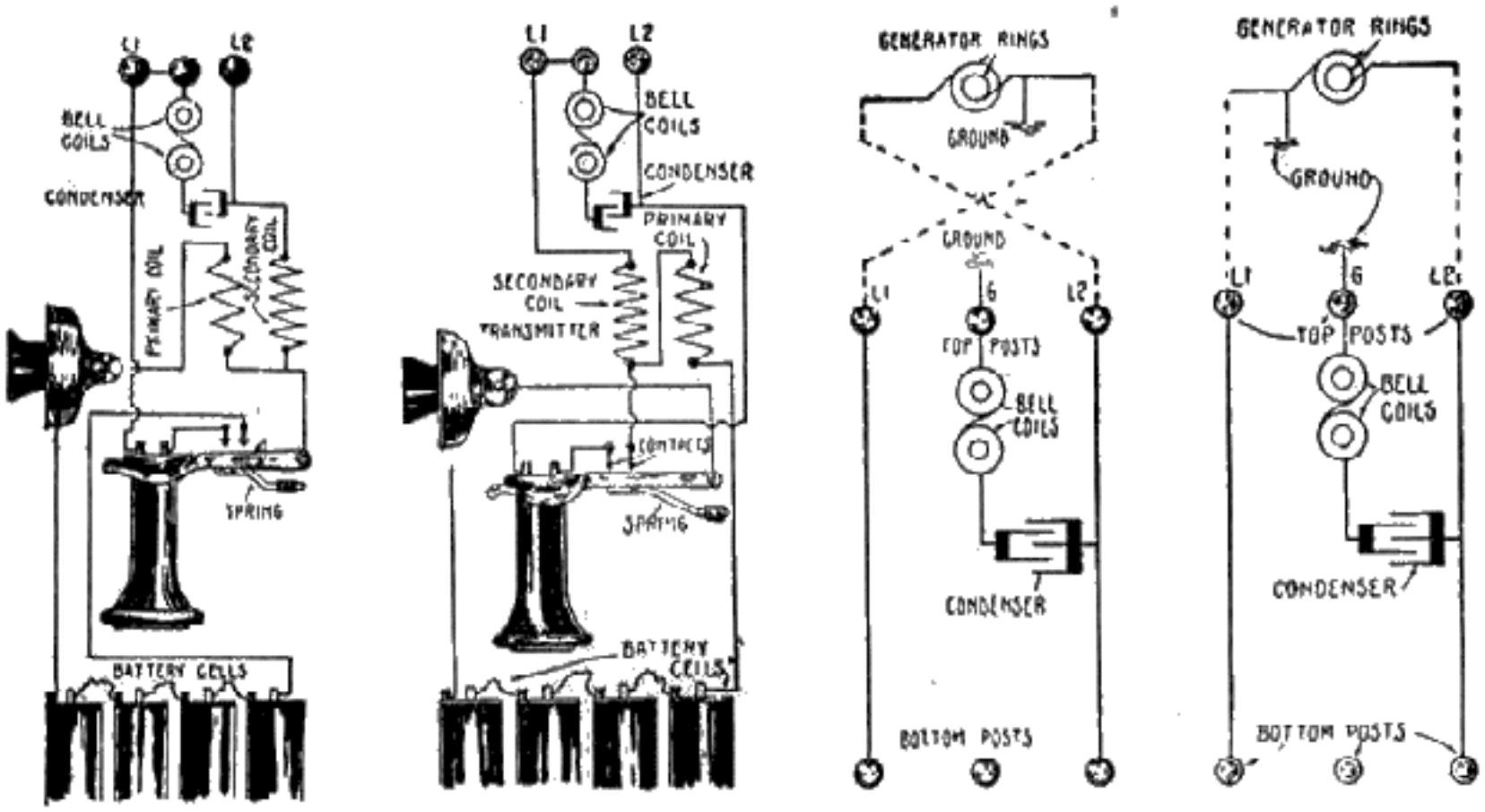


FIG. 8,395.—Booster set with battery connected in the circuit to strengthen transmitting and receiving power of common battery instrument.

FIG. 8,396.—Independent telephone station wired for local battery talking and common battery ringing.

FIG. 8,397.—Wiring diagram of two party line R, bell station with G, post represented as connected to ground and negative side of alternating current generator also grounded. When bell is rung, ringing key throws positive current in instrument at L2, across condenser and through bell and out at G, to negative side of generator through ground.

FIG. 8,398.—Wiring diagram of two party line J, bell station with G, post represented as connected to ground and negative side of alternating current generator also grounded. When bell is rung, ringing key throws positive current in instrument at L2, across condenser and through bell and out at G, to negative side of generator through ground.

The operators sit at the various "positions" of the switchboards, there being two types called the A and B boards. When a subscriber lifts the receiver, an electric light burns in a jack and the B, operator answers with the answering or back cord and throws her listening key and says number please.

When the subscriber gives the number she gives the B, operator the number by going into the B, operator's ear over a call circuit button on the A, board, the B, operator then sets the ringing key and gives the A, operator the assignment of a trunk and the A, operator plugs the calling or front cord in the outgoing trunk multiple in the jack which has been given her. The A, operator completes the connection when the subscriber who is connected through the B, board answers, the light or drop on the cord circuit goes out, and stays out until the parties hang up and then the light opens on the A, cord circuit and the A operator takes down the cords

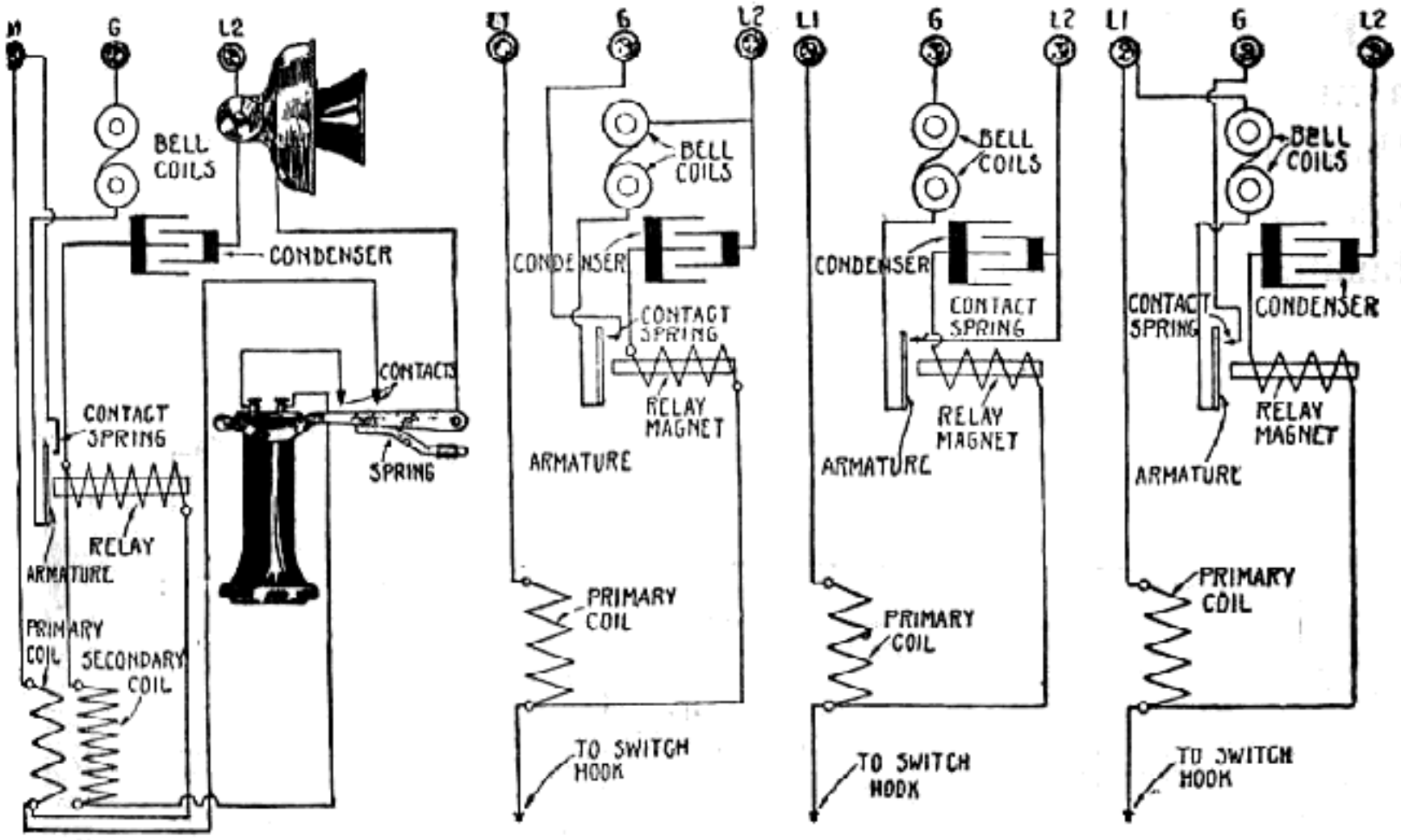


FIG. 8,399.—Four party line R, station showing the primary and secondary of the induction coil and the receiver and transmitter all of which are connected a shown in all party wire instruments. ***In operation,*** when the relay armature is held up against its contact spring, the bell circuit is complete to L1, post and rings through ground.

FIG. 8,400.—Wiring diagram of four party line J, bell station showing the primary of the induction coil, the selective ringing relay, and the condenser connected in series across the line. One end of the bell coil connects with post G, to ground and the other connects with the relay armature. When this armature is held up against its contact spring the bell circuit is complete to L2, post and rings through ground.

FIG. 8,401.—Wiring diagram of four party line M, bell station showing the primary of the induction coil, the selective ringing relay and the condenser connected in series across the line. One end of the bell coil connects with L2, post and the other end connects with the relay armature. When this armature is held up against its contact spring, the bell circuit is complete to G, post, and rings through ground.

FIG. 8,402.—Wiring diagram of four party line W, bell station showing the primary of the induction coil, the selective ringing relay, and the condenser connected in series across the line. One end of the bell coil connects with L1, post and the other end with the relay armature. When this armature is held up against its contact spring, the bell circuit is complete to ground, and rings through ground.

and as soon as the calling cord or front cord is taken out of the outgoing trunk jack the B, operator gets the disconnect signal and she disconnects the cord from the number in the subscriber's multiple. In all cases A, boards are connected to B, boards by call circuit buttons and the B, operator does not talk to the subscriber.

P.B.X. systems extension stations are arranged to terminate on jacks of the size suitable for the reception of the cord connecting plugs.

Party Lines.—These are so arranged, that the telephones of a number of subscribers may be connected on one circuit so that all have a common drop and jack at the exchange switch board. Systems of this type are frequently adopted where the business is small in proportion to the length of the line.

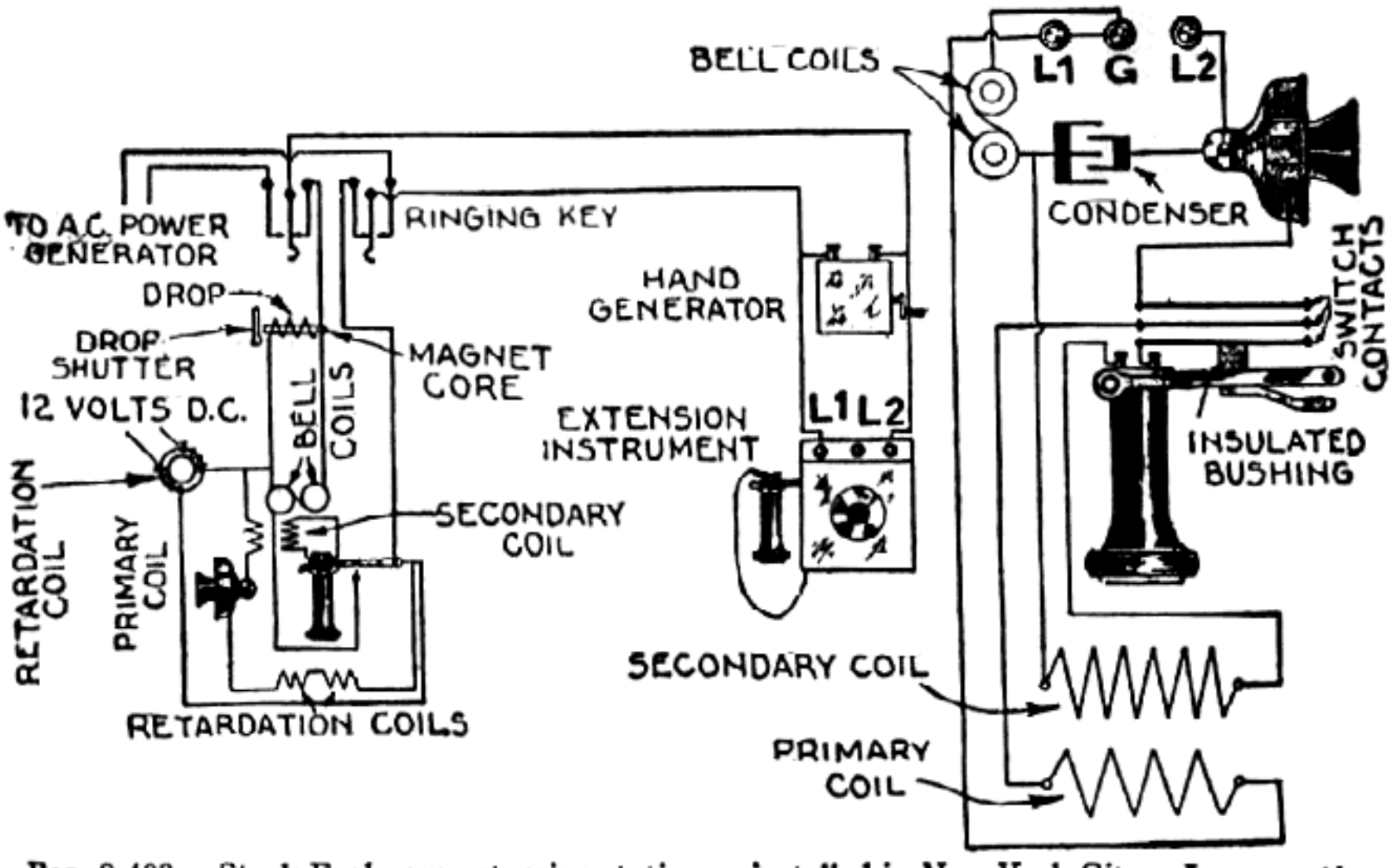


FIG. 8,403.—Stock Exchange extension station as installed in New York City. ***In operation,*** when main wants extension, the ringing key is used with ringing power. The extension bell is not connected but one can talk from the instrument.

FIG. 8,404.—Police signal box, showing the bell and condenser connected as usual across the line between L2 and G posts. ***In construction,*** the switch hook is insulated from the instrument by hard rubber bushings.

90 TELEPHONE TROUBLES

Subscribers' Troubles

1. Open bell. 2. Open condenser. 3. Open bell strap wire.
4. Bell out of adjustment. 5. Open auxiliary bell.
Effect: Can call central but central cannot ring subscriber although both can talk.

6. Open receiver. 7. Open receiver cord. 8. Open secondary coil.
9. Open switch hook contact. 10. Receiver diaphragm missing.
Effect: Can hear central ring but cannot hear talking with receiver.

11. Open primary coil. 12. Open switch hook contact.
13. Open transmitter. 14. Open transmitter cord.
Effect: Can hear central ring and talk but cannot talk back.

15. Dented receiver diaphragm.
16. Swinging open (cut out) receiver cord.
17. Short circuited induction coil.
18. Reversed secondary connections.
Effect: Can hear bell ring but can hear talking only faintly.

19. Packed carbon granules in transmitter.
20. Cut out transmitter cord.
21. Primary coil reversed.
Effect: Can hear central ring and talk but cannot be heard clearly.

22. Swinging ground on ring side of line.
23. Line crossed with other lines.
24. Party wire biasing spring out of adjustment.
Effect: Bell rings occasionally without cause.

25. Loose connection at one or both sides of line.
26. Cut out desk stand cord.
Effect: Noisy line.

27. Open line wire. 28. Open inside wire.
29. Badly corroded inside or outside wire.

Effect: Subscriber cannot call or be called. ***Test:*** Strap out opens with test receiver. Disconnect short circuited lines and then test by strapping in test receiver. Shake cut out cords to locate trouble.

Private Branch Exchange (P.B.X.) Troubles

30. Generator feeder not correctly poled.

Effect: Pressing ringing key while plugging cord into any station jack, all extension bells will ring or tap. Clear by reversing connections.

31. Generator feeder open.

32. Buzzer ringer coils open.

33. Buzzer relay contact does not make.

Effect: Central cannot ring P.B.X. operator on any drop. ***Test*** by following out circuit with test receiver.

34. Battery feed open.

Effect: Buzzer relay vibrates while plugging trunk jack until E, key is thrown. ***Test*** by following up battery with test receiver.

35. Short circuited or grounded ring of battery feed.

Effect: Battery of insufficient strength to talk and extensions cannot get switch board. ***Test*** by first removing wires from binding posts at cross connecting box and tapping with test receiver or 24 volt lamp strapped across wires of incoming feed. If lamp light bright or receiver click loud, battery is coming in O. K. Reconnect the tip side of feed, connect one side of a test receiver to ring binding post and tap the other side several times on end of loose wire. If receiver click, trouble must be toward switch board. Then at back of switch board open ring side of battery and tap as before at cable end of wires. If click be heard, trouble is in switch board cable; if no click be heard, trouble is in switch board.

36. Short circuited cord plug.

Effect: Cord plugs are hot or plugs emit smoke when dampness has crept in bushings separating the three parts of plug. ***Test*** by throwing up all listening keys and placing operator's receiver to the ear, start from first and depress each ringing key separately. Clicking noise in receiver indicates short circuit. Turn down each cord where clicking noise is heard and disconnect each cord so turned down at cord lug connections.

37. Cord circuit at relay contacts short circuited.

38. Cord circuit shortened by touching of keyboard wires.

39. Ringing key contacts crossed.

Effect: Clicking still heard in operator's receiver when turned down cords

are disconnected and ringing keys are again depressed. If ringing key contacts be thought to short circuit because the inner contact spring makes contact with the outer before breaking from the inner, the G, key can be thrown, which will temporarily clear the trouble. Then the contacts must be adjusted.

40. Positive supervision relay sticks.

41. Bull's eye cord signal sticks.

Effect ***(of 41):*** Operator cannot tell when parties have finished talking. ***Test*** by jarring relay and clear by making good adjustment.

42. Open trunk jack springs.

43. Open trunk line condenser. 44. Open trunk drop winding.

Effect: Central cannot ring local P.B.X. trunk drop.

45. Buzzer relay open. 46. Buzzer contact spring does not make.

47. 500 ohm resistance coil open.

48. Ring or ground side of battery open.

49. Ground wire open where springs make contact in falling.

Effect ***(of 49):*** Drop shutters fall when central rings but buzzer does not ring or buzz.

50. Broken wire at trunk jack common to all jacks.

51. Open 100 ohm resistance coil.

Effect: Banging noise is heard when local operator plugs into central jack.

52. Cut out hand receiver cord. 53. Cut out head receiver cord.

54. Cut out transmitter cord.

Effect ***(of 54):*** Breaking of circuit is noticeable by occasional breaks in the conversation. The conversation may be carried on O.K. if all cords be kept perfectly motionless, but as soon as moved or shaken there are noticeable cut outs in the conversation.

Test: Throw any listening key and place tip of either plug of that pair of cord on first one binding post and then on another of the receivers, at the same time shaking the cords. The trouble is generally located at the cord tips or connections.

55. Transmitter open.

56. Primary coil of operator's set open.

57. Transmitter cord open. 58. Listening key contacts open.

***Effect** (**of 58**):* Central cannot hear local operator on any cords, nor can P.B.X. operator hear central.

59. Receiver open. 60. Secondary coil open.

61. Receiver cord open.

Effect: P.B.X. operator cannot hear central operator but central can hear P.B.X.

62. Short circuited trunk line condenser. 63. Short circuited jack springs. 64. Drop winding crossed with frame.

***Effect** (**of 64**):* Central gets steady light from P.B.X.

65. Open station signal. 66. Open station jack contacts.

67. Open wire between jack and signal.

Effect: One extension station cannot get local operator.

68. Open common wire to jacks.

69. Open common wire to signals.

Effect: All extension stations fail to get local operator.

70. Open plug or cord. 71. Open contact at ringing key.

72. Open positive supervision relay. Open cord relay contacts.

Effect: Cord in question cannot be used.

73. Open condenser at operator's set.

Effect: Operator cannot hear but can be heard O.K.

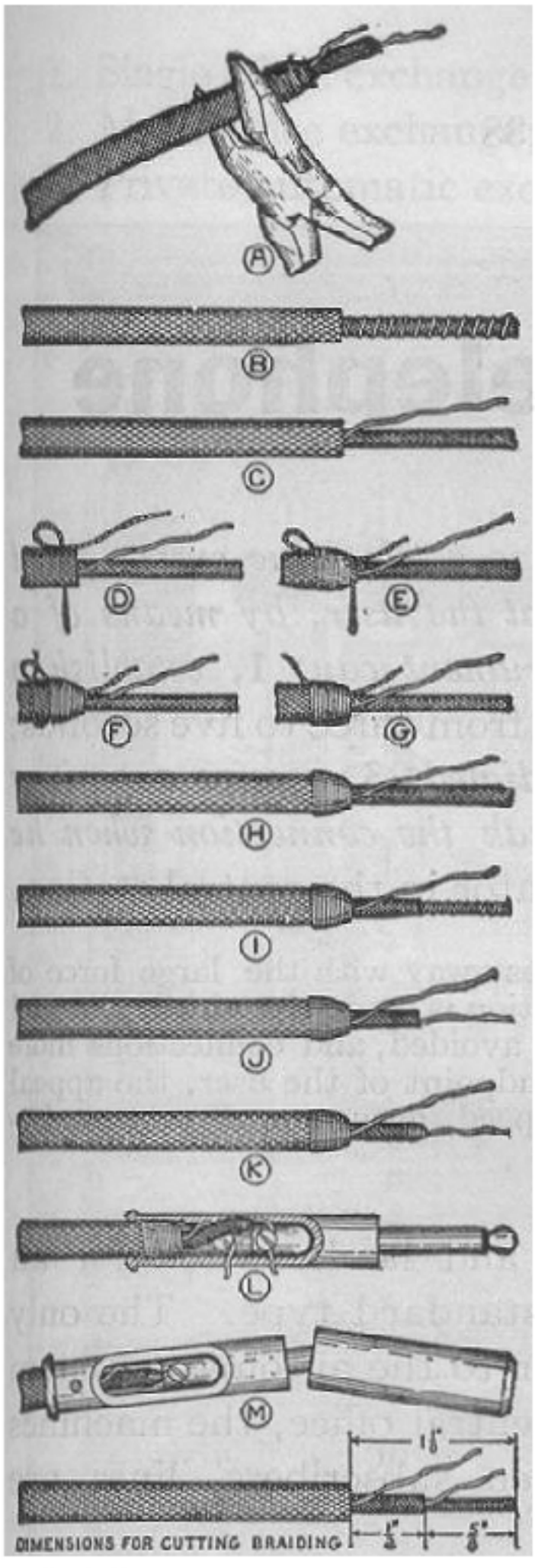
74. Open between battery feed and listening key. 75. Open between listening key and E, key. 76. Open between battery feed and E, key. 77. Short circuited induction coil.

***Effect** (**of 71**):* Throwing of listening keys does not give usual side tone (live sound heard by tapping on transmitter) until E, key is thrown.

78. Open holding coil. 79. Open N, key contacts.

80. Open upper relay contact.

Effect: When an extension station is connected through to central and receiver is hung up (such as a night connection) the central disconnecting signal shows. The holding coil should prevent this with its high resistance shunted across the line when N, key is thrown.



FIGS. 8,405 to 8,418. — ***Repairing Western Electric Steel Cords.*** A, remove the plug from the cord and cut off the worn end of cord; B, cut back outer braiding and sewing with a pair of snips about 1⅛" leaving sleeve conductor bare; C, pull out spiral sleeve conductor with a pair of pliers and cut to about 1" in length; D,E,F,G, and H, bind outer braiding 5/16" back with W.E. three ply gilling thread; I, cut back inner braiding ½" leaving tip conductor bare; J, pull out tip conductor and trim inner core to length; K, bind inner braiding with gilling thread about 5/16" back from end, the operation in accomplishing this being the same as outlined under D,E,F,G, and H; L, screw into plug; M, fasten sleeve and tip conductors under screws and replace shell.

Plan Troubles

81. Hand generator turns hard.

82. On plan 3 or 5, listening key contacts are crossed.

Effect: System is short circuited.

83. Plan 3 or plan 5 generator handle sticks.

84. Short circuited condenser.

85. Wet desk stand cord.

86. Ringing key contacts on plan 5 are crossed because plunger sticks.

Effect: Both extension station bells will ring when one listening key is thrown.

87. Desk stand cord short circuited on plan 3 or 5 extension.

Effect: That extension bell will ring or tingle at same time that main bell rings.

88. Desk stand cord connected wrong on either extension.

Effect: Plan will become confused and appear to be wired wrong, according to how the cord is wired.

89. Open strap wire at plan 3 or 5 listening key.

Effect: In any case the main instrument would be cut off by an open line and not by a short circuit for which the strap is used.

90. Listening key contacts open on plan 8 key.

Effect: Main station can ring extension but cannot talk. If key be not down normal for ringing and thrown for talking main, cannot get extension station.