FUNDAMENTAL CIRCUIT AND OPERATING FEATURES COMMON MANUAL PBX SWITCHBOARDS

CONTENTS

1. GENERAL:

1.1 This section covers a description of the fundamental circuit and operating features of common manually operated P.B.X. switchboards. It is not intended to cover all the features to be found in these boards but only the outstanding ones, in order that the fundamental principles may be understood.

1.2 The P B X or Private Branch Exchange switchboard is generally operated by a subscriber for his service exclusively, making available exchange and intercommunicating services. There are several types of P B X switchboards in service, each with its own features. However, as they must work with standard central office and station equipment, all P B X switchboards have some common circuit and operating features.

2. EXTENSION LINE CIRCUITS:

2.1 In beginning a study of P B X circuits, a knowledge of the station circuit shown in Fig. 1 is necessary. The bell and the condenser are in series across the line, the condenser preventing a direct current flow but allowing ringing current to pass through the circuit to ring the bell. With the receiver on the hook, the line is open to the flow of direct current; with the receiver off the hook, a path for direct current is closed through the primary winding of the induction coil, switch hook contacts and transmitter.

Cord Type P B X Switchboards:

2.2 Each extension line is terminated on a jack at the P B X The tip side of the extension line connects L2 at the station to the tip spring of the jack, and the ring side of the line connects L1 to the ring spring of the jack.

2.3 The sleeve of the jack makes electrical contact with the plug sleeve, thereby providing a circuit for supervisory (signaling) or other purposes to be described later.

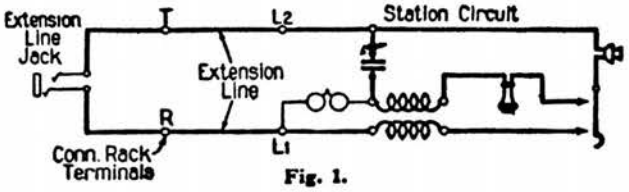


Fig. 1.

2.4 Each extension line circuit is provided with apparatus to signal the attendant. This is done by adding two springs to the jack, one of which is connected to ground and the other through a lamp, line relay or magnetic signal to battery. Each jack has its associated lamp or magnetic signal as shown in Fig. 2.

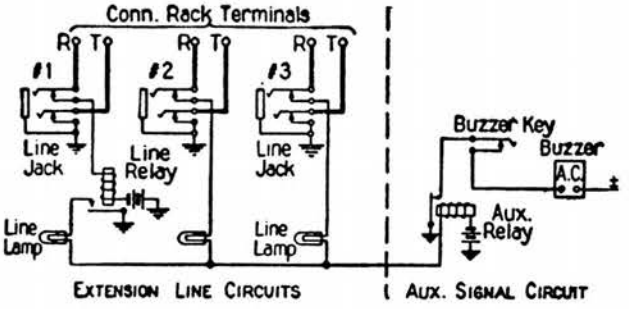


Fig. 2.

2.5 When the extension receiver is lifted from the switch hook; for example, at extension stations No. 2 and No. 3 (Fig. 2), direct current flows from the battery through the extension line lamp, jack contacts, ring side of the line, primary winding of induction coil, switch hook contacts, transmitter tip side of the line, jack contacts, to ground, thereby lighting the line lamp. When the attendant inserts a plug into the jack, the line lamp is extinguished due to opening the inner contacts of the tip and ring jack springs which open the signaling battery and ground supply.

2.6 If the extension station is off the premises or some distance from the P B X (as extension line circuit No. 1, Fig. 2) the resistance of the extension line may not permit the flow of sufficient current to properly light the lamp. In these cases a line relay which requires less current for its operation than the lamp is used. The operation of the line relay closes the circuit of the line lamp, thereby lighting it. The attendant inserts a plug into the jack, thus releasing the line relay and extinguishing the line lamp.

Cordless Type P B X Switchboards:

2.7 On cordless type P B X switchboards the extension line circuits terminate in keys in place of jacks and in signals in

ce of lamps. Connections are established by the operation keys to a connecting path which is similar to a cord circuit.

3. AUXILIARY SIGNAL CIRCUIT:

3.1 An audible signal, in addition to the visual signals, is provided by connecting a low resistance relay in the common supply lead to the lamp or magnetic signals with a buzzer circuit which is controlled by the contacts of the relay as shown in Fig. 2. A buzzer key is provided in the buzzer circuit so that the attendant may disconnect the buzzer in case the signal is not required. A circuit such as this is known as an auxiliary signal circuit or a night alarm circuit.

4. TALKING CIRCUIT — EXTENSION-TO-EXTENSION CONNECTION:

4.1 In cord type switchboards, connections are established by means of cord circuits. Imagine that a three conductor cord with a plug at each end is cut in half with the cord circuit apparatus between, as shown in Fig. 3. There are now two cords: a front cord and a back cord. These two cords, their terminating plugs and the associated apparatus comprise a cord circuit. Each P B X is equipped with several cord circuits so that a number of different connections can be made simultaneously.

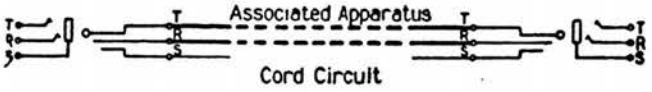


Fig. 3.

2 The talking circuit is established by means of the tip and ring cord circuit conductors. Talking current is provided by connecting ground to the tip and battery to the ring of the cord circuit. Each P.B X has a battery and a ground bus bar or group of terminals to which battery and ground connections are made. The cord circuits of most P B X switchboards are equipped with retardation coils, one winding of which is placed between the tip and common ground bus bar and the other between the ring and common battery bus bar as shown in Fig. 4. These retardation coils prevent the voice currents from reaching the common bus bars and also prevent noises on the battery feeders from reaching the talking circuit.

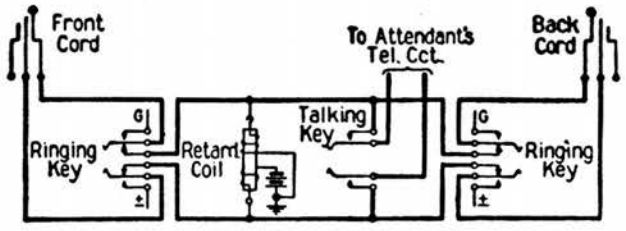


Fig. 4.

5. ATTENDANT'S TELEPHONE CIRCUITS:

5.1 The P B X attendant must be provided with a telephone set circuit to originate and answer calls. A talking key is provided for each cord circuit. The operation of this key connects the attendant's telephone set across the tip and ring of the cord circuit. There are several types of attendant's telephone sets in use. Three common types are shown in Fig. 5. The one shown as (A) is used principally in cordless boards. is similar to the station circuit shown in Fig. 1 except that the ringer is omitted. The direct current for operating the transmitter is supplied from the P B X connecting circuit.

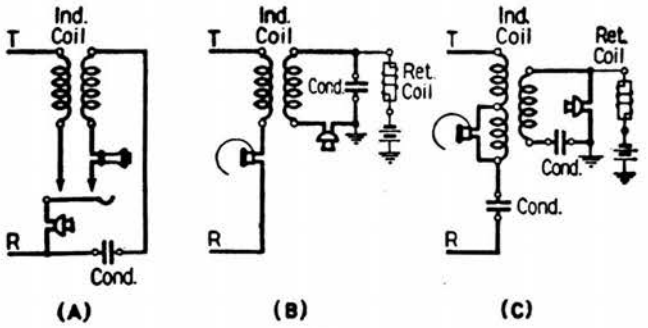


Fig. 5.

5.2 The telephone circuits shown as (B) and (C) in Fig. 5 are so arranged that the transmitter current is supplied directly from the P B X battery through a retardation coil. The retardation coil limits the transmitter current to a safe value and prevents any noise condition that may be present in the battery supply from entering the telephone set. The induction coils used in these telephone circuits transform the current variations set up by the transmitter into an alternating current which is sent out on the line on which the attendant is talking. The coil acts as a step-up transformer, thereby raising the value of the voltage fluctuations set up by the transmitter.

5.3 The secondary winding of the induction coil shown as (C), Fig. 5, is provided with a balancing winding which is connected in parallel with the receiver. The line on which the attendant is talking, the balancing winding, the attendant's receiver and the other part of the secondary winding are arranged in a manner similar to a Wheatstone bridge. With this arrangement and with direct current excluded from the primary winding, the receiver will respond to incoming voice currents but will not be subject to voice or noise disturbances from the attendant's transmitter. The receiver is slightly affected by transmitter noises, as a perfect balance cannot be obtained.

5.4 The condenser associated with the primary side of the induction coil provides a path for the voice currents around the retardation coil and battery. The condenser associated with the secondary side of the induction coil prevents the flow of direct current through the attendant's receiver. A direct current flow through the receiver would cause the receiver to be less responsive to voice currents.

6. RINGING CIRCUITS:

6.1 In a cord type P B X switchboard each front and back cord is provided with a ringing key which, when operated, disconnects the talking circuit from the cord and connects alternating current to the ring of the cord and ground to the tip of the cord to ring the bell at the extension. This function is accomplished in a cordless P B X switchboard by the operation of a ringing key associated with each extension line circuit. A hand generator may be provided in place of power ringing current or may be provided for emergency use in case of failure of the central office power ringing current. When the generator key is operated, the ringing leads are disconnected from the central office ringing supply and are connected to the hand generator.

7. SUPERVISORY CIRCUITS:

7.1 With the apparatus shown in Fig. 4, the attendant may establish extension-to-extension connections. However, without listening in occasionally, the attendant would not be able to tell when to take the connection down. Also, the extensions would not be able to signal the attendant, as the line lamp circuit is open at the jack.

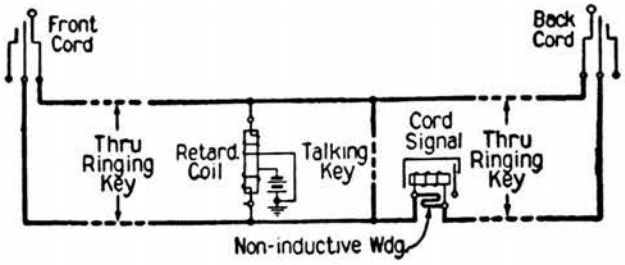


Fig. 6.

7.2 It is evident that supervisory (signaling) apparatus is necessary to attract the attendant's attention when required and to indicate to the attendant when to take down the connection. In some types of P B X switchboards, a cord signal is inserted in series with the ring side of the back cord circuit as shown in Fig. 6. As long as the receiver is off the hook at the extension which is connected to the back cord, the current will flow through the cord signal, causing its target to be displayed. When the receiver is replaced, the circuit is opened at the switch hook contacts and the target will restore.

7.3 This arrangement permits the extension on the back cord to attract the attendant's attention by moving the switch hook up and down; and, as it gives supervision on one cord only, this arrangement is termed "single supervision." However, it may also be termed "negative single supervision," as the cord signal is displayed when the controlling extension has the receiver off the hook, warning the attendant not to take the connection down.

7.4 In other types of P B X switchboards a supervisory relay and lamp have been substituted for the cord signal. When the signal is displayed, it indicates that the attendant's attention is required. This may be termed as "positive single supervision."

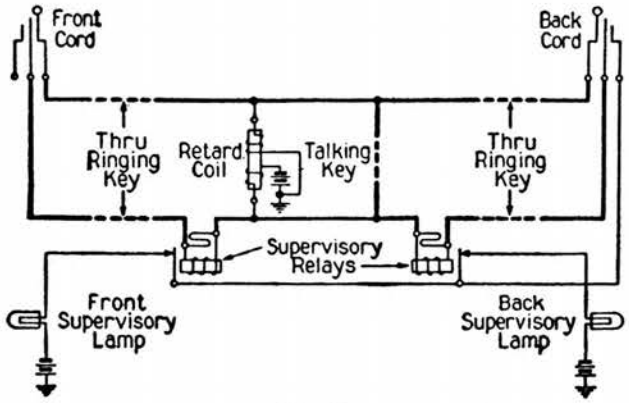


Fig. 7.

7.5 A supervisory relay has also been placed in series with the ring side of the front cord circuit to give double supervision, i.e., supervision on both front and back cords as shown in Fig. 7. The back cord sleeve circuit serves both relays, as the front cord sleeve circuit is used for another purpose, to be described later.

7.6 Inasmuch as the cord signal or supervisory relay is connected in series with the talking circuit, a non-inductive winding must be provided in parallel with the inductive winding to aid transmission by providing a path for the voice currents.

7.7 The cord circuit as described so far provides means for completing extension-to-extension connections. Additional equipment described in the following paragraphs is required to provide facilities for giving both incoming and outgoing central office service.

8. TRUNK CIRCUITS:

8.1 It is impractical to provide each P B X trunk with a bell to indicate incoming calls. In some switchboards a condenser and a trunk drop are bridged in series across the tip and ring of the trunk. Ringing current operates a magnet which lifts the latch to drop the shutter, thereby connecting a ground to an auxiliary signal circuit. The shutter is restored manually. This arrangement is shown in Fig. 8 (A).

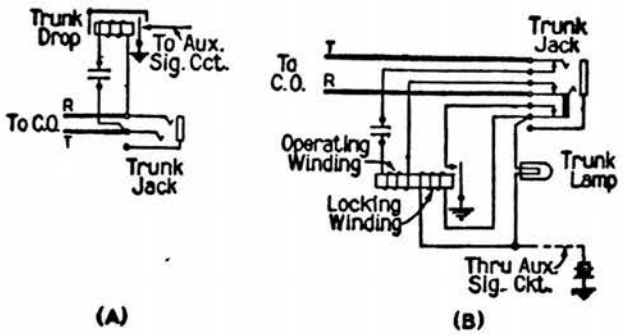


Fig. 8.

8.2 The trunk circuits of boards using lamp signals have some additional features. A common arrangement is shown in Fig. 8 (B). Ringing current energizes the operating winding of the trunk relay, causing it to operate. The closure of its contact lights the trunk lamp and completes a circuit through the locking winding, holding the relay operated. Plugging into the trunk jack opens the locking circuit, thereby allowing the relay to fall back, opens the lamp circuit to extinguish the lamp and also opens the circuit through the operating winding, to improve transmission.

9. CORD CIRCUIT ARRANGED FOR CENTRAL OFFICE CONNECTIONS:

9.1 In order to furnish central office supervision, central office battery must flow over the trunk. In some P B X switchboards this same current is supplied to the transmitter at the extension, when the extension is connected to the central office trunk. In these boards local battery and ground used for extension-to-extension connections is connected through the break contacts of a cut-off relay. One side of the cut-off relay winding is grounded and the other is connected to the front

cord sleeve conductor. Battery is placed on the trunk jack ...es as shown in Fig. 9. When a front cord is connected to a trunk jack, the cut-off relay operates, removing the local battery and ground from the cord circuit.

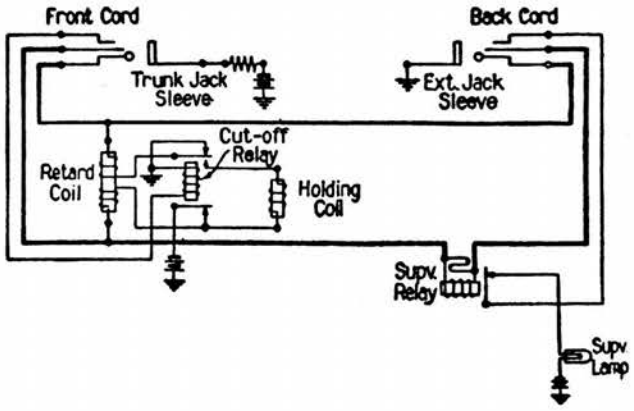


Fig. 9.

9.2 A resistance is placed in the trunk sleeve circuit or the trunk sleeve circuit is kept open through a pair of contacts on the trunk jack until the tip of the plug has passed by the sleeve of the jack, so that a sharp click will not be heard if the attendant has the talking key operated when plugging into the jack.

9.3 In central offices where machine ringing is used, ringing ...ent at regular intervals is applied to the trunk until the ...ard call is either answered by the P B X attendant or the call is abandoned by the calling party. Means must be provided at the P B X for tripping or cutting off the machine ringing when the call is answered. This generally is done by arranging the cord circuit so that when the cut-off relay operates, it not only cuts off the local battery and ground from the cord circuit but connects a bridge across the circuit consisting of the two windings of the retardation coil previously mentioned. These windings provide a suitable path for the flow of direct current or of ringing current in order to trip the machine ringing and to operate the central office supervisory apparatus. In some cases a holding coil is placed in series with the retardation coil in order to increase the resistance of the bridge, thereby preventing the bridge from shunting too much of the direct current away from the extension on central office connections. This arrangement is shown in Fig. 9.

9.4 In one type of P B X arranged as shown in Fig. 9, the resistance of the retardation and holding coils in series is high for transmission purposes, and as this would prevent the prompt tripping of machine ringing when the attendant answers, an alternating current relay in series with a condenser is bridged across the attendant's telephone circuit. With a listening key operated, this relay operates on ringing current and places a lower resistance bridge across the circuit which trips the ringing. There is also a bridge across the attendant's telephone set to provide for the tripping of the ringing circuit during the silent interval.

9.5 In other types of circuits, the machine ringing is tripped by the cord circuit retardation coil. When the extension answers, after being rung by the attendant, another winding on the retardation coil of high resistance is placed in series with the low resistance windings of the coil to improve transmission. These circuits are described later.

9.6 In addition to tripping machine ringing, the bridge holds the central office supervisory relay operated. Moving the switch hook up and down at the extension flashes the P B X supervisory lamp, but not the central office supervisory lamp. This is known as non-through supervision.

9.7 The cord circuit bridge may be opened by means of a bridge relay, controlled by the operation of the cut-off and back supervisory relays, upon answer at the extension.

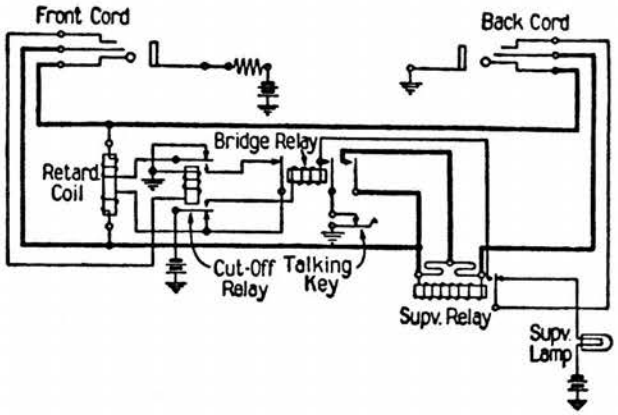


Fig. 10.

9.8 With the circuit arranged as shown in Fig. 10, on a trunk-to-extension connection, the cord circuit bridge consists of the two windings of the retardation coil until the extension answers; the bridge relay then operates and opens this bridge, the extension holds the central office supervisory relay operated.

9.9 The bridge relay locks up under control of a break contact on the talking key. If the extension flashes or hangs up, the central office supervisory relay and the P B X supervisory relay will release. This arrangement permits the extension to flash through the P B X to the central office and is called "through supervision."

9.10 By having the bridge relay cut in a high resistance retardation coil instead of opening the bridge, satisfactory transmission may be obtained without having through supervision. Upon answer at the extension, the resistance of the cord circuit bridge is raised so that its effect on transmission is negligible. The bridge is, however, of low enough resistance to hold the central office supervisory relay operated during the brief interval from the time the switch hook contacts break at the extension to the time the bridge relay releases and reconnects the low resistance bridge (Fig. 11). In this case it will be noted that the make-before-break springs on the bridge relay prevent the opening of the cord circuit bridge when the relay is releasing.

9.11 Another pair of contacts has been added to the bridge relay, which short circuits part of the non-inductive winding of the supervisory relay, to further improve transmission.

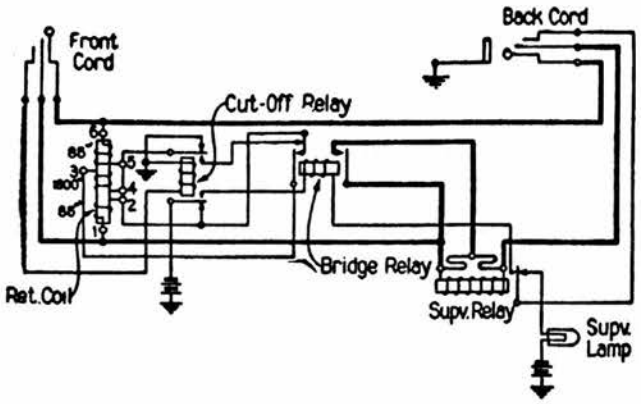


Fig. 11.

10. RECALLING:

10.1 There are cases where the P B X attendant may leave a trunk connection up, after the extension has disconnected. In this case, to permit the central office operator (particularly the toll operator) to call back the P B X attendant on the trunk, a recall circuit is provided.

10.2 An arrangement widely used consists of an alternating current operated relay bridged across the cord in series with a condenser. Its operation lights the front supervisory lamp during the ringing period.

10.3 Another type of recall circuit is shown in Fig. 12. The operation of the talking key causes the recall relay to operate; it locks up through its front contact, which connects the holding winding in parallel with one winding of the retardation coil. After the release of the talking key the recall relay holds up through its holding winding through which current from the central office battery is flowing (over the trunk). Should the operator at the central office wish to recall the P B X attendant, ringing on the trunk will interrupt the flow of direct current through the holding winding of the recall relay. This will release or unlock the relay, which in turn will cause the lighting of the supervisory lamp as a recall signal.

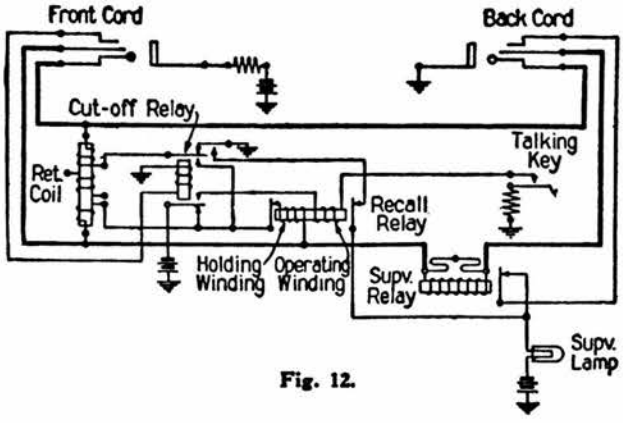


Fig. 12.

11. NIGHT SERVICE:

11.1 Service is often desired at times when the P B X is unattended and generally is provided by connecting the extensions through the P B X to the central office by means of the P B X cord circuits. However, particular arrangements are made so that the bridge across each cord circuit will not operate the central office apparatus and falsely signal the central office. To give night service, a night key for each cord circuit is provided, which, when operated, converts the cord circuit to a patching cord similar to that shown in Fig. 3. A trunk may then be connected to an extension and as there is no bridge across the cord circuit when the night key is operated, the central office trunk will be directly under the control of the extension. Inward calls will ring the bell at the extension and outward calls can be made from the extension as though it were an individual line. A battery key is provided to disconnect the battery when night connections are up, as otherwise there would be a considerable drain on the battery through the supervisory lamps.

12. CORDLESS P.B.X.:

12.1 Where only a few trunks and extensions are to be connected, a cordless P B X may be utilized. The trunk drops and extension line signals are mounted in a row across the top of the face of a fully equipped board. Associated with each drop and signal is a three lever key mounted in a vertical position. An additional key of the same type is associated with the attendant's telephone set at the right end (making three horizontal rows of key levers).

12.2 Each key lever has an up and a down position besides the normal position. These two positions on the two upper horizontal rows and the up position on the lowest row are locking and are used for establishing connections corresponding to five cord circuits. The down position on the lowest row is used as follows: the trunk keys are locking and are used for holding, the extension keys are non-locking and are used for ringing, the attendant's key is locking in the newer boards and is used as a night key (not shown).

12.3 Fig. 13 shows both positions of the lowest row and one position of the upper row. A trunk and an extension or two extensions may be connected by operating their associated keys in any horizontal row to the same position either up or down (excepting the down position of the lowest row).

12.4 Each connecting circuit is arranged to supply talking battery through the normally closed contacts of the trunk key so that on trunk connections the operation of the trunk key removes the local battery (corresponding to the cut-off relay operation). The operation of an extension key furnishes ground for the supervisory signal (corresponding to sleeve ground on the extension line jacks in cord P B X switchboards), one of which is provided for each connecting circuit.

12.5 This type of circuit provides through supervision. The extension can flash through the board to the central office. The attendant may hold incoming calls either by leaving the receiver off the hook at the attendant's telephone set with the proper keys thrown, or by operating the hold key of the trunk until the called extension answers.

13. MULTIPLE P B X 'S:

13.1 Where the requirements are such that each of several attendants should have direct access to all lines and trunks for completing calls, each line and trunk is then placed within reach of each attendant by means of jacks multipled at regular intervals along the board. This type of board is known as a multiple board. At some boards the line answering jacks are not multipled more than once.

13.2 In order to prevent an attendant from interrupting service by plugging into a jack already in use, a busy test or

al is provided. Associated with each trunk jack is a busy signal or a lamp so connected that current flowing through the trunk sleeve circuit causes the busy signal to be displayed or the busy lamp to be lighted. Before inserting a plug into an extension line the attendant with the talking key operated touches the tip of the plug to the sleeve of the extension line jack; if the line is busy, a click will be heard in the attendant's receiver each time the plug is tapped on the jack sleeve. No click will be heard if the line is idle. At some boards, when an extension line is busy, ground is connected to the sleeve of the jack. When the tip of the plug touches the sleeve of the jack the tip winding of the retardation coil is shunted out. This increases the flow of current in the cord circuit and the voltage across the attendant's telephone set, thus producing a click in the attendant's telephone set. See Fig. 14.

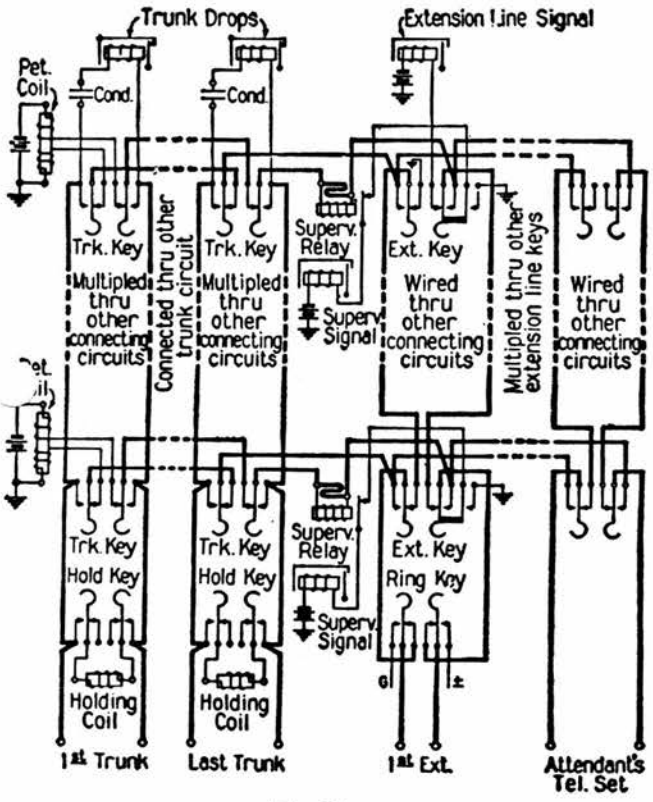


Fig. 13.

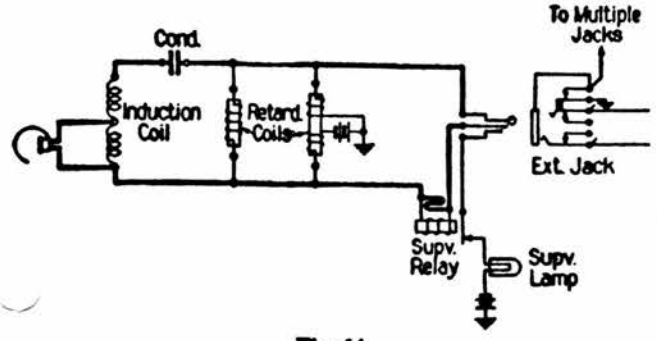


Fig. 14.

Aside from the provision of the busy-test feature, the principles of operation of the smaller multiple P B X switchboards are, in general, the same as those of the non-multiple P B X switchboards.

14. SWITCHBOARDS ARRANGED FOR OPERATION IN CONNECTION WITH DIAL SYSTEM CENTRAL OFFICES:

14.1 The introduction of the dial system has necessitated the addition of a dial and dialing equipment to furnish the pulses which control the central office apparatus on outgoing calls. The dial circuit of P B X switchboards is associated with the attendant's telephone circuit so that it may be connected to the particular cord circuit on which the attendant desires to dial.

14.2 As the dial pulses are momentary breaks in the circuit from the tip to the ring of the line, the cord circuit bridge must be removed before any dialing can be done. If the extension is to dial, the through dial key of the cord circuit used to connect the extension to the trunk is operated. The through dial key also serves as the night key, connecting the extension directly to the trunk and removing the cord circuit bridge.

14.3 When the attendant wishes to dial, the talk and dial key is operated, connecting the dial circuit to the cord circuit. The fundamental features of the arrangement in general use are shown in Fig. 15.

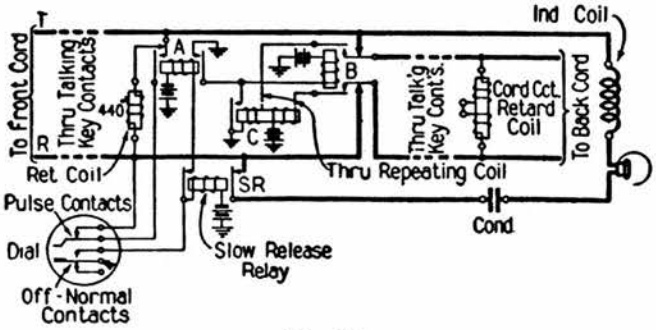


Fig. 15.

14.4 When the switchboard dial is moved off normal, the off-normal contacts close a circuit to operate the SR relay, which disconnects the attendant's telephone set in order to prevent the attendant from getting loud clicks in the receiver during the pulsing of the dial. The operation of the SR relay causes the A relay to operate. The A relay on operating disconnects the 440-ohm retardation coil from the circuit and connects in its place the pulse contacts of the dial. Relay A also causes relay B to operate, which separates the front cord circuit from the back cord circuit in order that the dial pulses may be transmitted out on the front cord without interference from equipment connected across the back cord circuit. The operation of relay C through the telephone instrument at the extension station depends on whether the party at the extension hangs up when the attendant is dialing or remains on the line. Relay C, when operated, holds relay B operated until the talking key is restored.

14.5 As the dial returns to normal, the pulse contacts momentarily open the circuit from the tip to the ring of the front cord, producing pulses corresponding to the number or letter selected. When the dial returns to normal, the circuits

of the SR and A relays are opened, causing them to release. The SR relay is a slow release type of relay, while the A relay is of the normal release type. The A relay therefore releases first, disconnecting the pulse contacts of the dial and reconnecting the retardation coil across the circuit before the SR relay releases. The release of the SR relay reconnects the attendant's telephone set to the line. By this sequence of release of the A and SR relays the clicks in the attendant's receiver are reduced to a minimum.

14.6 In dial system operation it is desirable in the case of the smaller P B X switchboards to provide for the release of the central office equipment when the extension hangs up, whether or not the attendant takes down the cords. The reason for this is that in dial system operation the central office equipment is held up as well as the called subscriber's line equipment until the calling party disconnects. If the equipment were so arranged that the central office apparatus would not be released until the cords were taken down at the P B X, the central office apparatus might be held up for a considerable time, as the smaller P B X switchboard attendants in general have other duties to perform than telephone operating and hence may not take the connections down promptly.

14.7 As shown in Fig. 16, upon answer at the extension, the supervisory relay operates and causes the bridge relay to operate and open the cord circuit bridge (to provide through supervision). The bridge relay locks up through the break contacts of the talk and dial key. Upon replacing the receiver on the switch hook at the extension, the supervisory relay releases and completes a circuit to operate the splitting relay. This relay operates and splits the cord circuit to prevent ringing the bell at the extension should a call come in before the attendant takes down the cords. Ringing current on such calls operates the recall relay which lights the front cord supervisory lamp to indicate to the attendant that a call is on the trunk.

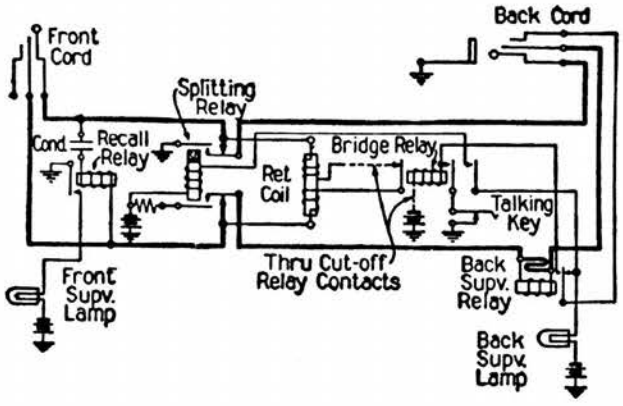


Fig. 16.

14.8 The splitting relay in operating furnishes the back cord with battery and ground, enabling the extension to originate another call by operating the supervisory relay, which in turn releases the splitting relay. The slow operating characteristic of the splitting relay prevents it from operating, due to the momentary interruption of current, as in the cases where the extension flashes on inward calls or the attendant inserts the plug into the trunk jack on outgoing calls from the P B X

14.9 One of the small multiple P B X switchboards is arranged so that non-through supervision is had on incoming calls and through supervision is had on outgoing calls dialed by the attendant. This is accomplished by means of a relay in each cord circuit which is operated when the attendant dials. The operation of this relay opens the bridge across the cord circuit (thus giving through supervision) and arranges the cord circuit so that when the receiver is hung up at the extension upon completion of the call, the cord circuit will be split as described in paragraphs 14.7 and 14.8.

14.10 The P B X circuit arrangements described above apply more particularly to boards of the No. 1, No. 505, No. 550 and No. 600 types than to the other types that may be found in the field. There are other manual boards, however, in somewhat general use that have not been covered. Among these boards are the No. 4 and the No. 604, the fundamental circuits of which are described below.

15. NO. 4 P B X:

15.1 The extension circuit is similar to those for the other types of switchboards previously covered.

15.2 The cord circuit arrangement generally used is shown in Fig. 17. This circuit is provided with the usual ringing, talking and night keys and supervisory relays and lamps, which function as previously described. Battery and ground for transmission and signaling purposes are also furnished to each cord through a retardation coil. It will be noted, however, that no cut-off relay is provided and therefore the talking battery is supplied to the extension from the P B X battery supply for both local and central office connections. In this respect the circuit differs from the cord circuits of the other P B X switchboards that were previously described, as in those P B X's the local cord circuit battery is disconnected from the cord circuit on central office connections and the battery for transmission purposes on trunk connections is supplied to the extension from the central office over the trunk conductors.

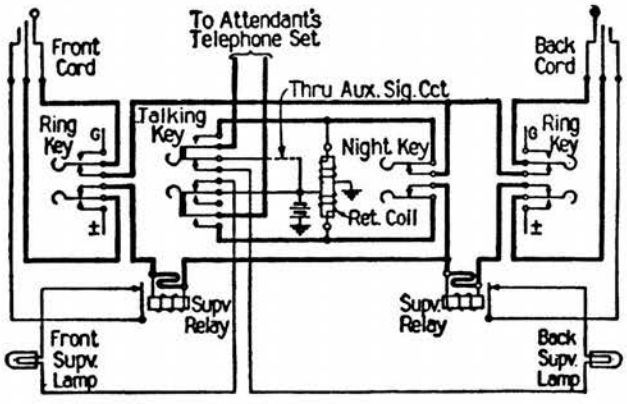


Fig. 17.

15.3 In the case of the No. 4 board, the trunk circuit is provided with blocking condensers connected in series with the tip and ring sides of the trunk as shown in Fig. 18. These condensers are necessary in order to separate the central office trunk battery from the local P B X cord circuit battery.

15.4 The central office trunk circuit is generally arranged as shown in Fig. 18. The trunk ringing relay is connected from the ring side of the trunk to ground and operates when ringing

current is applied to the ring side of the trunk. As the relay operates, its make-before-break contacts connect battery to the relay winding and disconnect it from the ring side of the trunk. This holds the relay operated. The other set of contacts on the ring-up relay closes the circuit of the trunk lamp.

15.5 As explained previously, in order to operate the central office supervisory apparatus and to trip machine ringing, a bridge must be provided across the trunk. In the No. 4 P B X this bridge consists of a retardation coil in series with a recall relay which is bridged across the trunk through the local make contacts of the trunk jack. In order to provide for the tripping of the machine ringing during the ringing interval, an arrangement is provided whereby the retardation coil is short-circuited for a brief interval after the bridge is connected on incoming calls. This is done by a set of contacts on the sleeve relay which operate when the ringing is started and release when the call is answered by the P B X attendant.

15.6 As has also been explained previously, means are generally provided so that the central office operator can recall the P B X attendant. In the No. 4 P B X, when the trunk is in use, battery from the central office holds the recall relay operated. Ringing from the central office interrupts the flow of direct current, which releases the recall relay. This causes the operation of the sleeve relay and lights the supervisory lamp associated with the cord connected to the trunk jack. The sleeve relay locks itself up independently of the recall relay, thus keeping the supervisory lamp lighted until the attendant in response to the recall signal operates the talking key. The operation of the talking key disconnects battery from the supervisory lamp. This extinguishes the supervisory lamp and releases the sleeve relay.

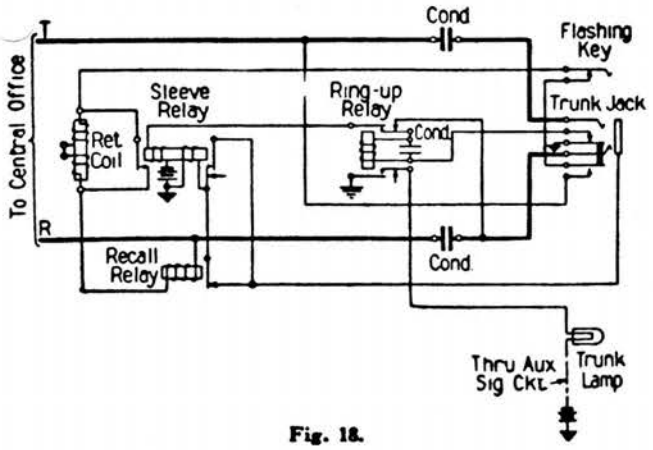


Fig. 18.

16. NO. 604 P B X:

16.1 The P B X circuits that we have previously considered apply more particularly to the general type of P B X installations than to the very large installations. For the large installations, repeating coil cord circuits have been provided rather than retardation coil cord circuits previously described. In the repeating coil cord circuit, battery and ground are supplied to each cord through the windings of a repeating coil as shown in Fig. 19. With this arrangement the current supply to each extension will, of course, depend directly upon the voltage of the battery, the resistance of the cord circuit apparatus and the extension loop and subset resistance. In the case of the retardation coil cord circuit, the current supplied to an extension in the case of a local connection between two extensions will depend not only on the factors just mentioned, but also upon the resistance of the other extension loop involved in the connection.

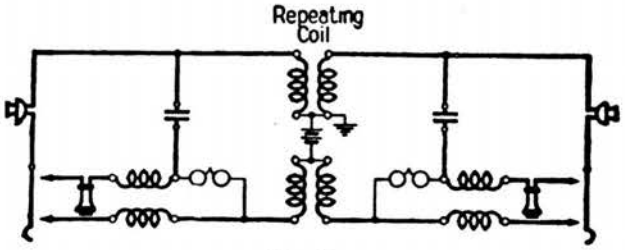
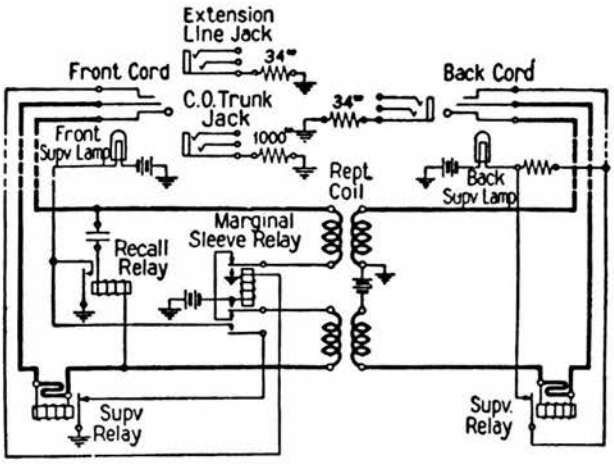


Fig. 19.

In this way, should two extensions be connected together through a retardation coil cord circuit, one having a very short loop and the other a very long loop, it would be found that the extension with the short loop will get most of the transmitter current, while the extension with the longer loop, needing most of the transmitter current, will get the least. It is for this reason that where an extensive P B X system is to be provided and where consequently many of the extension loops will be long and many will be short, it has been the practice to provide repeating coil cord circuits so as to furnish a more uniform grade of transmission between the various extensions on local connections. The retardation coil cord circuits, however, work quite satisfactorily where only a small P B X system is involved, as in this case the various extension loops are generally short and of about the same resistance.

16.2 The fundamental features of a typical repeating coil cord circuit are shown in Fig. 20. Battery for transmission purposes is supplied to the extensions on local connections through windings of the repeating coil. When the front cord is connected to an extension line jack on an extension-to-extension call, the marginal sleeve relay functions, as it receives sufficient current to operate it, due to the low resistance of the extension line sleeve circuit. On a trunk connection, however, when the front cord is connected to a trunk jack, the marginal sleeve relay is not operated, as the relay does not receive sufficient current for its operation, due to the high resistance of the trunk sleeve circuit. In this way local battery and ground are not connected to the windings of the repeating coil associated with the front cord. Instead, a bridge consisting of the two windings of the repeating coils is connected across the tip and ring of the front cord, in order to provide a path to operate the central office supervisory apparatus.



NOTE

The marginal sleeve relay operates when the front cord is connected to an extension line jack but not when connected to a C.O trunk jack.

Fig. 20.