

# CORD TYPE LAMP SIGNALLING P.M.B.X. (CE.250)

(PREVIOUSLY MS 082)

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## 1. INTRODUCTION.

1.1 Switchboards used as Private Manual Branch Exchanges are of two main types, namely Cordless P.M.B.X's and Cord type P.M.B.X's. The facilities, manual operation and circuit description of cordless P.M.B.X's are given in the Miscellaneous Note MS 062.

1.2 This note describes the facilities, manual operation and circuit description of the standard cord type Lamp Signalling P.M.B.X. The circuit description relates to drawing CE 250 Sheet 4 Issue 1 which is known as the Mark 2 version of the P.M.B.X. As there are only small differences between the Mark 2 and the Mark 1 versions, the same circuit description may be applied to both types.

1.3 When studying the circuit description, reference should also be made to CS 010 which is a simplified schematic circuit of the complete P.M.B.X.

1.4 The cord type Lamp Signalling P.M.B.X. uses 6V lamps for indicating exchange and extension calls, and for cord circuit supervision. The P.M.B.X. can be used in either automatic or manual Central Battery areas.

2. FACILITIES.

2.1 The facilities provided by the P.M.B.X. are:-

- (i) Any extension can be connected to any other extension.
- (ii) Any extension can be connected to any exchange or tie line.
- (iii) "Through dialling" is provided so that extensions connected to exchange lines can dial the required number.
- (iv) Night Service can be given to any extension on any exchange line.
- (v) A "follow on" call is trapped at the P.M.B.X. and does not ring the extension to which the cords are still connected.
- (vi) Supervision is provided on all calls.
- (vii) Any extension fitted with a recall button can recall the operator during an extension to exchange call.
- (viii) The operator can hold any exchange call and transfer it from one extension to another.
- (ix) A voice frequency termination is connected during switching to ensure balanced conditions on exchange calls which may be connected to trunk lines.
- (x) Tie lines from P.A.B.Xs. or other P.M.B.Xs. may be provided.
- (xi) Connection between two exchange lines or between an exchange line and a tie line is automatically prevented.
- (xii) Coupling of cord circuit commons is provided on multi-position P.M.B.Xs.
- (xiii) An exchange release facility permits the operator to release an operator to exchange call during dialling without withdrawing plugs.

3. COMPONENTS.

3.1 Construction and Sizes. The P.M.B.X. is floor mounted and made in the one standard size, irrespective of the number of lines fitted. The ultimate capacity of one switchboard is 15 exchange lines, 80 extension lines, 3 tie lines and 16 pairs of switching cords, together with the necessary associated keys, relay sets etc. Many P.M.B.Xs. are installed only partly equipped.

When the required number of extension or exchange lines exceeds the ultimate capacity of one switchboard, a multi-position P.M.B.X may be formed by installing two or more switchboards side by side.

3.2 Relay Sets. The relays associated with the exchange line circuits, tie line circuits, cord circuits and night alarm are all mounted on "jack in" relay bases inside the switchboard. In a switchboard fitted for the ultimate capacity the following relay sets are provided:-

- 5 exchange line bases (3 circuits per base)
- 1 tie line base (3 circuits per base)
- 4 cord circuit bases (4 circuits per base)
- 1 Telephonist and Miscellaneous base (containing the coils, capacitors, resistors, pilot relay and retards for the telephonist's circuit, night alarm circuit and other circuits associated with the power supply and cord testing).

3.3 Face Components. The components mounted on the face of the switchboard and their functions are:-

- (i) Exchange, tie line and extension lamps - indicate an incoming call on these lines.
- (ii) Pilot lamp - indicates that there is an unanswered call.
- (iii) Fuse alarm lamp - indicates a blown fuse.
- (iv) Exchange, tie line and extension jacks - used to connect to these lines.
- (v) Night Service jacks - used instead of the normal exchange line jacks when providing night service between an exchange line and an extension.
- (vi) Ring Change over Key - changes from power ring to hand generator.
- (vii) Battery Cut off Key (BCO) - connects the DC power to the P.M.B.X.
- (viii) Night Alarm Key - connects the night alarm buzzer when required.

3.4 Keyshelf Components. Most of the components mounted on the keyshelf are arranged in groups to provide a switching circuit associated with each pair of cords. Each group consists of two cords, two lamps and two lever keys. The functions of these components are:-

- (i) Rear Plug and Cord - used to answer all extension calls, and to complete exchange to extension or tie line to extension switching.
- (ii) Front Plug and Cord - used to answer or originate all exchange and tie line calls and to complete the switching on an extension to extension call.
- (iii) Front and Rear Supervisory Lamps - indicate to the P.M.B.X. operator the progress of the call.
- (iv) Dial and Hold and Ring Rear Key - In the locking position (Dial and Hold) it connects the operator's dialling circuit across the tip and ring of the front cord for dialling, or for holding an exchange call during transfer. In the non-locking position (Ring Rear) it connects the ring supply to the rear cord.  
  
Speak and Ring Front Key - In the locking Speak positive, it connects the operators speaking circuit to cord circuit. In the non-locking (Ring Front) position, it connects the ringing supply to the front cord.

One other key - the Coupling and Exchange Release key is situated at the right hand end of the shelf. In the locking (Coupling) position, it is used on a multiposition P.M.B.X. to extend the cord commons of a vacant position to the operator's circuit on the next position. This enables the one operator to use the cord circuits of both positions. In the non-locking (Exchange Release) position, it opens the operator's dialling circuit, allowing the release of an outgoing operator originated exchange call without removing the cord.

A hand generator is supplied to provide ringing current where power ring is not connected, or when the supply has failed. The handle of the generator projects from a vertical face of the P.M.B.X. below the keyboard.

4. MANUAL OPERATION.

4.1 Extension Calls:

- (i) Extension signals P.M.B.X. Extension lifts handset and extension lamp glows.
- (ii) Operator Answers. The rear cord is inserted in the extension jack and the lamp is extinguished. The Speak key is operated, allowing the operator to speak to the calling extension.
- (iii) Caller connected to another extension. The front cord of the same pair of cords is inserted in the required extension jack and the associated Ring Front key is operated for several seconds. The Speak key is restored. Until the extension answers, the front supervisory lamp glows. When the extension answers, the front lamp is extinguished. If the extension on the rear cord replaces the handset the rear supervisory lamp glows, and if the extension on the front cord replaces the handset the front supervisory glows. The call is cleared and the lamps extinguished when the operator withdraws the plugs from the extension jacks.
- (iv) Calling Extension connected to Exchange Line. The front cord of the pair is inserted in an exchange line jack with the Speak key operated. If the extension is to dial the number, the operator restores the Speak key and the extension controls the call. If the operator is to dial the number, the Dial and Hold key is operated and the number is dialled. At the completion of dialling the keys are restored and the call is automatically connected to the extension.

When the extension replaces the handset both supervisory lamps glow and the operator clears the call by withdrawing the plugs from the jacks.

- (v) Calling Extension connected to Tie Line. The operator inserts the front plug into the tie line jack with the Speak key still operated. The Ring Front key is operated for several seconds and then restored. When the extension replaces the handset both supervisory lamps glow and the telephonist clears the call by withdrawing the plugs.

4.2 Incoming Exchange Call.

- (i) Incoming Call - Exchange call lamp and pilot lamp glow.
- (ii) Operator Answers. The operator inserts the front cord into the exchange line jack and operates the Speak key. The lamps are extinguished when the plug is inserted in the jack.
- (iii) Exchange line connected to Extension. The rear plug is inserted into the required extension jack and the Ring Rear key is operated for several seconds. The rear supervisory lamp glows until the extension answers.

At the end of the call both supervisory lamps glow when the extension clears. The call is cleared when the operator withdraws the plugs from the jacks.

- 4.3 Follow-on Exchange Call. A follow-on exchange call is one which is received while cords are still inserted from a previous exchange to extension call. When such a call is received the supervisory and pilot lamps flash alternately in synchronism with the exchange ring. If there is another call waiting to be answered the pilot lamp will be glowing continuously and the only indication of the follow-on call is a flashing of the supervisory lamps.

The call is answered by operating both the Speak and Dial and Hold keys.

After the operator speaks to the caller and ascertains the required extension, the rear plug is withdrawn, the Dial and Hold key is restored and the rear plug is inserted in the required extension jack as for an exchange to extension call.

- 4.4 Recall Facility. An extension connected to an exchange line can attract the attention of the operator by intermittently pressing a recall button which may be fitted to any extension telephone. Each operation of the recall button flashes both of the supervisory lamps on the cord circuit associated with the call. By operating the Speak key of the cord circuit concerned, the operator can speak and hear on the connection.
- 4.5 Transfer of Exchange Call. An exchange call may be transferred to another extension, the manual operation being similar to that used on the follow on call.
- The Speak and Dial and Hold keys are operated before the rear plug is transferred to the new extension jack, and the Ring Rear key is operated when the rear plug has been transferred to the new extension jack.
- The keys are restored to normal and the rear supervisory lamp glows until the new extension answers.
- 4.6 Connection for Night Service. Any extension may be night switched to any exchange line by inserting the rear plug of a pair of cords into the night switching jack of the selected exchange line, and inserting the front plug into the jack of the extension.
- If the board is to be vacated, operate the B.C.O. key to the "Off" position.
- The extension is connected directly to the exchange line and is able to make calls direct. Any incoming exchange calls ring the extension bell and do not give any indication at the switchboard.
- The same form of connection is used when an extension is to be tested from the local exchange test desk. As this usually occurs during the normal P.M.B.X. operating time the power cannot be disconnected by the B.C.O. key, and the front supervisory lamp will glow for the time the cord connection is maintained. On such a connection it is necessary to ring the P.M.B.X. operator on another line to advise when the cord should be cleared.
- 4.7 Incoming Tie Line Call. A call is indicated by the tie line call lamp and the pilot lamp. The operator answers the call by inserting a front plug into the tie line jack and operating the Speak key. The lamps are extinguished when the plug is inserted. If an extension is required the rear plug is inserted into the required extension jack as for an exchange to extension call (para 4.2).
- 4.8 Outgoing Tie Line Call by Operator. The operator inserts a front plug into the tie line jack and operates the Speak key. The other P.M.B.X. is signalled by operating the Ring Front key. The Speak key is operated again to await answer by the other P.M.B.X. operator. It is essential to operate the Speak key before ringing on the tie line.
- Extension to Tie Line operation is described in para 4.1 (v).
- 4.9 Cord Testing. The last two jacks in the row of Exchange line jacks are used as cord test jacks to test the switching cords. The manual operation when testing a pair of cords is as follows:-
- (i) Insert rear cord halfway into the rear test jack. The rear supervisory lamp should glow.
  - (ii) Insert rear cord fully. The lamp is extinguished.
  - (iii) With rear cord still in jack, insert front plug halfway into the front cord test jack. The front supervisory lamp should glow.
  - (iv) Insert the front plug fully. The lamp is extinguished.
  - (v) Operate the Speak key. Shake both cords and listen for noises indicating fractures in cord conductors.
  - (vi) With the Speak key still operated, operate the Dial and Hold key and shake the front cord, listening once more for noises indicating fractures in cord conductors.

5. EXTENSION CALLS.

5.1 Extension Line Circuit. Each extension line is connected via an extension jack to a 6 volt Call Lamp and limiting resistors. A number of extension call lamp circuits are connected via a fuse to a Pilot Relay (Fig. 1).

NOTE :- ADJUST CURRENT IN LINE LAMP LIMITS OF 35-45mA BY STRAPPING 200Ω N.I.R. OF YC RES. WHEN NECESSARY ON LONG EXTN LINES. 700Ω N.I.R. OF YC SHOULD NOT BE STRAPPED.

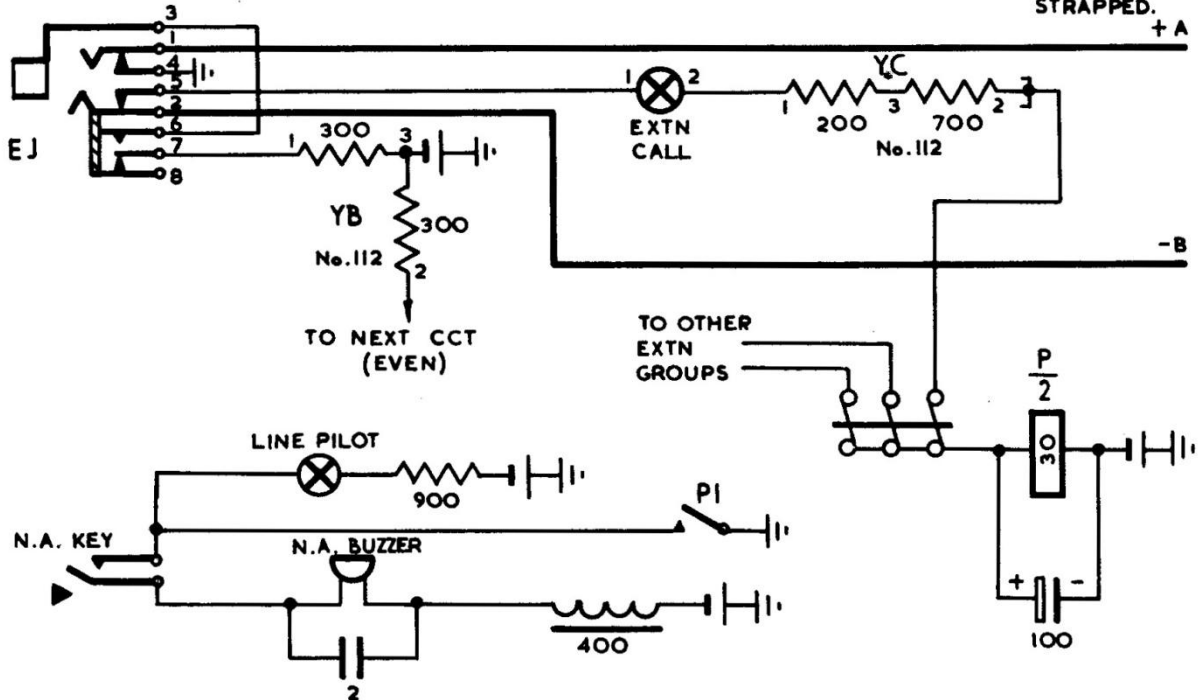


FIG. 1. EXTENSION CALL CIRCUIT.

5.2 Extension Signals the Switchboard. The extension lifts his handset and the P relay operates in series with the extension loop and extension call lamp. The Line Pilot lamp glows and, if the Night Alarm Key is operated, the night alarm buzzer operates.

5.3 The operator Answers. To answer the call the operator selects a rear cord from a free pair of cords and plugs into the calling extension jack. Operation of the extension jack springs disconnect the extension call lamp, and places a negative potential on the sleeve circuit of the rear cord.

Relay C in the cord circuit operates via the rear supervisory lamp and connects the B relay across the tip and ring of the rear cord circuit. Almost immediately the B relay operates in series with the extension loop, and B1 contacts short-circuit the rear supervisory lamp (Fig. 2).

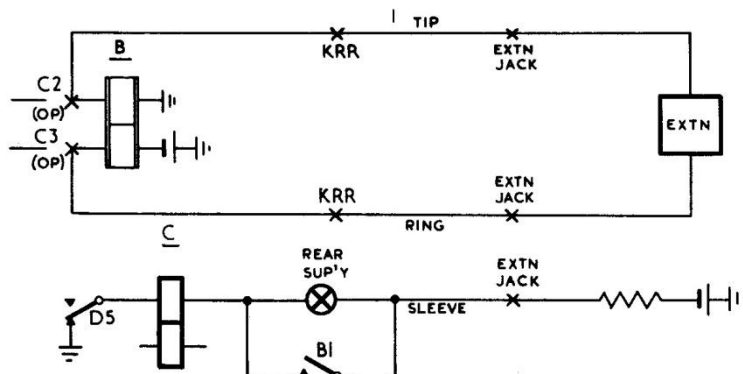


FIG. 2. ANSWERING AN EXTENSION CALL.

Operation of the Speak key (KS) associated with the selected cord circuit connects the tip and ring of the cord circuit to T and R of the telephonist circuit via two coupling capacitors (Fig. 3).

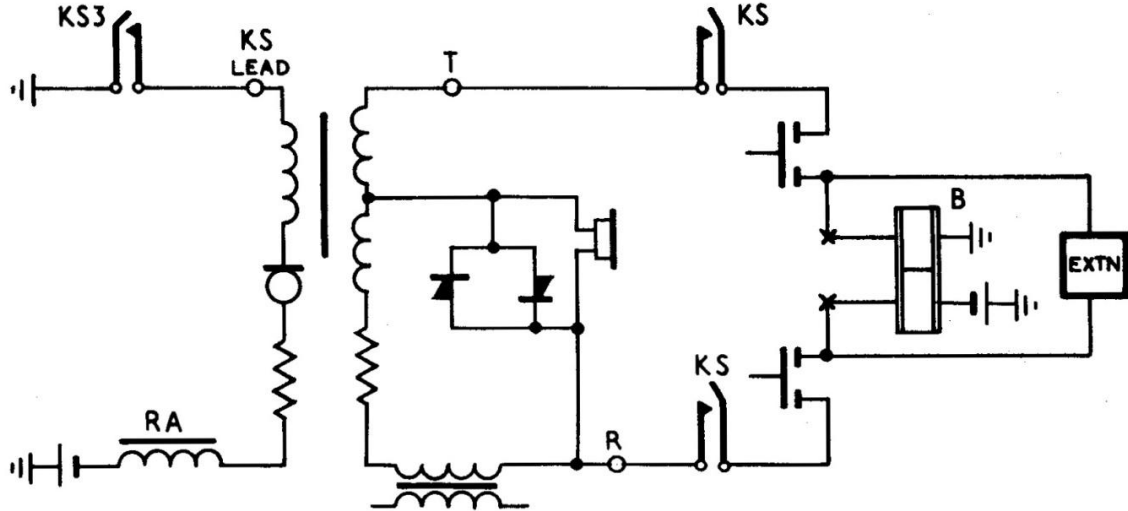


FIG. 3. EXTENSION CONNECTED TO OPERATOR.

Transmission battery for the extension is obtained from the rear cord via the B relay, and the telephonist's circuit is provided with a separate supply via retard RA.

- 5.4 Extension Connected to Another Extension. When another extension is required, the operator inserts the front cord of the selected pair of cords into the required extension jack, and operates the Ring Front key (KRF). The lamp circuit of the called extension is disconnected at the jack springs, and when the Ring key and Speak key are restored, the front supervisory lamp glows until the called extension answers (Fig. 4). If the Speak key is left operated, the front lamp does not glow.

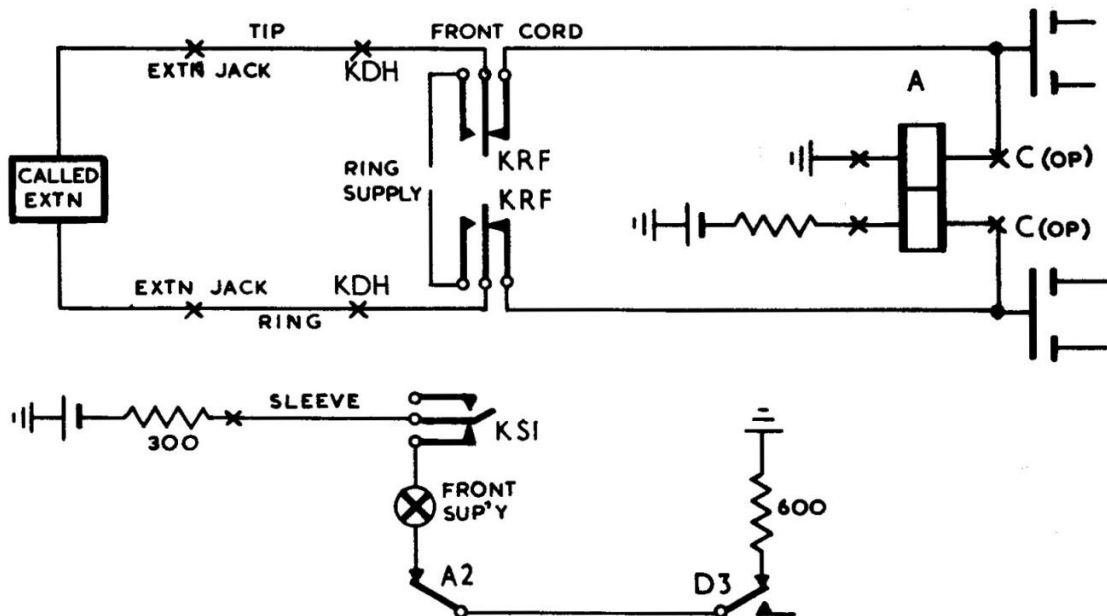


FIG. 4. CALLING THE REQUIRED EXTENSION.

When the required extension answers, relay A operates via the extension loop and at A2 disconnects the circuit of the front supervisory lamp. The two extensions are connected together in a Stone type transmission bridge. Relays A and B combine the functions of battery feed retards and supervisory relays (Fig. 5).

5.5 Supervision. During conversation, relays A and B are both operated and both supervisory lamps are extinguished. When the extension on the rear cord (calling extension) restores the handset, the B relay releases, removes the short circuit from the rear supervisory lamp and the rear lamp glows. When the called extension (front cord) restores the handset, relay A releases and the front supervisory lamp glows. The operator withdraws the plugs from the extension jacks and the cord circuit is restored to normal.

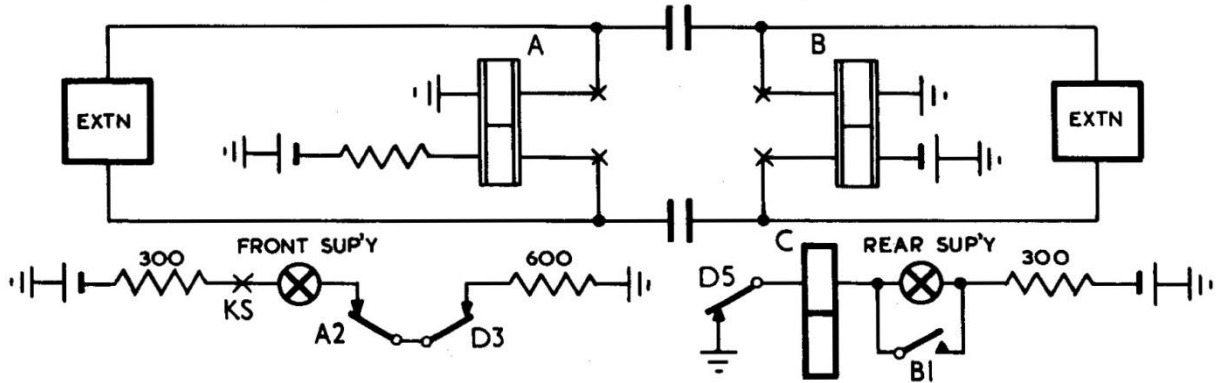


FIG. 5. EXTENSION TO EXTENSION.

5.5 Extension to Exchange Call. The extension signals the switchboard and is answered by the operator in the manner described in paragraphs 5.1 - 5.3.

The front plug of the selected pair of cords is plugged into a free exchange line jack, and the Speak key is operated. The operated exchange line jack springs disconnect the exchange call lamp circuit, and prepare the operating circuit of the K relay. Earth at the exchange jack sleeve circuit operates relay D in the cord circuit (Fig. 6).

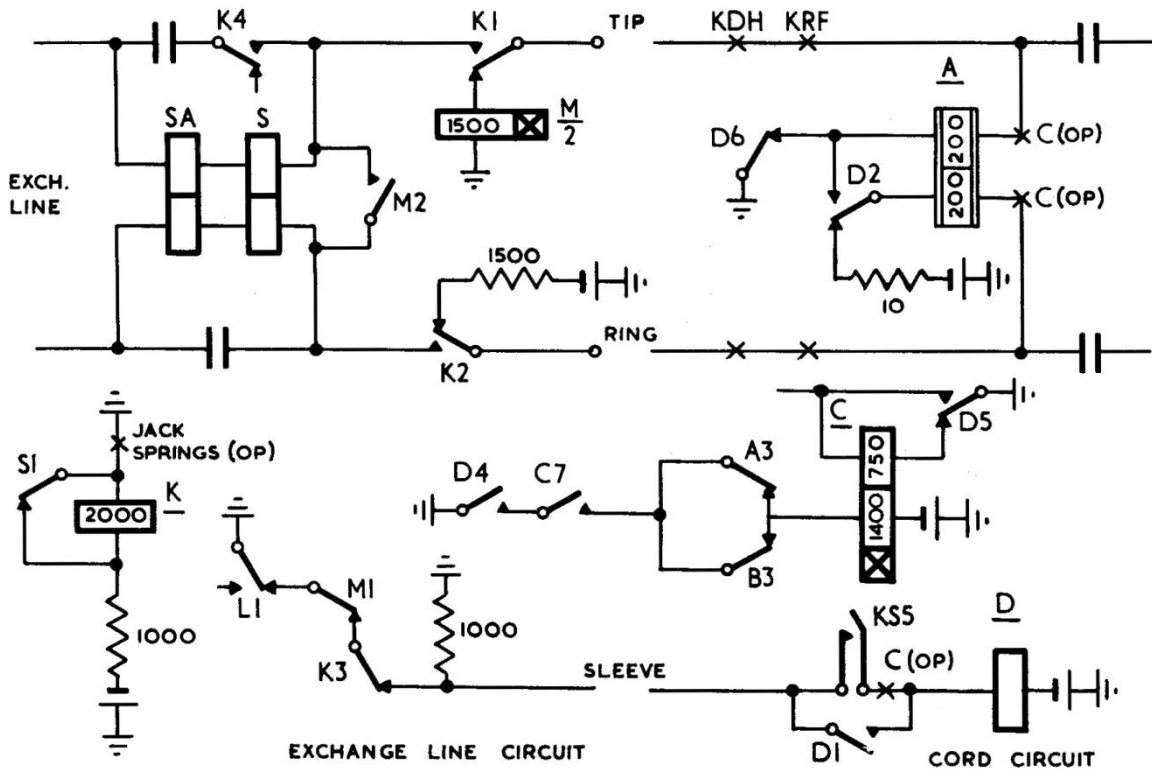


FIG. 6. CONNECTION TO EXCHANGE LINE CIRCUIT.



Contacts D2 and D6 disconnect the local transmission battery from the front cord and at the same time connect the two coils of relay A in a series loop across the tip and ring of the front cord. D1 provides a holding circuit for D relay independent of the Speak key and C relay contacts. D5 short circuits the 750Ω winding of C relay, but C holds on its 1400Ω to earth at D4.

The 400Ω A relay loop operates relay M in the exchange line circuit and M2 contacts place relays SA and A in series to loop the exchange line. Relay B operates to the current from the exchange, but relay SA does not operate under these conditions because of the differential connection of its two windings. S1 contacts remove the short-circuit from the K relay, and K operates, switching the exchange line through to the cord circuit and disconnecting relay M. At this point the exchange loop is provided by the series connected A relay, which operates to the exchange line potential.

As relay B was previously operated by the calling extension loop, the holding path for relay C has been via contact A3. When A operates, relay C releases, and at C1, C2, C3 and C4 disconnects the A and B relays and connects the exchange line through to the calling extension. The operator hears dial tone and restores the Speak key. The exchange line is held by the extension loop (Fig. 7) and the extension is able to dial the required number.

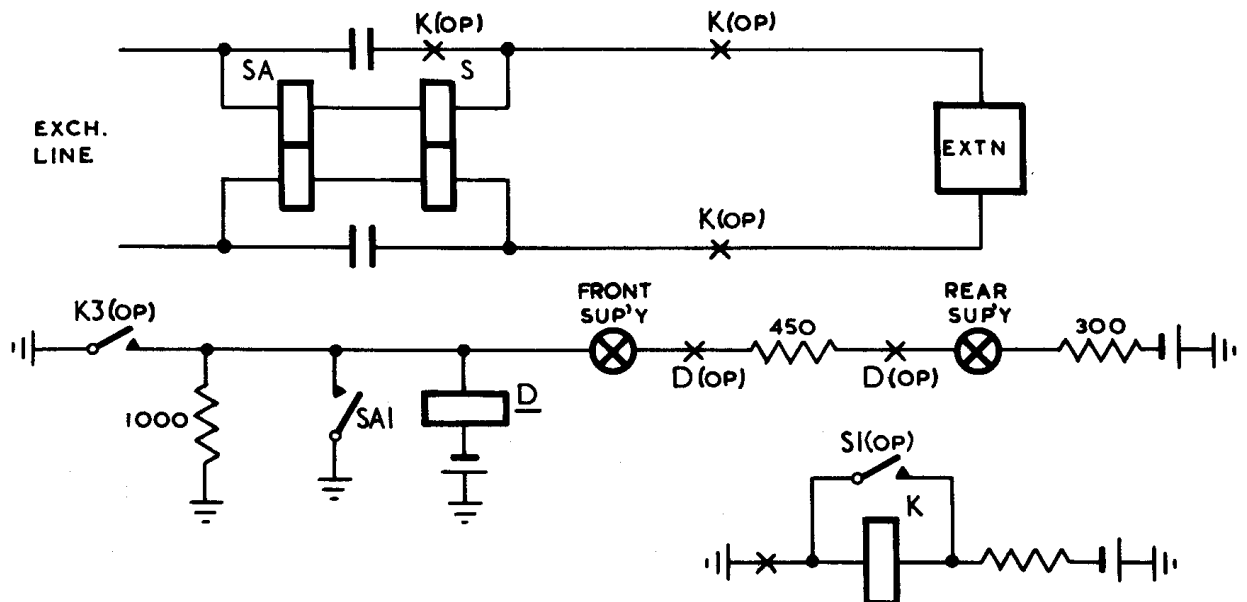


FIG. 7. EXTENSION TO EXCHANGE - THROUGH CONDITION.

During conversation, relay D in the cord circuit and relays S and K in the exchange line circuit remain operated. The current through the two supervisory lamps is not sufficient to cause these lamps to glow. At the end of the call, the extension handset is replaced, relay S releases and at S1 short circuits relay K. K contacts disconnect the through condition and place the L relay across the exchange line to receive any incoming calls. K3 places a direct earth on the sleeve circuit to light both supervisory lamps in the cord circuit.

Relay D in the cord circuit remains operated until the plugs are withdrawn from the jacks, when all relays are restored and the supervisory lamps are extinguished.

**6. EXCHANGE CALLS.**

**6.1 Outgoing Exchange Call by Operator.** A free pair of cords is selected, the front plug is inserted into the exchange line jack, and the Speak key is operated. Relay C in the circuit operates on its 1400Ω winding from earth at the exchange jack sleeve circuit (Fig. 8).

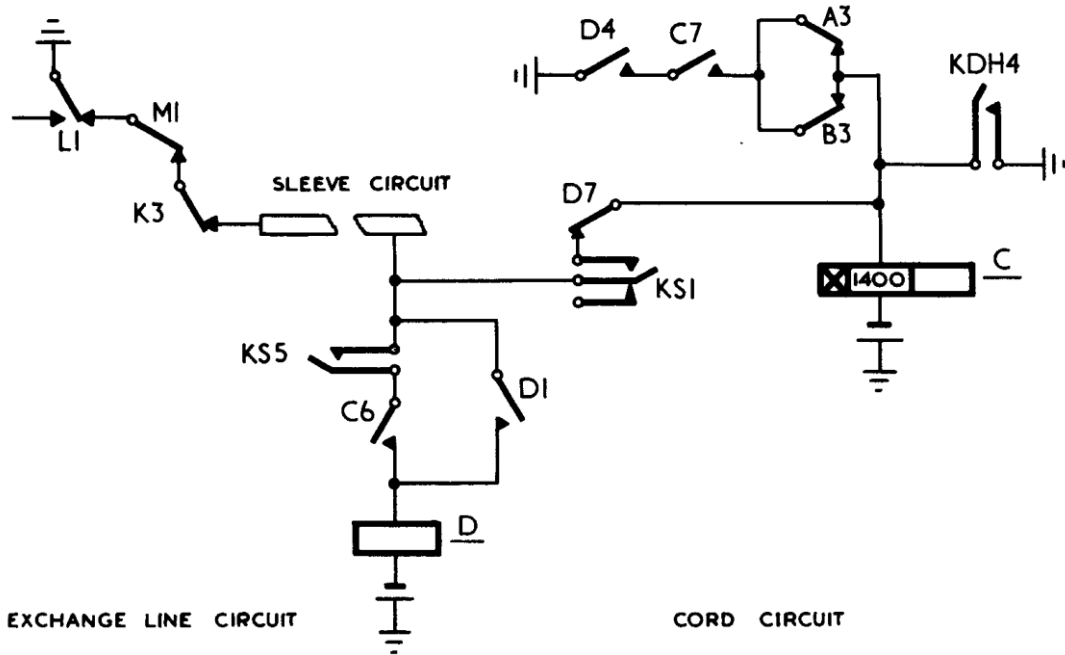


FIG. 8. OPERATION OF C AND D RELAYS.

C6 contact operates relay D from earth at the exchange line sleeve circuit. The original operating circuit of relay C is opened at D7, but C now holds via A3, C7 and D4.

With cord circuit relays C and D both operated, the two coils of relay A are connected across the tip and ring of the front cord, and relays M, S and K in the exchange line circuit are operated as described in paragraph 5.6. As relay B has not been operated, relay C holds via B3, the exchange line is held by the A relay loop, and the telephonist's circuit is connected via KS2, KS4 and leads T and R (Fig. 9).

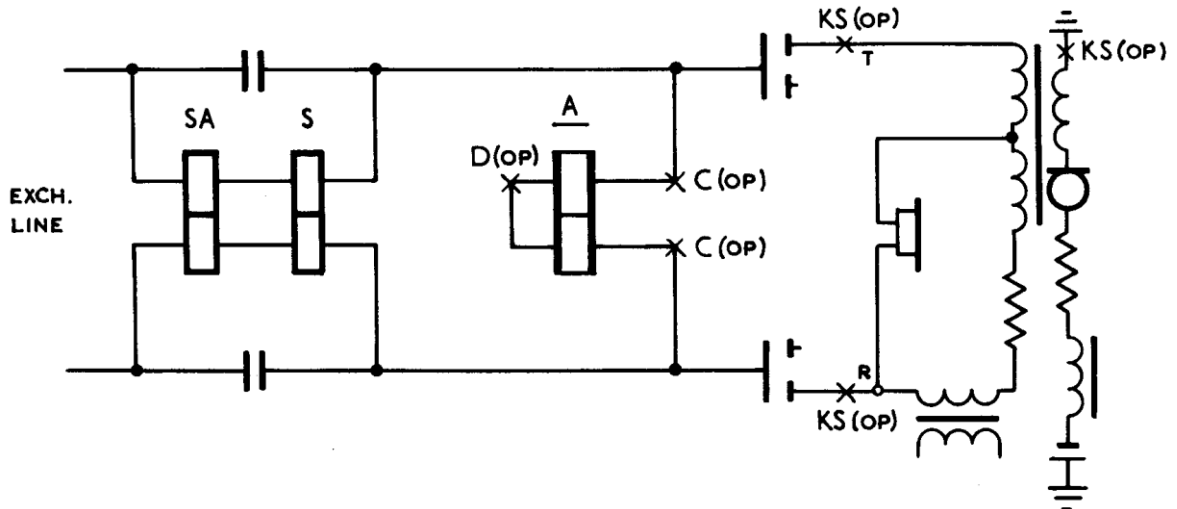


FIG. 9. EXCHANGE TO OPERATOR.

Where the local exchange is a manual exchange, the operator is able to ask for the required number. When the local exchange is an automatic exchange, the operator, in addition to operating the Speak key, also operates the dial and Hold key (KDH). The exchange line holding loop is transferred from the A relay to the dialling circuit in the telephonist's circuit via KDH1, KDH2 and leads A and B (Fig. 10).

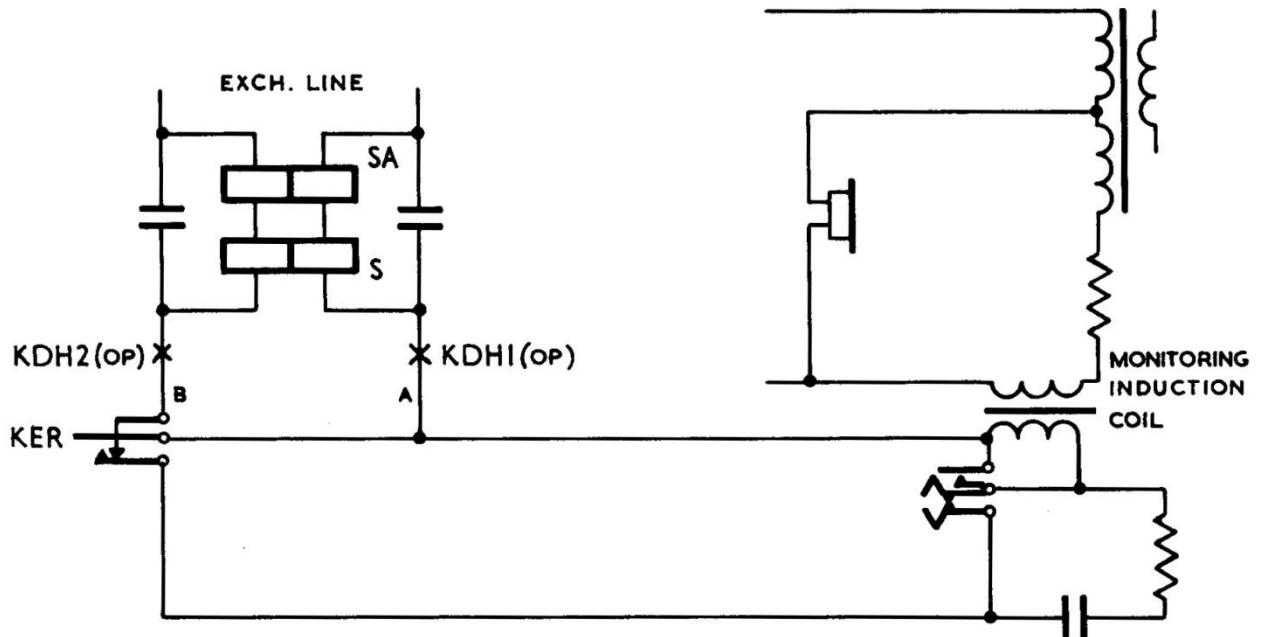


FIG. 10. OPERATOR DIALLING CONDITIONS.

The dialling circuit loop consists of Exchange Release key contacts, dial pulsing contacts, and one winding of a monitoring induction coil. The operator is able to hear dial tone and other supervisory tones via the monitoring induction coil.

During each pulse train the dial off-normal springs short circuit the monitoring induction coil to prevent clicks in the operator's receiver. Mounted across the receiver are two rectifiers which act as an acoustic shock suppressor. For normal speech voltages the rectifiers are high resistance, but when a high voltage surge appears in the receiver circuit, one of the rectifiers becomes low resistance and shunts the surge away from the receiver.

Should the operator make a dialling error or receive busy tone during dialling, she may erase the dialled number by momentarily operating the non locking Exchange Release key. This opens the dialling loop, releases the exchange connection and enables the operator to recommence dialling without withdrawing and reconnecting the front plug.

After dialling is completed, the Dial and Hold key is restored. The A relay once more provides the exchange line holding circuit, and when the called number answers, the operator is able to speak using the normal transmission circuit via T and R leads.

- 6.2 Incoming Exchange Call. Ringing current operates L relay in the exchange line circuit on its 1000Ω winding via the capacitor C3 and contact K4. The L relay is able to operate on ringing current as the 1000Ω winding is shunted by a rectifier. L1 contact completes a circuit to operate the pilot relay (P) and L2 provides a holding circuit for L relay via the Exchange Call lamp which glows to indicate the incoming call (Fig. 11). The pilot lamp glows to indicate a call waiting to be answered, and if the N.A. key is operated an audible signal is given by the N.A. buzzer.

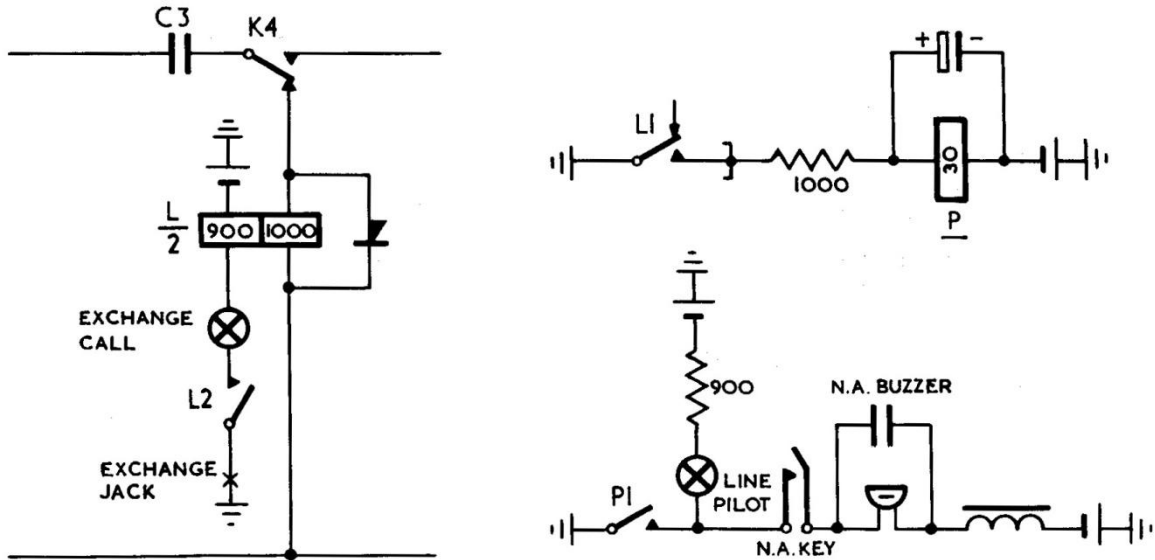


FIG. 11. INCOMING EXCHANGE CALL.

The operator answers the call by inserting the plug of a front cord into the exchange jack associated with the calling line. Operating of the exchange jack springs opens the exchange call lamp circuit and the locking circuit of L relay. L relay releases during the next silent period of the ring.

The Speak key of the selected cord circuit is operated and earth from the exchange jack sleeve operates relay C in the cord circuit on its 1400Ω winding. The operation of relays D, M, S, K and A occur as described in paragraph 2.6. The ring is tripped when M operates and the M@ contact places a loop consisting of the SA and S relays across the exchange line (Fig. 12).

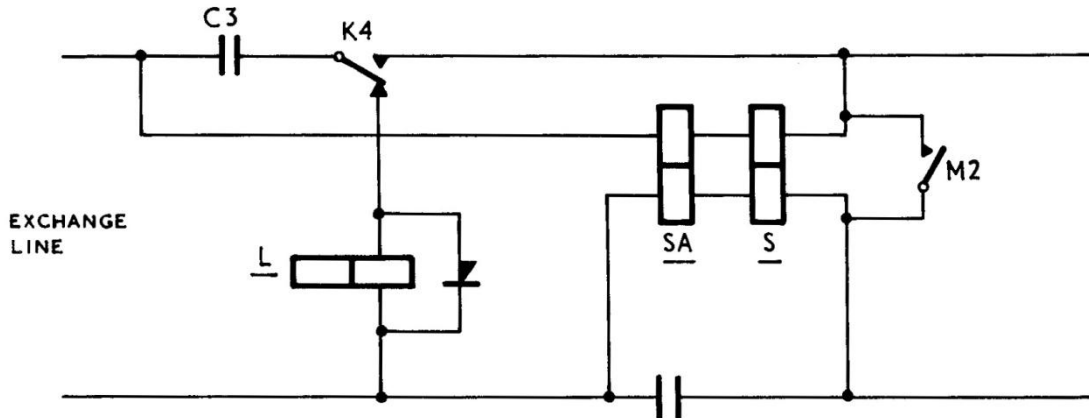


FIG. 12. RING TRIP CONDITIONS.

When the operator is speaking to the caller, the loop across the exchange line is provided by the two series connected windings of relay A. At this stage relays S and K are operated in the exchange line circuit and relays A, C and D in the cord circuit.

- 6.3 Exchange Call Connected to Extension. If the caller requires an extension, the operator takes the rear cord of the same pair of cords, inserts the plug into the required extension jack, and momentarily operates the non-locking Ring Rear key (KRR). Plugging into the extension jack operates the jack springs, disconnecting the extension call lamp circuit and connecting battery via 300Ω to the sleeve circuit of the rear cord. The rear supervisory lamp glows until the extension answers (Fig. 13). The operator may restore the Speak key at this stage or remain across the connection until the extension answers.

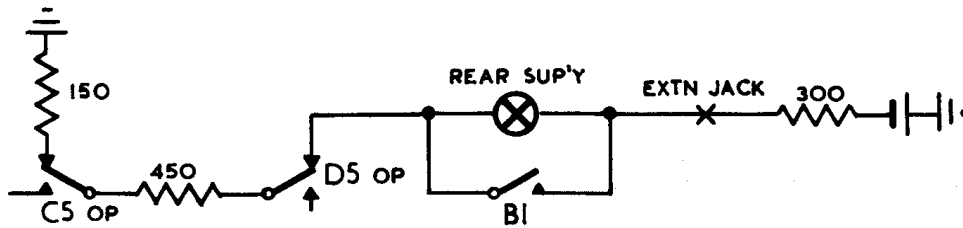


FIG. 13. SUPERVISION BEFORE EXTENSION ANSWERS.

When the extension answers, the extension loop operates relay B, which was connected across the tip and ring of the rear cord when contacts C2 and C3 operated at an earlier stage. B1 short-circuits the rear supervisory lamp. B3 breaks the holding circuit of C relay, and C releases followed by the release of relays A and B. The exchange line holding loop is now provided by the extension telephone and the conditions are as shown in Fig. 7. When the extension handset is replaced, relays S and K release and both supervisory lamps glow. The operator restores the exchange line, extension line and cord circuits to normal by withdrawing the front plug from the exchange line jack and the rear plug from the extension line jack.

6.4 Exchange Line Call Trap Facility. When the extension handset is replaced after an exchange to extension call, both supervisory lamps glow. As the loop has been removed from the exchange line, it is possible for another call to be received on the same line before the operator has withdrawn the cords.

If such a "follow-on" call occurs, the incoming ring current operates the L relay on its 1000Ω winding. As the locking circuit of the L relay is open at the operated exchange jack springs, the L relay operates during each ringing period and releases again during each silent period (Fig. 14). The ring does not pass through to the extension as the K relay is unoperated.

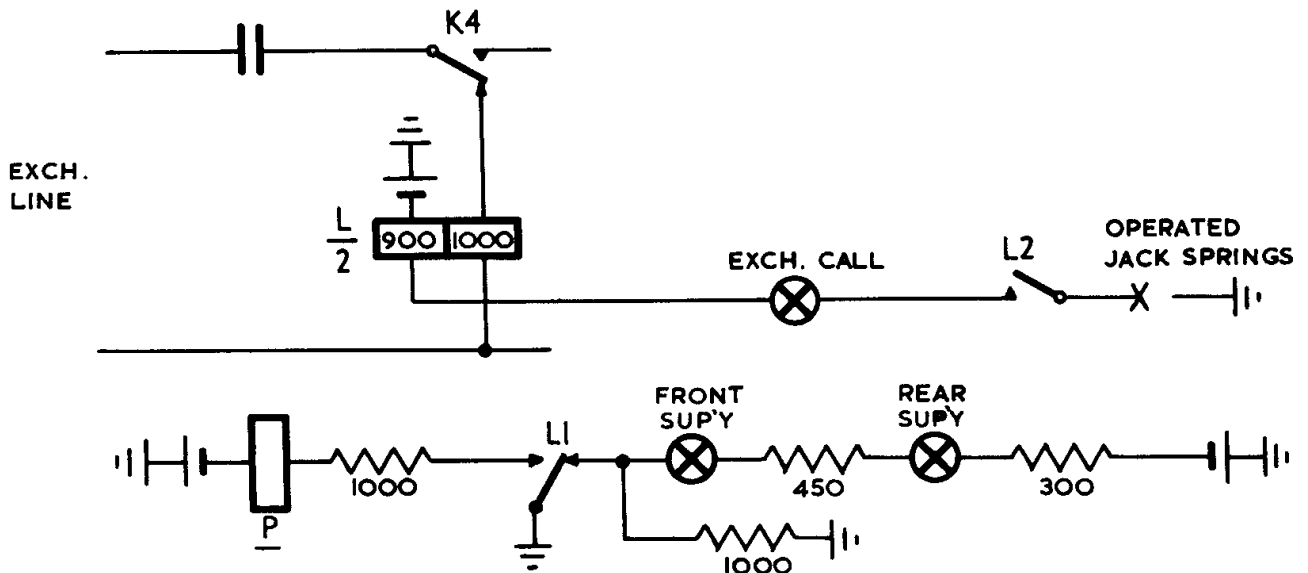


FIG. 14. TRAPPED CALL FACILITY.

Each time the L relay operates, the direct earth is removed from the supervisory lamp circuit and applied to the pilot relay circuit. The supervisory lamps are extinguished and the Line Pilot lamp glows. (If there is another call on the P.M.B.X. waiting to be answered the Line Pilot lamp will be glowing). Each time the L relay releases, the earth is re-applied to the sleeve circuit and the both supervisory lamps glow. The resultant effect is that the supervisory lamps flash off and so on at ringing frequency.

A follow-on call is answered by operating both the Speak key and the Dial and Hold key. The dialling circuit is applied to the front cord and operates relay M in the exchange line circuit (Fig. 15). Relay C is re-operated from earth at KDB4, and provides an additional self-holding circuit via C7.

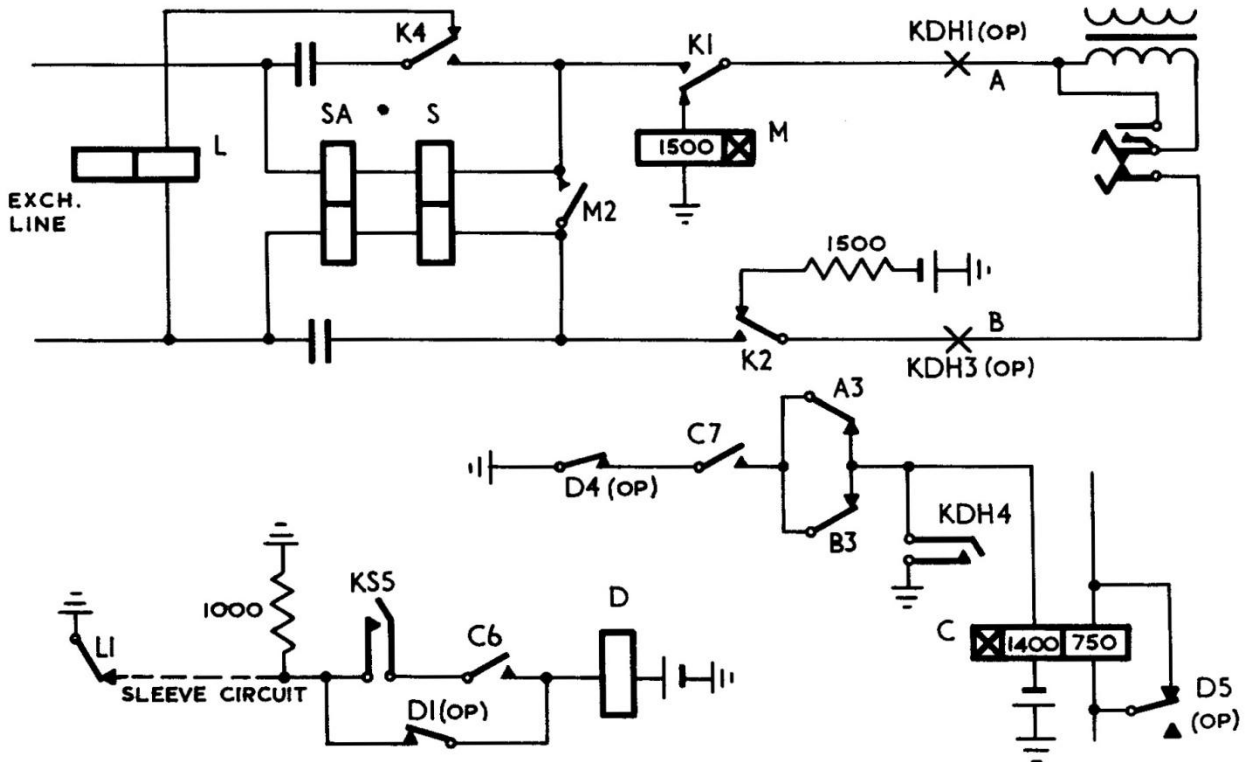


FIG. 15. ANSWERING A FOLLOW-ON CALL.

The ring is tripped when M connects the SA and S relays across the exchange line. Relay S operates, removes the short-circuit from relay K, and K4, K1 and K2 switch the exchange line through to the cord circuit. The operator removes the rear plug from the extension jack, restores the Dial and Hold key and speaks to the caller. The loop across the exchange line is maintained by the two coils of relay A. If an extension is required, the exchange call is connected to the extension line as described in paragraph 6.3.

- If the handset of the extension telephone is removed to make a second call before the cord circuit has been restored to normal after an exchange call, the extension loop operates the M relay, and M2 contacts connect the SA and S relays across the exchange line. S1 removes the short circuit from K relay, and K contacts disconnect the L and M relays and extend the exchange line through to the extension. M1 and then K3 remove the direct earth from the sleeve of the exchange line jack and the supervisory lamps in the cord circuit are extinguished.

Relays S and K in the exchange line circuit remain operated while the extension loop is maintained, and relay D in the cord circuit remains operated until the cord circuit is disconnected.

- 6.5 Recall Facility on Exchange to Extension Calls. On extension to exchange calls, any extension telephone fitted with an earthing type recall button is able to recall the operator without releasing the exchange line. When the extension alternately presses and releases the recall button, an earth is intermittently placed on one side of the extension line. The current through the two differentially connected windings of relay SA is unbalanced, and relay SA operates (Fig. 16).

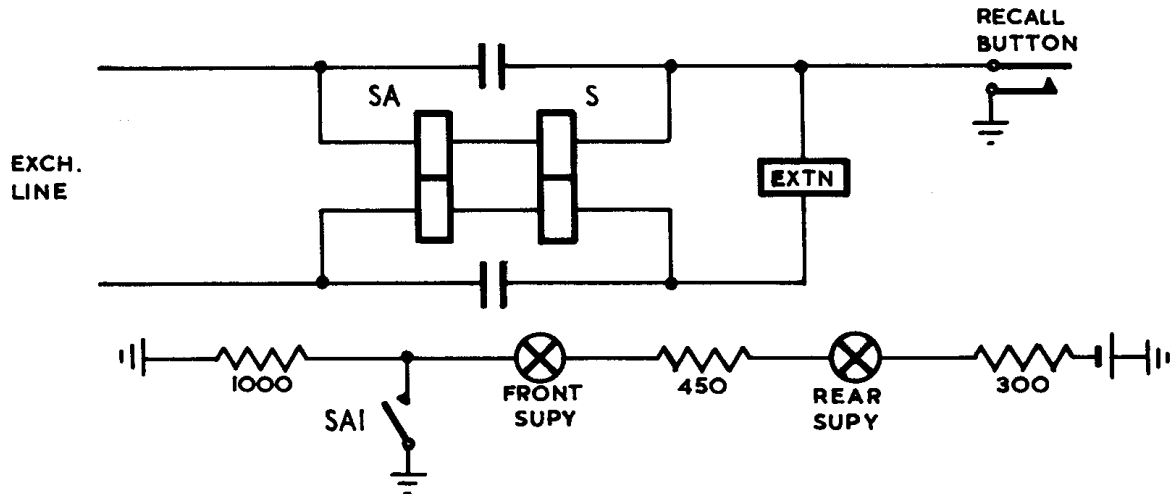


FIG. 16. RECALLING OPERATOR.

Each time SA operates, SAI places a direct earth on the sleeve circuit, causing the supervisory lamps to glow. The operator notices the flashing supervisory lights and supervises the call by operating the Speak key. The call can then be transferred to another extension if required.

6.6 Transfer of Exchange Call. An incoming or outgoing exchange call can be transferred to another extension. Generally, this action results from a recall by the extension (paragraph 6.5). After the operator has answered the recall by operating the Speak key, the procedure of transferring the call is as follows:-

- (i) Operate the Dial and Hold key (in addition to the Speak key already operated).
- (ii) Withdraw the rear plug.
- (iii) Insert the rear plug into the new extension jack and operate the Dial and Hold key into the Ring Rear position.
- (iv) Restore keys to normal. The rear supervisory lamp glows until the extension answers.

Operation of the Dial and Hold key re-operates the C relay and at the same time provides a holding loop for the exchange line via the dialling circuit. (Figs. 8 and 10). With relays C and D both operated, the two coils of relay A are connected in series to prepare a 400Ω loop circuit.

As the original extension loop was holding the exchange line, it is essential that the dial and Hold key is operated to supply a new loop circuit before the rear plug is withdrawn and before the original extension has replaced his handset. When the rear plug is inserted into the jack of the new extension and the Ring Rear key operated, the dial and Hold key is automatically restored, as the Ring Rear and Dial and Hold are two positions of the same lever key. The 400Ω A relay loop is now connected across the tip and ring of the front cord and acts as a holding loop for the exchange line.

When the keys are restored, the circuit conditions are the same as if an exchange call had just been answered, and the rear supervisory lamp glows until the extension answers. The extension loop operates the B relay, which at B3 breaks the holding circuit of the C relay. Relays C, A and B release, and the exchange line loop is now provided by the extension telephone.

6.7 Exchange Line Termination. To maintain satisfactory impedance matching when the exchange line is connected to a trunk line, a satisfactory voice frequency termination must be maintained across the line. During the period when the operator or the extension are speaking on the line, the telephone circuit provides the necessary termination.

After the operator has connected an exchange line to an extension line and restored the cord circuit keys, there is no telephone loop across the line until the extension answers. The high impedance holding circuit provided by the A relay coils is not regarded as a satisfactory termination. It is necessary therefore to provide an alternative termination during this switching period. Fig. 17 shows how the termination is connected.

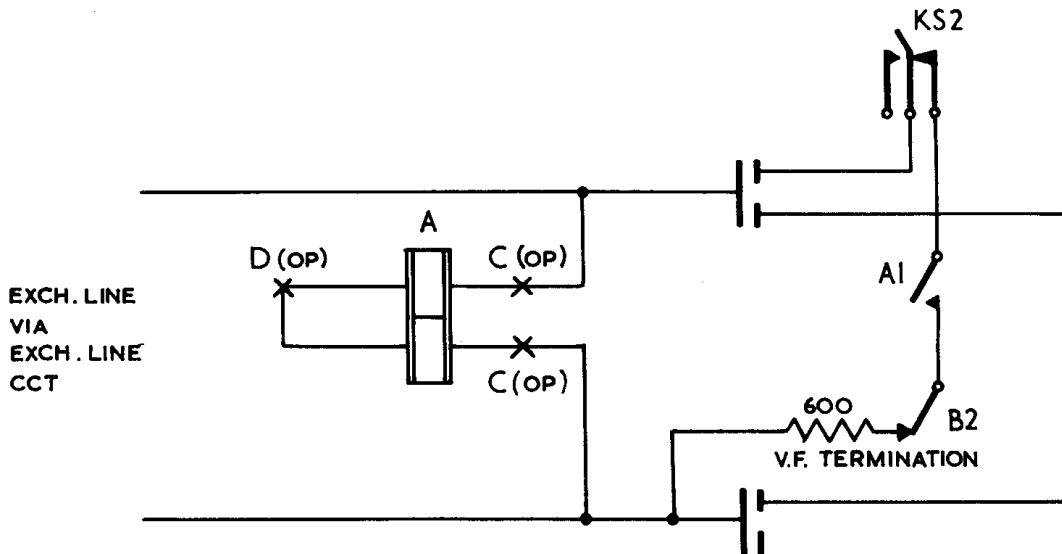


FIG. 17. CONNECTION OF VF TERMINATION.

The series arrangement of KS2, A1 and B2 contacts ensures that the termination is only connected for the desired switching period, and is disconnected to avoid shunting of speech currents whenever the operator or the extension loop is connected across the line.

6.8 Night Service. Any extension on the P.M.B.X. is able to be night switched to any exchange line. When an extension is night switched, the extension is able to make direct exchange calls by lifting the handset and dialling the required number. Any incoming calls on the night switched exchange line ring the bell at the extension phone and do not register at the P.M.B.X. To night switch an extension the procedure is as follows:-

- (i) Insert the rear cord into the night switching jack of the selected exchange line, and the front cord into the jack of the extension to be night switched.
- (ii) Operate the B.C.O key to the "Off" position.

In this "reversed cord" method of switching, the C relay in the cord circuit does not operate, and so the through connection is always maintained. By connecting the rear cord into the night switching jack, the exchange line circuit is bypassed. If such a connection is required while the P.M.B.X. is working, power must be maintained at the P.M.B.X., and as the B.C.O. key can not be switched to the "Off" position, the front supervisory lamp will glow while the extension is night switched (Fig. 18). There is no indication that a call is in progress and care must be taken to monitor before such a connection is taken down.



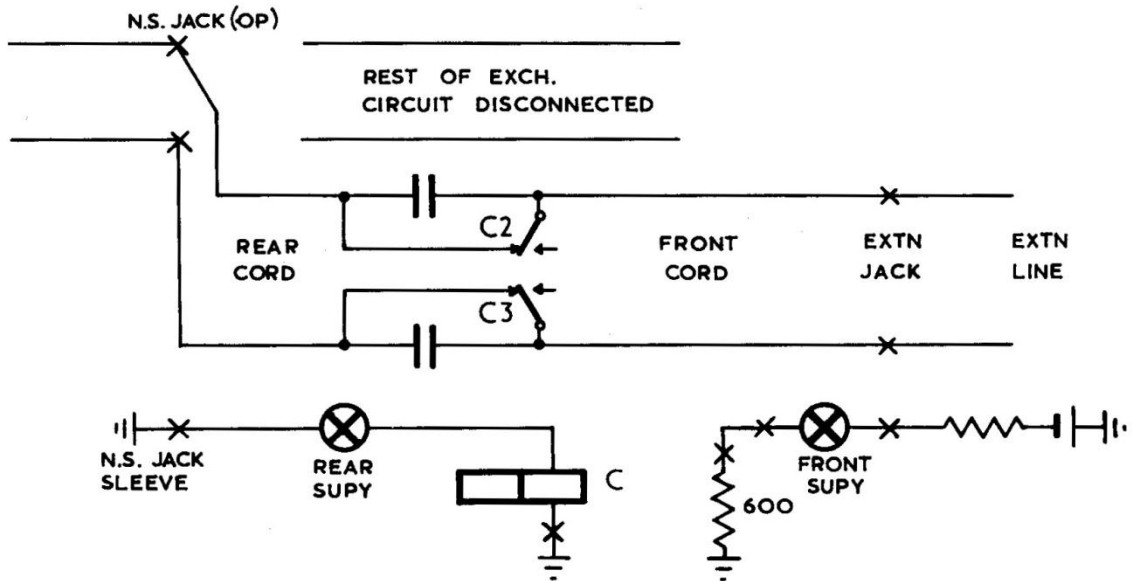


FIG. 18. REVERSED CORD CONNECTION.

7. TIE LINE CALLS.

7.1 Tile Lines. Tie lines are direct lines between two Private Branch Exchanges (Automatic or Manual) which are rented by the same firm or corporation. These lines enable calls to be made between extensions of one P.B.X. and extensions of the other P.B.X. without using the public exchange switching equipment. No charge is made for these calls but a yearly rental is made for the tie line. Generally tie lines are prevented from having exchange access but exchange access at one end may be permitted.

7.2 P.A.B.X. Tie Line Call. The exchange line circuit of this P.M.B.X. may be used to connect to a P.A.B.X. tie line. The operation of the exchange line circuit when used on a P.A.B.X. tie line is exactly the same as that described for a normal exchange call. An exchange line circuit that is used as a P.A.B.X. tie line cannot be switched to an exchange line, as the circuit design is such that the front cord is required for connecting to either circuit.

The tie line is allotted a normal extension number of the P.A.B.X., and an extension at the P.A.B.X. may gain access to the P.M.B.X. and its extension by dialling the extension number allotted to the tie line.

When a P.M.B.X. extension is connected to the tie line by the operator, he is able to dial any of the P.A.B.X. extensions in the same way as described for an exchange call.

7.3 C.B. or Magneto Tie Line. C.B. or Magneto tie lines are connected to a special tie line circuit (Fig. 19). Exchange access over these tie lines is not given, as they are designed solely to allow extensions of one switchboard to be connected direct to extensions of the other switchboard.

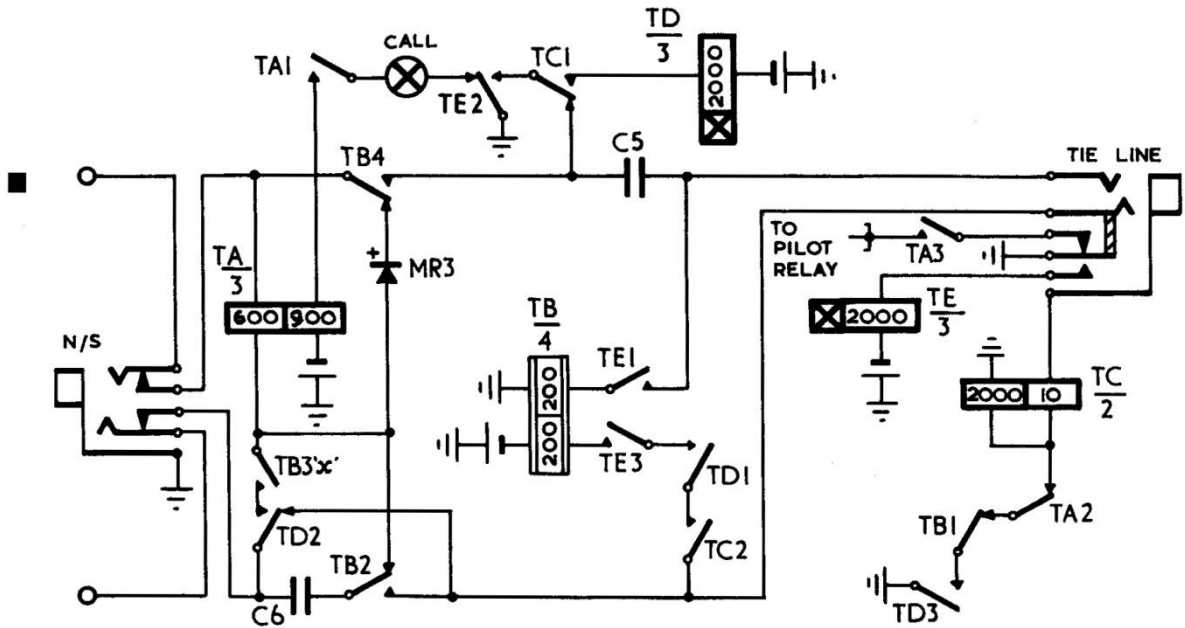


FIG. 19. TIE LINE CIRCUIT.

7.4 Incoming Tie Line Call. Incoming ring on the tie line circuit operates relay TA on its 600Ω winding. TA completes a self holding circuit via the call lamp and extends an earth to operate the pilot relay (Fig. 20). TA2 removes the shunt from the 2000 ohm winding of relay TC.

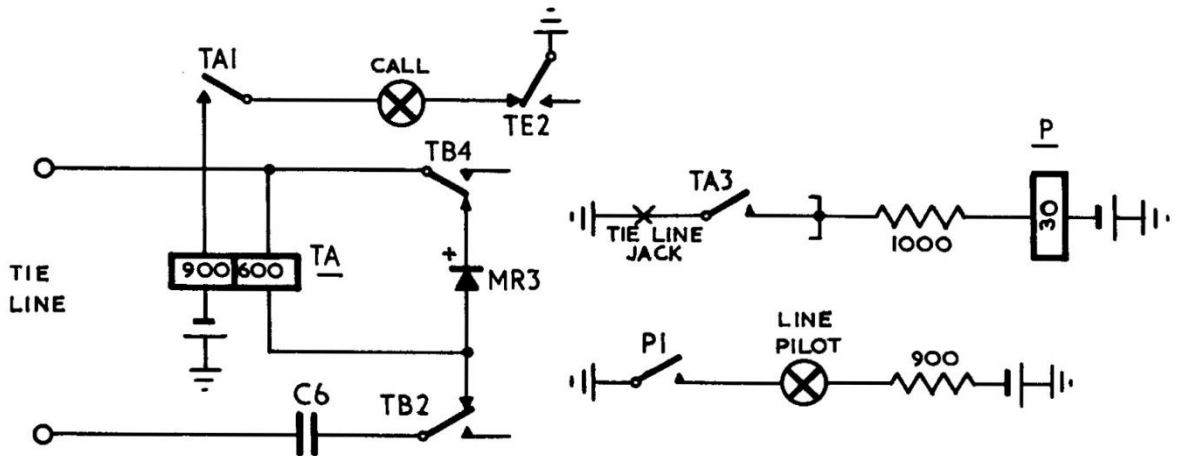


FIG. 20. INCOMING TIE LINE CALL.

The tie line call lamp glows and the operator answers the call by inserting a front plug into the tie line jack and operating the Speak key associated with the selected cord circuit.

Battery from behind the 1400Ω winding of C relay in the cord circuit is applied to the sleeve circuit and operates relay TC in the tie line circuit via the 10Ω and 2000Ω windings in series (Fig. 21). The C relay does not operate with this value of current.

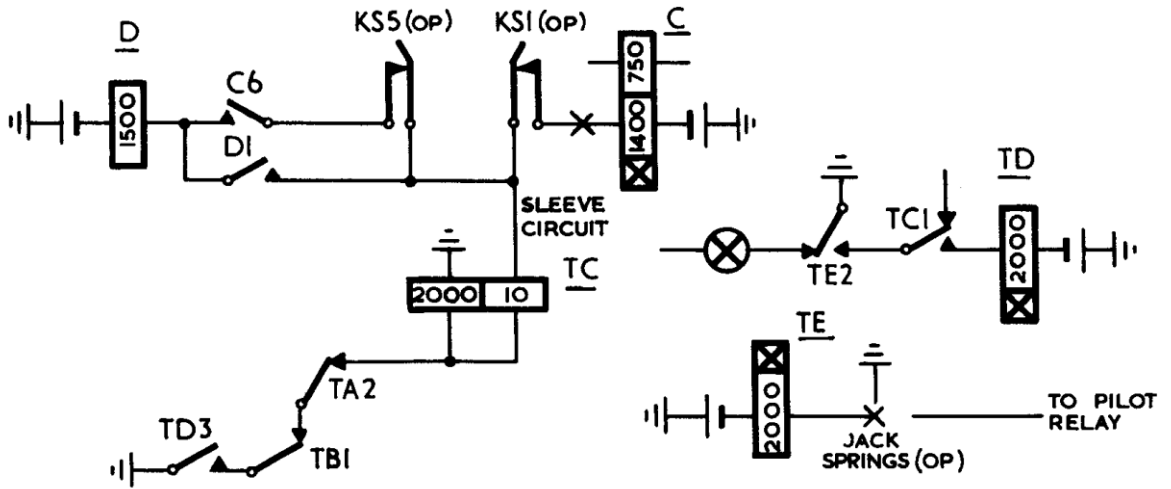


FIG. 21. ANSWERING A TIE LINE CALL.

At the same time the operated tie line jack springs operate relay TE and break the circuit to the pilot relay. TE2 opens the holding circuit of TA, extinguishes the tie line call lamp, and in conjunction with TC1 operates relay TD. When TA releases, a shunting earth via TD3, TB1 and TA2 is applied to the sleeve circuit and operates relay C in the cord circuit, followed by relay D.

The operation of relays C and D in the cord circuit places the two coils of relay A in series across the tip and ring of the front cord. The 400Ω loop provided by A operates relay TB in the tie line circuit. TB3 places the 600Ω winding of TA across the tie line to provide a supervisory loop in the case of a tie line from a C.B. switchboard. TB2 and TB4 disconnect the rectifier MR1 from across the 600Ω winding of TA, disconnect the original ring receiving circuit and through connect the A and B sides of the tie line via transmission capacitors C5 and C6. TB1 removes the short circuit from the 2000Ω winding of TC. Relay D in the cord circuit remains operated in series with this additional resistance. Fig. 22 shows the conditions when the operator is connected to the tie-line. Relays A, C and D are operated in the cord circuit, and relays TA, TB, TC, TD and TE are operated in the tie line circuit.

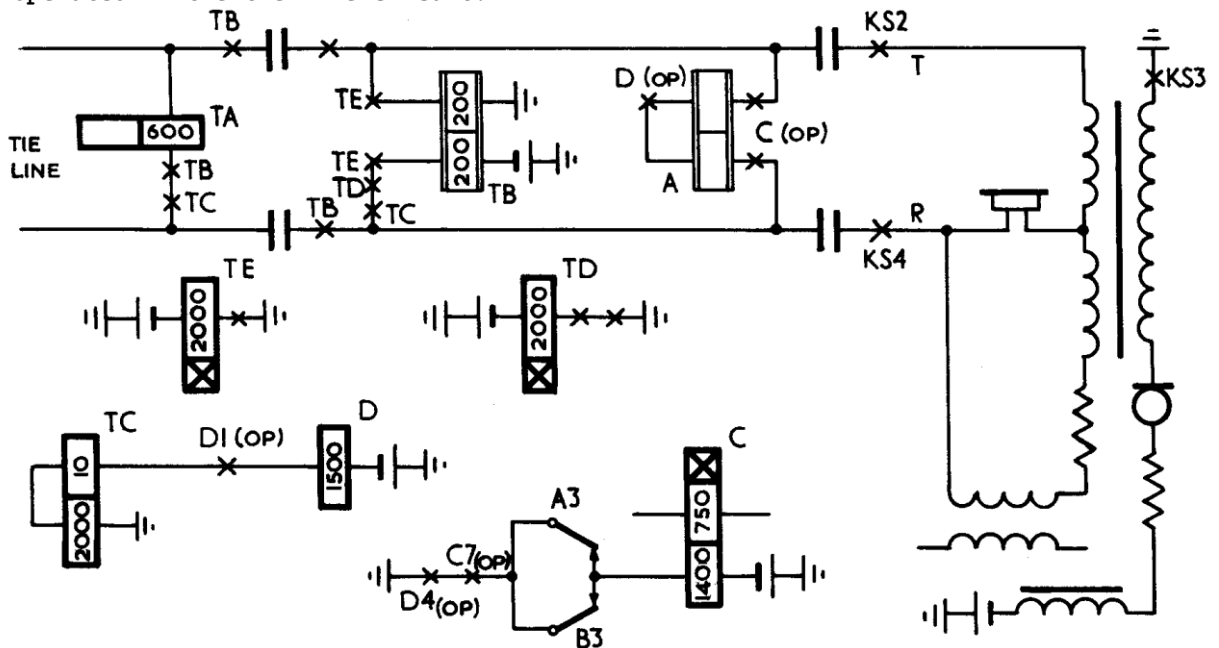


FIG. 22. ANSWERING A TIE LINE CALL.

7.5 Tie Line to Extension. The operator connects the rear cord to the required extension jack and momentarily operates the Ring Rear key. The rear supervisory lamp glows until the extension answers.

When the extension answers, the extension loop operates relay B in the cord circuit, and B1 contacts short-circuit the rear supervisory lamp. B3 opens the C relay holding circuit, and C relay releases, followed by relays A and B. The extension loop holds relay TB in the tie line circuit and the extension telephone obtains transmission battery from behind the TB relay (Fig, 23). The 2000Ω resistance of TC limits the current through the supervisory lamps and they do not glow. At the end of the cell, the extension clears, TB releases and the supervisory lamps glow.

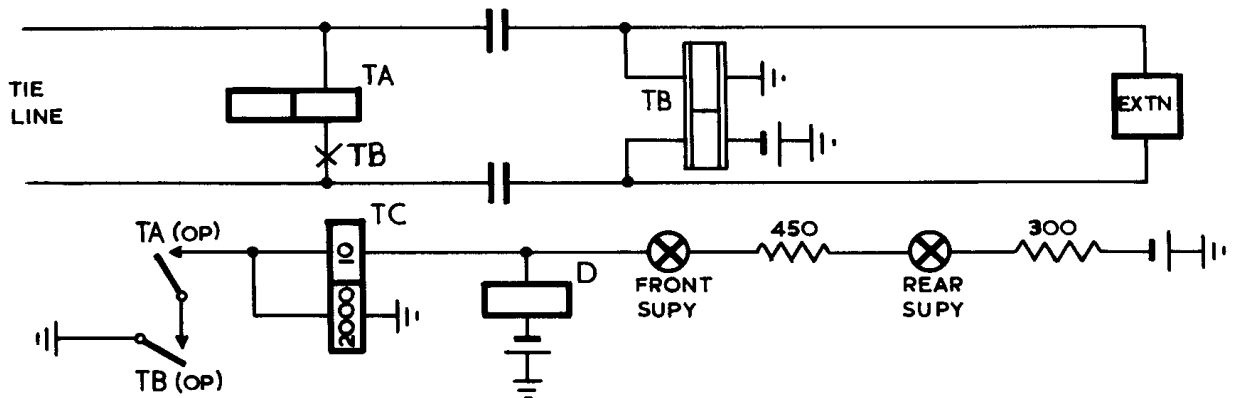


FIG. 23. TIE LINE TO EXTENSION.

7.6 Outgoing Tie Line Call by Operator. To signal over the tie-line, the operator inserts a front plug into the tie line jack, operates the Speak key for a moment, operates the key into the Ring Front position, and then restores the key into the Speak position.

The first operation of the Speak key allows relay TC in the tie line circuit to operate in series with relay C in the cord circuit. Operation of the tie line jack springs operates TE, and relay TD operates via TE2 and TC1. TD3 places a short circuit across the 2000Ω winding of TC, enabling the C relay in the cord circuit to operate on its 1400Ω winding. C6 completes a circuit for relay D, which operates and closes a self holding circuit at D1. C relay and D relay contacts place the two coils of A in series to form a 400Ω loop across the front cord tip and ring. The A relay loop operates relay TB in the tie line circuit and contacts TB4 and TB2 switch the tie line to the cord circuit.

When the Ring Front key (KBF) is operated, the loop circuit to relay TB is broken, but TB remains operated on one winding from battery behind the ring return circuit (Fig. 24). Earth via D4 and KRF2 is applied to the front cord sleeve circuit, causing the release of relay TC by short circuiting the 10Ω winding. TC1 releases relay TD and TC2 opens the circuit to one winding of TB. Ring is applied to the B side of the tie line via normal contacts TD2. The return path on the A side is via TB4, TC1 to earth at TE2.

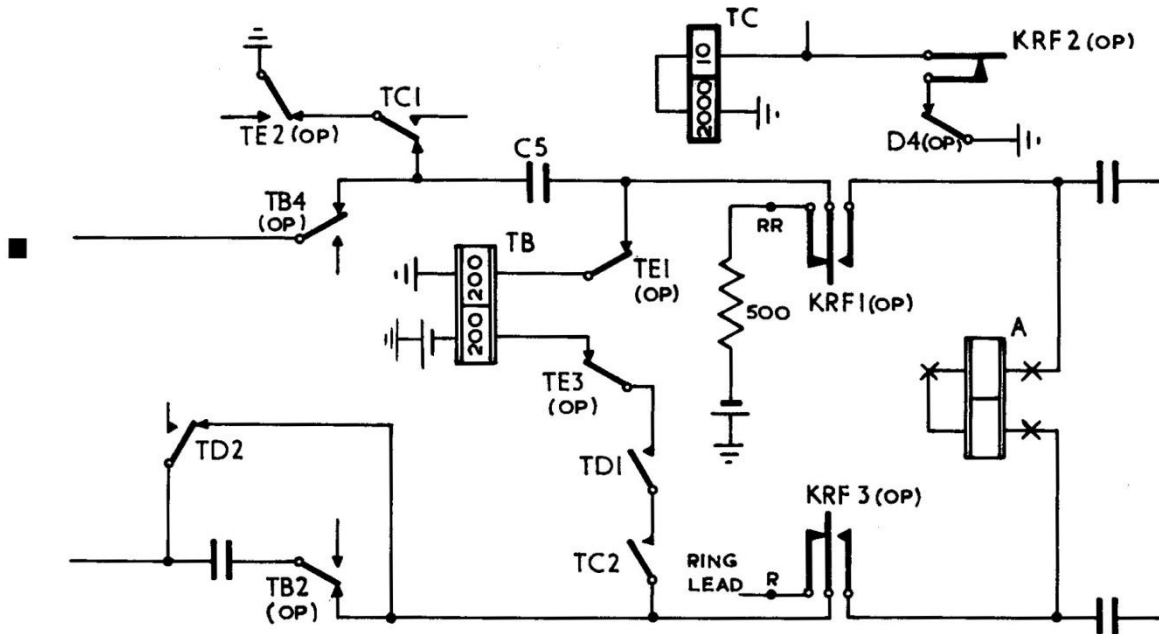


FIG. 24. RINGING ON THE TIE LINE.

When the key is operated into the Speak position, the ringing circuit is disconnected, relays TC and TD re-operate in the toe line circuit, and relay TB is once more held on both windings by the A relay loop. If desired, the call may be extended to an extension as described in para 7.5.

## 8. TESTING.

8.1 Testing from the Exchange Test Desk. When an extension is to be tested from the exchange test desk, the connection is made with reversed cords in exactly the same way as for a night switched extension (para. 6.8). If the testing is done while the switchboard is in use, it is not possible to turn off the power, and the front supervisory lamp will glow while the cords are connected. As there is no supervision on this type of call, the operator must be advised on another line when the connection is to be taken down.

8.2 Cord Testing. Two test jacks wired to identical circuits (Fig. 25) allow any pair of cords to be tested for:-

- (i) Continuity of tip, ring and sleeve cord conductors.
- (ii) Intermittent fractures in cord conductors.
- (iii) Operation of supervisory relays and lamps.
- (iv) Connection to Operators circuit.

The cord test is commenced by inserting the rear cord halfway into test jack 1, so that the sleeve circuit makes contact but not the tip and ring. Battery on the sleeve of the test jack operates the C relay and lights the rear supervisory lamp. The rear cord is now fully inserted, and the loop across the tip and ring of the test jack circuit operates relay B, which short-circuits the rear supervisory lamp. With the rear cord still in test jack 1, the front plug is inserted half-way into test jack 2. Battery on the sleeve circuit operates the front supervisory lamp. When the front plug is fully inserted, the loop applied by the test circuit operates relay A, which disconnects the circuit of the front supervisory lamp.

With both cords still connected and the Speak key operated, each cord is shaken to test for the noise in the receiver indicating fractures in the cord. This tests the T, R and S conductors in the rear cord and the T and R conductors in the front cord. To test for fractures in the sleeve conductor of the front cord it is necessary to also operate the Dial and Hold key. Earth via  $300\Omega$  is applied via KDH2 and KS1 to the sleeve circuit, and via the cord to battery on the test jack sleeve. Fractures in the sleeve circuit cause an induction into the tip and ring, and are heard in the operator's receiver.

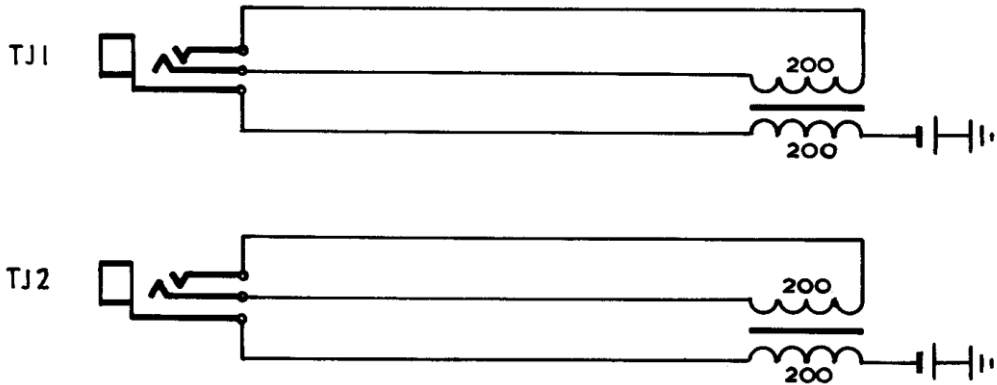


FIG. 25. CORD TEST CIRCUIT.

9. MISCELLANEOUS FEATURES.

9.1 Ringing Current Supply. Each lamp signalling cord type P.M.B.X. is provided with a locking type push-key, which permits a changeover from a ringing supply to a hand generator (Fig. 26).

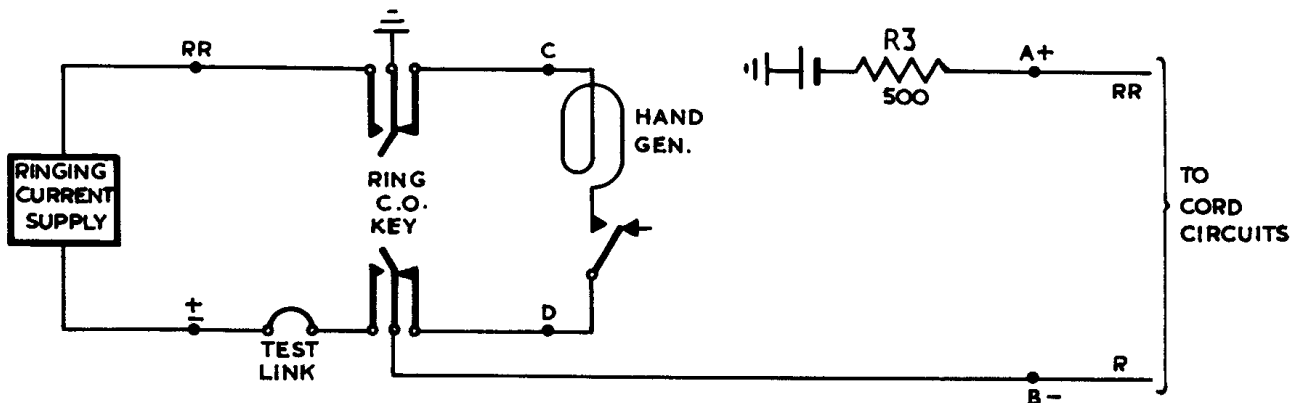


FIG. 26. RING SUPPLY CIRCUIT.

The ringing current supply source may be a ringing lead from the local exchange or from an auxiliary secondary winding on the transformer of the local power supply rectifier (eliminator).

When ringing extensions, the return circuit for the ring is via the  $500\Omega$  R3. When ringing on tie lines the battery behind R3 is used to hold relay TB in the tie line circuit, and the ring return circuit is to an earth at TE2 in the tie line relay set.

9.2 D.C. Power Supply. The D.C. power for the P.M.B.X. may be obtained via a power lead from the local exchange or from a locally located rectifier unit. The voltage measured at the P.M.B.X, under load conditions must be within the range 40-50 volts to ensure correct operation of the relays and to obtain 6 volts across each lamp. The D.C. supply to the P.M.B.X. is controlled by a switch which, when the power is disconnected, earths the battery leads within the P.M.B.X. to prevent false operation of relays from charges stored in capacitors etc. (Fig. 27).

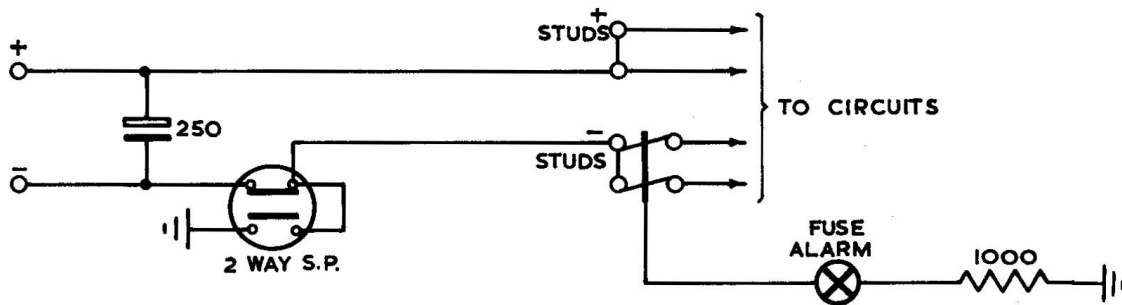


FIG. 27. D.C. SUPPLY CIRCUIT.

A red fuse lamp on the front of the P.M.B.X. gives a visual indication that a fuse has operated, but no audible alarm is provided for this condition.

9.3 Night Alarm. Common to all extension and exchange call circuits is a pilot (P) relay, which operates when a call is received and lights a line pilot lamp (Fig. 28).

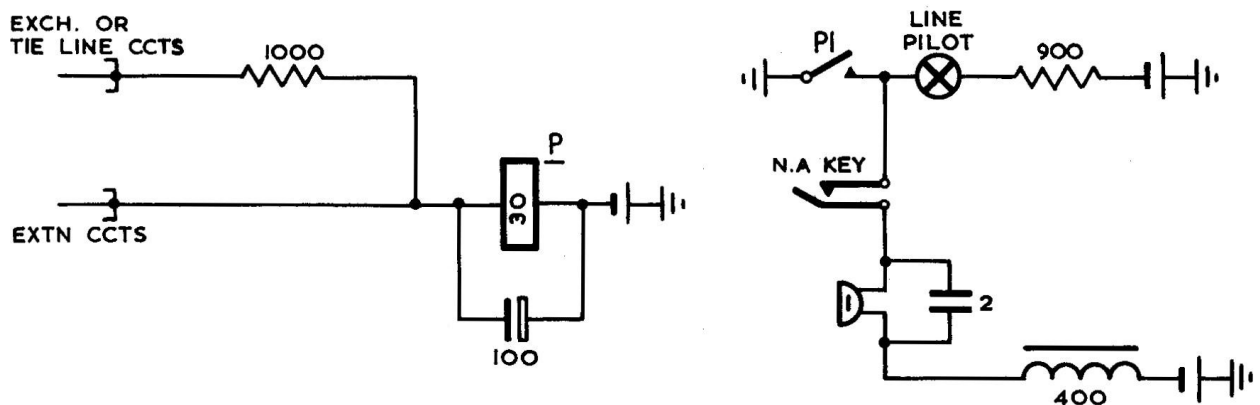


FIG. 28. NIGHT ALARM CIRCUIT.

In Issue 1 of the MARK 2 type P.M.B.X. there is no provision for audible alarm on the cord circuit supervision, but this facility will probably be included in the near future.

A 100µF electrolytic capacitor is connected across the pilot relay to prevent this relay acting as a retard in a speech transmission bridge when two or more calling extensions are waiting to be answered by the operator.

9.4 P.M.B.X. Coupling Facility. On the right hand end of the key shelf of each P.M.B.X. is a key which in the non-locking direction acts as an Exchange Release key and in the locking direction becomes a Coupling key. The coupling facility allows the cord circuits of more than one position to be connected to the operator's circuit of one P.M.B.X. position.

The cord circuit commons of one switchboard are normally connected to the operator's circuit of the same switchboard via contacts of the coupling key (Fig. 29). If the operator leaves the switchboard, the operation of the coupling key on that switchboard extends the cord circuit commons from that position to the operators circuit in the adjacent P.M.B.X. positions.

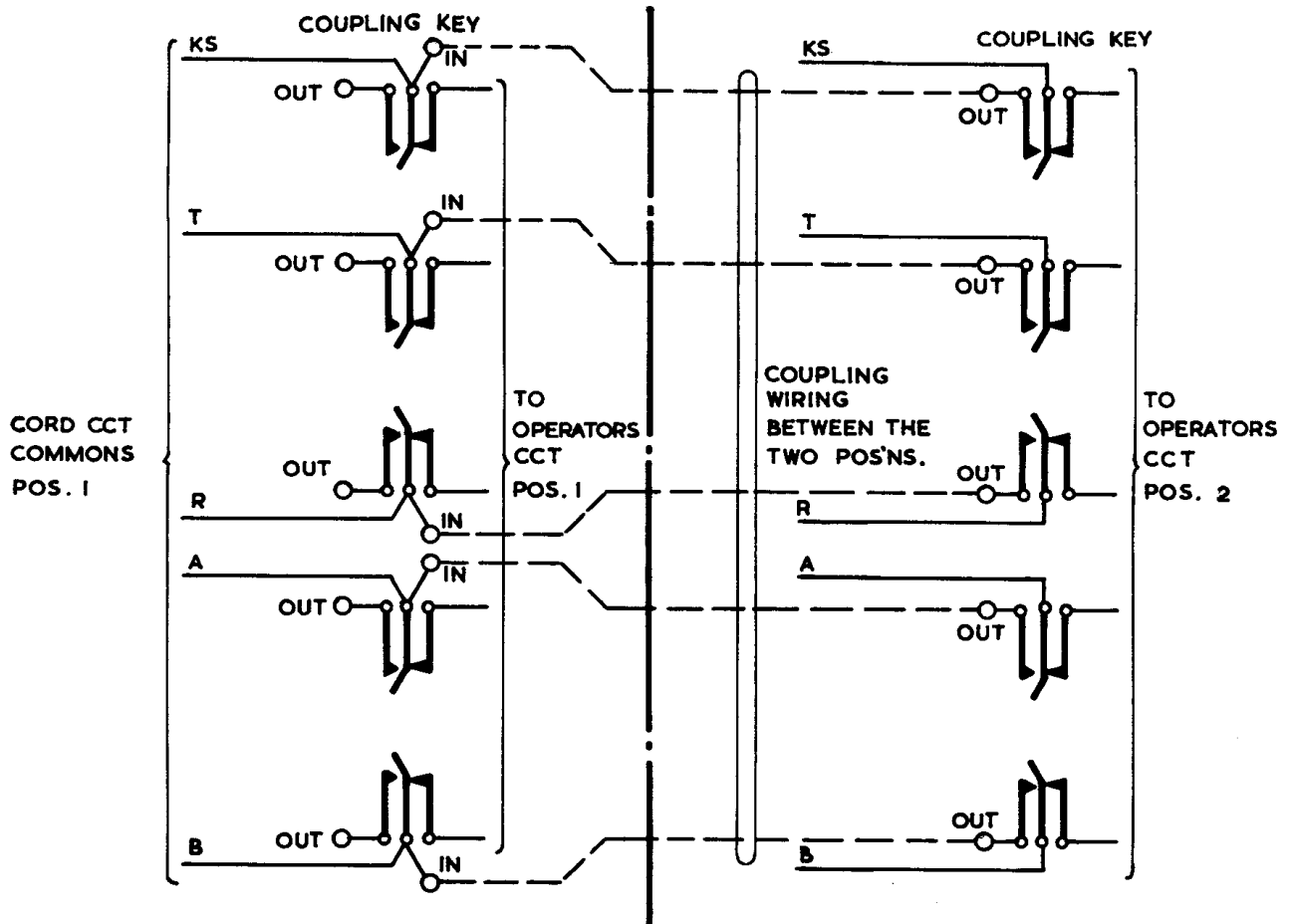


FIG. 29. COUPLING BETWEEN TWO POSITIONS.

When the P.M.B.X. consists of only one switchboard, the normally made contacts on the coupling key are strapped to prevent accidental disconnection of the operator's circuit.



