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A New Lamp-Signalling Cord P.M.B.X.— Switchboard, P.M.B.X., No. 4/1A

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The new range of modern private manual branch exchanges, which has so far included three desk-mounted cordless switchboards, has now been extended by the introduction of a new cord-type, floor-pattern switchboard. It is a lamp-signalling switchboard incorporating novel electrical and constructional features, and has a capacity for 160 extensions when used as a single position and for 200 extensions when multiplied. Its 50-volt d.c. power supply is normally derived from a separate mains-driven power unit. The new P.M.B.X. is suitable for connexion to all types of exchange except magneto.

INTRODUCTION

Switchboard, P.M.B.X., No. 4/1A has been designed to replace existing types of switchboards of the following sizes: 10 + 30, 10 + 50 and 10 + 60. When multiplied, it is intended to supersede double 10 + 50 switchboards and P.M.B.X.s No. 1 up to a capacity of 40 exchange lines, 10 private circuits and 200 extensions. The use of a 2-panel repetition for the multiple means that an installation can grow from a single position to a multiple suite, up to a maximum of four positions, with each operator having access to all lines on her own position. An installation is, in general, referred to simply as a "P.M.B.X. No. 4."

The switchboard is of a modern appearance approved by the Council of Industrial Design, and, in its standard colour scheme of 2-tone grey, matches other new items of subscribers' apparatus and harmonizes with modern office fittings and furnishings. Great attention has been paid to detail, as exemplified by such things as the use of nickel-silver bushes for jacks, white brass (i.e. brass with a 7 per cent content of nickel silver) for plugs, chrome finish for designation strips, and plug sleeves coloured light French grey. Extensive use has been made of laminated plastics for cladding.

The switchboard accommodates much of the equipment required for a complete installation, but the power unit, ringer, and signalling and distribution units are mounted externally. Extension circuits are 2-wire, with earth-loop recall.

FACILITIES PROVIDED

The main facilities provided by the switchboard are as follows.

- (a) Lamp signalling throughout.
- (b) Transmission power feed from the main exchange on extension-to-exchange calls.
- (c) Double clear on extension-to-exchange calls.
- (d) Follow-on call-trap on incoming exchange calls.
- (e) Automatic holding of exchange calls.
- (f) Divided power feed on extension-to-extension calls.
- (g) Individual supervision on extension-to-extension calls.
- (h) Through dialling and clearing from extensions.
- (i) Press-button recall on extension and exchange calls.
- (j) Jacks suitable for private and inter-P.B.X. circuits.

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(k) A transmission and signalling limit of 500 ohms for extension circuits, and 920 ohms for exchange-to-extension connexions when connected to an exchange equipped for 1,000-ohm lines.

(l) Sidetone suppression and automatic control of received speech level in the operator's circuit. The operator's instrument can be either a headset or a handset, with, if required, a transmitter cut-out key.

(m) In the event of mains failure, exchange-to-extension calls are maintained, the operator can answer and originate exchange calls, and a non-locked calling signal is given on the exchange-line lamps.

(n) "Click" engaged-test on multiple installations.

(o) Automatic ringing of extensions from calling cords.

(p) Position coupling on multiple installations.

(q) Subscriber-controlled night busy of P.B.X.-group exchange lines where the main exchange is suitably equipped.

(r) Audible signal for use with double clear.

(s) Duplicate calling appearances on extension circuits on multiple installations.

(t) Ancillary calling appearances of exchange and inter-P.B.X. circuits on multiple installations.

(u) Free-line signalling on exchange and inter-P.B.X. circuits on multiple installations.

(v) Subscribers' private metering.

It should be noted that items (r) to (v) are added when required. In addition, means have been provided to facilitate the connexion of a keysender when suitable equipment becomes available.

PHYSICAL DESIGN

The Switchboard, P.M.B.X., No. 4/1A (Fig. 1) is constructed with a metal framework and plastic-faced panels. To permit the passage of the switchboard into premises with narrow doorways the desk in front of the keyshelf can be lowered through 90° to reduce the overall depth of the switchboard to 27½ in. (Fig. 2). In the assembly of a multiple suite the unwanted side panels are removed and adjacent switchboards are bolted together. The top and rear panels are readily removable for access to the equipment within.

The circuit and lamp jacks are of a new design comprising individual moulded units mounted in strips of 10 or 20 as required, thus permitting the replacement of single jacks. All circuit designations appear on the relative lamp opals, and these are mounted on metal strips that can readily be removed from the front of the switchboard to facilitate

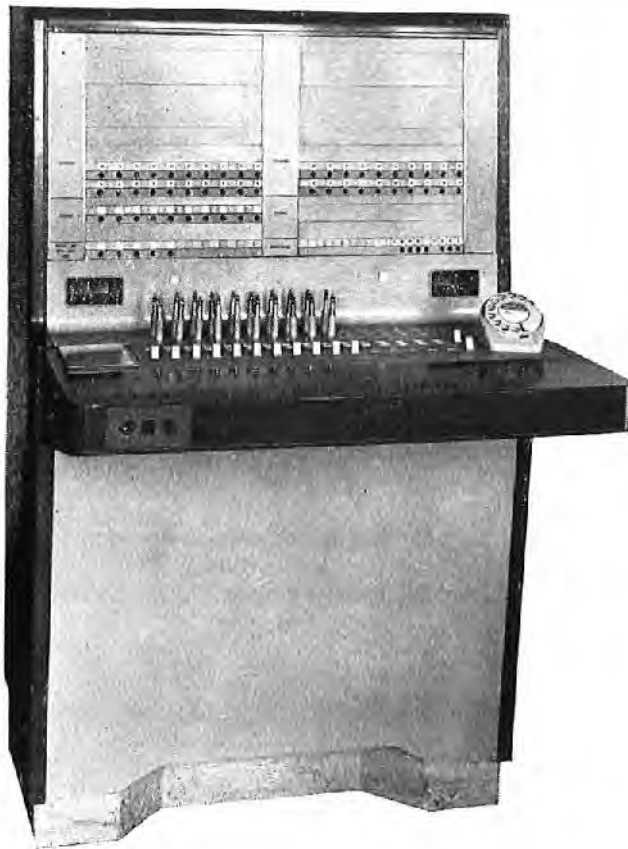


FIG. 1—Switchboard, P.M.B.X., No. 4/1A

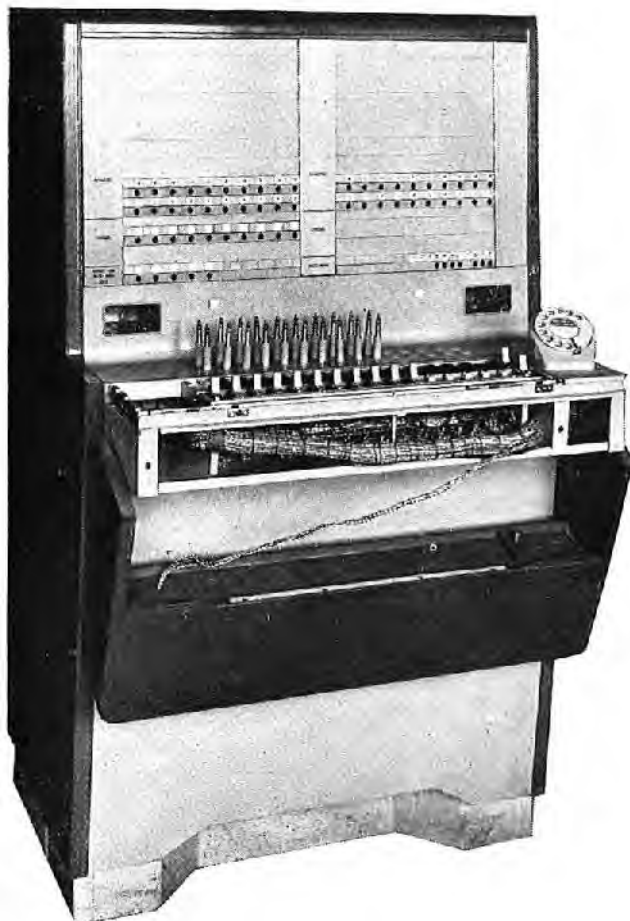


FIG. 2—Switchboard with desk lowered

changing the lamps. The designation strips are simply clipped in so that they too can be easily removed and the designation labels changed when required.

The key-plate cover has a quick-release feature, and, when the cover has been removed, the key-frame assembly, which is hinged, can be raised to give access to the key and lamp wiring (Fig. 3). When cord-circuit metering is required an

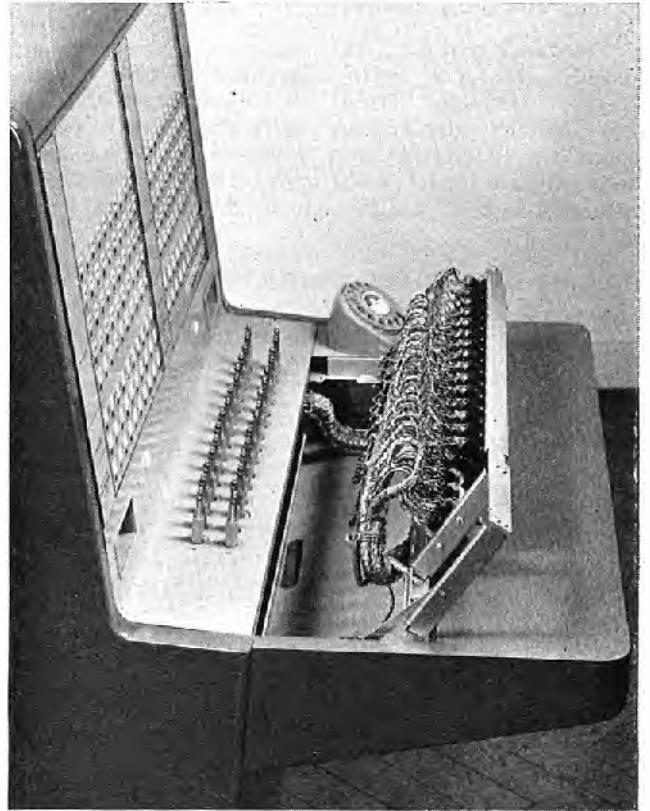


FIG. 3—Switchboard with keyshelf raised

alternative form of key-plate cover, with windows and cut-outs to enable the meters to be read and reset, can be fitted.

The switchboard is supplied fitted with 10 pairs of cords, out of a total capacity of 15, but the full quota of cord-circuit keys is provided, with those for circuits 11-15 retained out of sight below the key-plate cover until required to be brought into use.

A new type of quick-release dial mounting is used, and two operator's instrument jacks are provided; a switch can be fitted to give transmitter cut-out facilities. Two ticket boxes and a notice frame are provided, and a miscellaneous jack-and-lamp strip accommodates switchboard alarms, hold jacks and cord-test jacks.

The relay-sets for the exchange lines, cord circuits and operator's circuit are of the strip-mounted, jack-in type, all of which can be accommodated within the switchboard, with the exception of exchange-line relay-sets in excess of 12. Cord-circuit relay-sets having either one or two circuits per plate, and exchange-line relay-sets having either two or three circuits per plate, are held in stock, so enabling equipment provision to be economically matched to circuit requirements.

At the base of the switchboard are connexion strips for exchange-line circuits and the connexion of externally-mounted apparatus, and a holder for a small reserve battery, which is required to maintain certain facilities under conditions of mains failures. Cable entry to the switchboard is via three holes in the base, one on either side and one in the rear, or, if underfloor chases are available, directly into the bottom.

At the top of the switchboard is a 32-way fuse mounting,

for the distribution of the 50-volt d.c. supply, and connexion strips for extension circuits.

A Switchboard, P.M.B.X., No. 4/1 A, as stocked, is equipped to the following extent.

- (i) Extensions: wiring and face equipment for 40 circuits.
- (ii) Exchange lines: wiring for 20 jacks with face equipment for 10 circuits.
- (iii) Inter-P.B.X. lines or private circuits: wiring for 10 jacks with face equipment for five circuits.

When additional extension circuits are required they are added in units of 10, up to a maximum of 160 extensions. Strips of 10 jacks and 10 lamp jacks are stocked already wired to a connexion strip, and are readily fitted into the switchboard. The multiple jack-field on multiple suites is built up using similarly pre-fabricated units of 20 jacks wired to a connexion strip, to a maximum of 200 extensions.

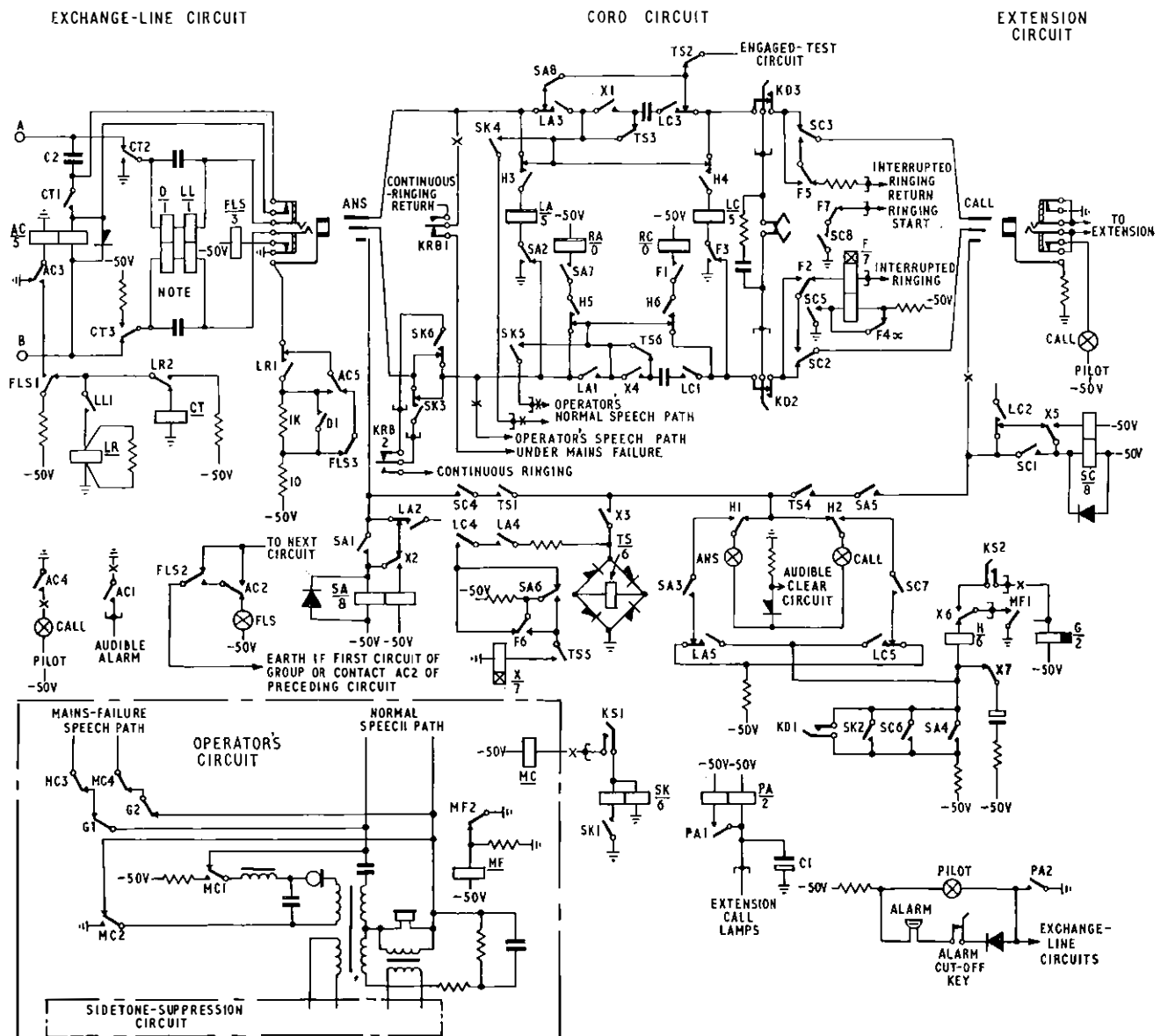
CIRCUIT DESIGN AND OPERATION

A simplified circuit diagram of the P.M.B.X. No. 4 is shown in Fig. 4. All extension circuits are 2-wire with earth-loop recall; for extension lines up to a 500-ohm loop resistance

the call lamp is lit directly from the telephone loop. Extensions up to a maximum loop resistance of 920 ohms can, however, be catered for by the introduction of a simple signalling unit; the telephone loop then operates a Type 12 relay, and the contact of this relay lights the call lamp. In practice, the permissible loop resistance may be governed by the exchange-to-extension limit.

Interconnexion of cord circuits, by the actuation of two keys to the SPEAK position, is prevented. The first key thrown operates relay SK in its own cord circuit. Relay SK, in operating, reduces the potential at the common point between the SK relays and the MC relay, thus preventing the operation of any other SK relay should another key then be operated to the SPEAK position. Interconnexion of two exchange lines via a single cord circuit is also prevented. With the answer plug in one exchange-line jack and the cord-circuit key thrown, relays H and LA operate and, if the call plug is inserted into another exchange-line jack, relay LC operates. Contacts LA4 and LC4 operate relay TS; contacts TS3 and TS6 split the cord circuit.

There is a specially-designed sidetone-suppression circuit in the operator's circuit. This new circuit has a dual function: to reduce the sidetone produced in the operator's receiver,



Note: Relay D is differentially connected

Fig. 4—Simplified circuit diagram of P.M.B.X. No. 4

and to limit loud received speech to an acceptable level on all types of call. Weak signals are not attenuated, and, for such signals, full advantage is taken of the increased efficiency of the receiver in the Headset No. 1.

The engaged-test circuit is a simple transistor switching circuit which operates to the negative potential present on the bush of an engaged jack to produce a click in the operator's receiver.

When free-line signalling (f.l.s.) is required, earth potential is connected to the f.l.s. contact chain in the first exchange-line circuit; subsequent circuits are strapped together to switch earth potential to the required f.l.s. lamp. The lamp is omitted from the first circuit of any group to save a permanent drain on the power supply.

Extension-to-Extension Call

When a call is originated at an extension, earth potential is connected via the jack-tip auxiliary springs, telephone loop and the jack-ring auxiliary springs to light the call lamp via the pilot relay, which operates. The pilot lamp lights and, if the ALARM CUT-OFF key is normal, the buzzer operates. Contact PA1 connects the low-resistance coil of relay PA in parallel with the higher-resistance operate-coil to prevent an excessive voltage drop being developed when several circuits are calling simultaneously. Capacitor C1 prevents overheating between unanswered extensions. The call is answered by operating the cord-circuit key, KS, to the SPEAK position and inserting the answer plug into the appropriate extension jack. Operation of key contact KS1 operates relays MC and SK: contacts SK4 and SK5 connect the operator's circuit to the cord-circuit tip and ring, contact SK2 operates relay H to earth at contact MF1 (relay MF is normally operated), contacts MC1 and MC2 connect energizing current for the operator's transmitter. Insertion of the answer plug causes the jack auxiliary springs to disconnect the extension loop from the lamp and the pilot relay. The extension loop is then extended to the cord-circuit tip and ring, and relay SA operates to the extension sleeve earth. The operation of relays SA and H permits the operation of the supervisory relay LA via the extension loop to prevent the lighting of the cord-circuit answer supervisory lamp. The +50-volt potential and earth from the RA and LA coils, respectively, provide transmission power feed to the calling extension. On multiple installations the operator makes an engaged test on the required extension jack (see Engaged Test). On a single position, if the extension is free, the operator restores key KS to deal with other calls and inserts the cord-circuit calling plug into the required jack. On plugging-in, the called-extension call lamp is disconnected by the operation of the jack auxiliary springs and relay SC operates to the sleeve earth. Contact SC8 provides a "start" earth for the ringing converter, and contacts SC2 and SC3 apply the interrupted ringing (0.75 second on, 2.25 seconds off) to the required extension. Contact SC7 lights the call supervisory lamp. When the called extension answers, relay F operates and locks. Contacts F2 and F5 extend the extension A-wire and B-wire to the transmission feed provided via coil RC and by relay LC, which also operates. Contact LC5 dims the call supervisory lamp.

Either extension may recall the operator by depressing the telephone RECALL button. The earthed loop from the extension releases relay LA or relay LC, as appropriate, and contact LA5 or LC5 lights the required supervisory lamp.

On completion of the call, relays LA and LC release when the extension handsets are replaced, and the supervisory lamps are lit. Removal of the plugs releases relays SA, SC and H.

Extension-to-Exchange Call

If the calling extension requests connexion to an exchange line, the operator, having verified that a line is free, inserts the

calling plug into the exchange-line jack. The relays operated up to this stage are SA, LA and H and, if the operator remains in circuit, MC and SK. Insertion of the calling plug operates the jack auxiliary break springs; one pair releases relay FLS and the other disconnects the operate path of relay AC. Connexion of the sleeve circuit does not operate relay SC, as both the cord-circuit sleeve and exchange-line sleeve are connected to -50 volts. Contact FLS1 operates relay CT. Contact FLS2 steps on the f.l.s. earth on a multiple suite. Contact FLS3 applies -50 volts via a low resistance to the exchange-line sleeve circuit. Contacts CT2 and CT3 provide local central-battery conditions to operate relay LC, which is loop connected, and relay LL. Relay D is differentially connected and does not operate at this stage. Contact LL1 operates relay LR. Contact LR2 releases relay CT, and contacts CT2 and CT3 extend the cord-circuit tip and ring to the exchange line. Contact LR1 increases the resistance of the sleeve circuit to maintain the cord-circuit supervisory darkened. When relay LC in the cord circuit operates, contact LC4 operates relay TS to -50 volts via contact F6. Contact TS5 operates relay X to -50 volts via a resistor and contact SA6 operated. Contact X6 releases relay H and operates relay G, and contact X3 prepares a hold circuit for relay TS. Contacts H3, H4, H5 and H6 disconnect relay LA, retard coil RC, retard coil RA and relay LC, and complete the through-clearing path of the cord circuit. The extension loop is now extended to the exchange line and holds relay LL to the exchange -50 volts and earth. Relays LA and LC release. Relay TS is now held via contacts X3, TS4, SA5 and LR1 to -50 volts. The extension can now dial the required number. During dialling, relay LL operates and releases, but relay LR holds.

The extension may recall the switchboard during an established extension-to-exchange call. Operation of the RECALL button causes the earth loop from the extension telephone to operate the D relay in the exchange-line circuit. Contact D1 reduces the sleeve resistance to 10 ohms to light both cord-circuit supervisory during the depression of the button.

Incoming Exchange Call

Incoming ringing current operates relay AC on one coil via a capacitor and the jack auxiliary springs. Contact AC1 operates the audible alarm, contact AC2 steps forward the f.l.s. earth, contact AC3 locks relay AC and contact AC4 lights the call lamp. The operator answers the call by operating the cord-circuit key to the SPEAK position and inserting the answering plug in the exchange-line jack. Insertion of the plug releases relay FLS and disconnects the operate path of relay AC. Relays SK and H operate in the cord circuit to connect relay LA across the tip and ring conductors. Contact FLS1, released, operates relay CT and releases relay AC. Contact FLS2 maintains the f.l.s. switching. Contact FLS3 connects -50 volts via a resistance to the exchange-line sleeve. Contacts CT2 and CT3 extend -50 volts and earth to the cord-circuit tip and ring to operate relays LL and LA. Contact LL1 operates relay LR, and contact LR1 connects -50 volts via a high resistance to the sleeve to keep the cord-circuit supervisory lamps dimmed. Contact LR2 releases relay CT. Contacts CT2 and CT3 extend the cord-circuit tip and ring to the exchange line, and relay LA trips the incoming ringing current (if the call is from an automatic exchange) and operates to the exchange -50 volts and earth. The exchange call can now be extended to an extension if required. The circuit functions as previously described, i.e. the extension is rung, the ringing is tripped and relay LC operates as for an extension-to-extension call. On the operation of relay LC, contact LC4 operates relay TS, and the circuit functions as for an extension-to-exchange call, except that relay TS is held via contacts TS1 and SC4 to the exchange-line jack sleeve connexion. If the operator has to leave the circuit and

the call is not extended to an extension the automatic hold condition is applied.

Automatic Holding of Exchange Calls

When an exchange call is answered (or originated) by the operator and the cord-circuit key has been actuated, relay H is operated (via key contact SK2) and relay LA (or LC) operates to the line conditions and applies a holding loop. Contact LA5 (or LC5) holds relay H via contact X6 to contact MF1 if the key is restored. This automatic hold condition is maintained until either the plug is removed or the call is extended to an extension; the cord circuit then provides through-clearing (relay H is released by contact X6, operated).

Follow-on-Call Trap

If, on an exchange-to-extension call, the extension clears but the operator does not remove the plugs, the bell on the extension is not rung should another incoming call be received on the exchange line.

When the extension clears, relay LL releases and contact LL1 releases relay LR. Contact LR2 released re-operates relay CT. Contact CT1 reconnects relay AC across the exchange line and contacts CT2 and CT3 disconnect the exchange line from the cord circuit. An incoming call received on the exchange line operates relay AC, but relay AC does not lock because relay FLS is released. Contact AC5 applies -50 volts via high and low resistances alternately to the exchange-line jack sleeve to flash both cord-circuit supervisory lamps.

Audible Clear

If provided, the audible-clear circuit is only operative when a double clear is obtained on a cord circuit. Under this condition the potential across a resistor in the cord circuit due to both lamp currents is approximately 7.2 volts. This potential, when applied to the base of transistor VT1 (Fig. 5),

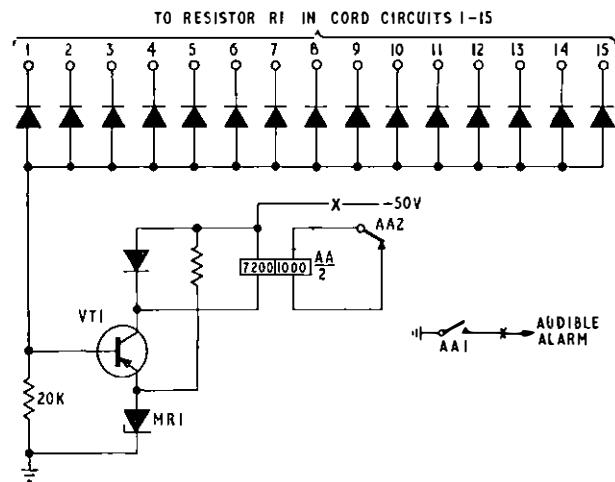


FIG. 5—Audible-clear circuit element

switches on the transistor and the emitter-collector current produced operates relay AA. Contact AA1 applies earth to the audible alarm. Relay AA is made slow to operate via contact AA2 to prevent the operation of relay AA during the warm-up time of one lamp, i.e. when the lamp is low resistance and taking sufficient current to produce a voltage sufficient to switch on the transistor. Zener diode MR1 ensures correct switching with lamps of different manufacture.

Reverted Call

A reverted call is one completed when the operator has an established exchange connexion on the calling cord and requires to ring an extension on the answer cord. The outgoing call is set up as previously described for an extension-to-

exchange call except that relays LA and SA are not operated, and, therefore, relays X and TS are not operated and relay H does not release. The answer plug is inserted into the required extension jack, and the cord-circuit key and common RING ANSWER key actuated. Continuous ringing is applied to the answer-cord tip and ring via contacts KRB1 and KRB2 and SK3. When the called extension answers, relay LA operates to the extension loop and the cord circuit gives through clearing when contact LA4 operates relay TS.

Engaged Test

The engaging potential on the bush of a busy circuit may be between -13 volts and -50 volts, depending on circuit conditions. An engaged test is made in the usual manner, with the cord-circuit key operated to the SPEAK position, by tapping the tip of the calling (or answering) plug on the bush of the required circuit. The bush potential is passed via contacts SC3, KD3, LC3 and TS2 to the engaged-test circuit (Fig. 6). For the answer plug the circuit is via contacts LA3,

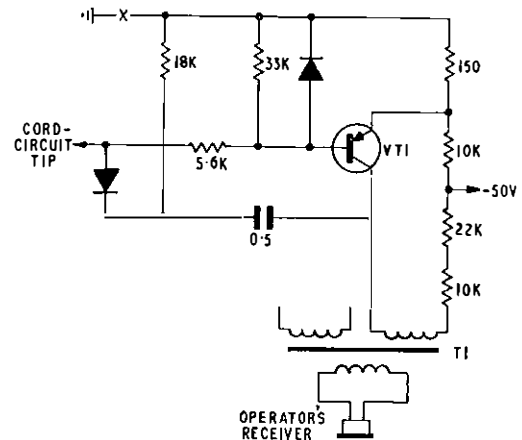


FIG. 6—Engaged-test circuit element

SA8 and TS2. The busying potential applied to the base of the transistor VT1 causes the transistor to switch on and a pulse of current to flow in the emitter-collector circuit. The pulse of current through the winding of transformer T1 causes the click in the receiver.

Metering

Centralized extension, cord-circuit trip and exchange-line totals metering may be provided independently or in any combination. Fig. 7 shows the circuit arrangement for the three facilities.

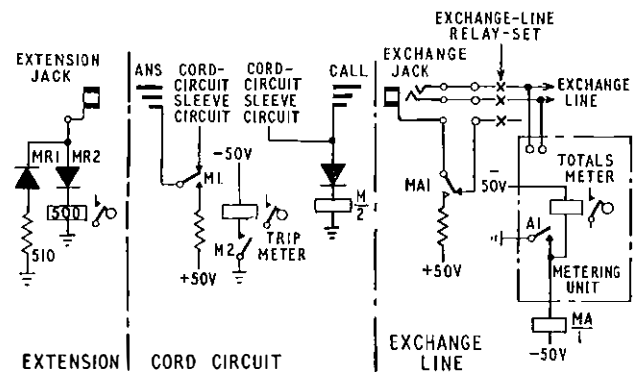


FIG. 7—S.T.D. metering circuit element

A metering unit is associated with the exchange line on the line side of the exchange-line relay-set. Subscriber-trunk-dialling meter pulses received in the metering unit cause the operation of relay A. If totals metering is required, contact A1 steps the totals meter only. If cord-circuit or extension

metering is required, relay MA is provided in association with the exchange-line metering unit, and relay M is provided in the cord circuit. Relay MA operates when pulses are received and contact MA1 connects a positive potential to the sleeve circuits to operate relay M in the cord circuit. If cord-circuit trip metering is required the trip meter is provided; it is operated by contact M2. If centralized extension metering is required a Meter No. 150A and diodes MR1 and MR2 are provided on the extension sleeve circuit; the meter operates to a positive potential connected to the sleeve circuits by contact M1.

Relays M and MA and associated resistors and diodes are provided in units mounted external to the switchboard. The positive supply is obtained from a separate mains-operated power unit or rectifier-and-battery arrangement, as required.

Mains Failure

The circuit design has been arranged so that, at installations supplied from a mains-operated power-unit, exchange-line service is maintained in the event of a mains failure.

On an established exchange-to-extension call the speech path through the cord circuit is via unoperated relay contacts, and the release of relays SA, SC, X and TS does not affect the call. If the power is restored during a call the circuit is set up again as for a normal call. Extension-to-extension calls will fail, as all relays are released and the transmission power feeds are lost.

Selected extensions can be given direct exchange access during mains failure by suitable connexion of cords. Under this arrangement the call cord is connected to the exchange line to prevent the extension telephone being rung on restoration of the power. The operator may originate calls on any cord-circuit call cord if the answer cord is connected to a hold jack, as, during mains failure, the operator's circuit is a common-battery type circuit via contacts MCI and MC2. Operator-originated calls cannot be connected to an extension.

Incoming calls are indicated by a non-locked signal on the exchange-line lamps, the reserve —50-volt battery being used to light the lamp. An incoming call operates relay AC, and contact AC4 lights the call lamp for the period of ringing current. On plugging-in, the operator disconnects the operate circuit of relay AC and the ringing is tripped by the telephone loop. The hold jacks may be utilized to hold the call if the operator needs to answer a further call.

Night Service

Operation of the NIGHT SERVICE key disconnects the —50-volt supply from the switchboard, one key being provided per position. Night service is set up in a similar manner to the mains-failure arrangement for connecting selected extensions to exchange lines.

Inter-PBX Extensions and Private Circuits

The type of jack used for inter-P.B.X. extensions and private circuits has one auxiliary make-contact unit in addition to the normal tip, ring and sleeve contacts. Use is made of this auxiliary contact unit to set up relays in the signalling units associated with these circuits. The signalling units are mounted external to the switchboard.

CONCLUSION

The versatility, better appearance, additional facilities and improved circuit design of the P.M.B.X. No. 4 should prove attractive to subscribers, and provide greater reliability and ease of maintenance for the Post Office.

ACKNOWLEDGEMENT

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