

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL



Vol. 55 Part 4

JANUARY 1963

New Cordless P.M.B.X. Switchboards—P.M.B.X.s No. 2/3A and 2/4A

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U.D.C. 621.395.23

The new range of private manual branch exchange switchboards of the cordless type is completed by the introduction of two further switchboards with maximum capacities of three exchange lines and 12 extensions and of four exchange lines and 18 extensions, respectively. These have lamp-signalling and are of compact design similar to, but providing more facilities than, the first switchboard of the series, which provides for only two exchange lines and six extensions.

INTRODUCTION

IN an earlier article¹ a new type of cordless private manual branch exchange (P.M.B.X. No. 2/2A) was described. This type of switchboard was the result of an entirely new approach to the problems of physical design and circuit arrangement; it has a capacity of two exchange lines and six extensions and was the first of a new series of cordless switchboards that has been planned to supersede the existing types. Two larger switchboards similar in general design to the P.M.B.X. No. 2/2A are now being introduced. The first (P.M.B.X. No. 2/3A) has a maximum capacity of three exchange lines and 12 extensions; the second (P.M.B.X. No. 2/4A) is equipped for four exchange lines and 18 extensions. These two switchboards complete the new range of cordless P.M.B.X.s.

As a result of research into present-day requirements, the exchange-line-to-extension ratios of the new switchboards differ from those of the superseded models. The P.M.B.X. No. 2/2A, which is equipped for two exchange lines and six extensions (2+6), replaces the old 2+4 type; the new P.M.B.X. No. 2/3A (3+12) will replace the old 3+9 type and the P.M.B.X. No. 2/4A (4+18) will cater for much of the demand which previously was met by the 5+20 floor-pattern cord type. The remaining demand for the 5+20 switchboard will in future be met by a new floor-pattern cord-type board.

The introduction of the three new cordless P.M.B.X.s has, therefore, made it possible to provide a range of equipment in accordance with modern needs.

FACILITIES PROVIDED

The adoption of the 4-wire extension principle,² which entails running an extra wire plus an earth to each extension telephone for supervisory purposes, has enabled the requisite facilities to be provided in the most economical manner. An auxiliary unit has been designed for use with external-extension circuits

that are routed in the public-exchange local-line network and so require conversion from 4-wire to 2-wire working. All the extension circuits on the switchboards can be used as 4-wire extensions if desired. Alternatively, by simple

rearrangement of cords and straps within the switchboards and the connexion of the appropriate auxiliary unit, extension circuits 7–12 on the P.M.B.X. No. 2/3A and extension circuits 10–18 on the P.M.B.X. No. 2/4A can be used for 2-wire extensions, inter-switchboard extensions or private circuits.

The power supply for these switchboards is derived from an external a.c. mains-driven power unit³ supplying 50 volts d.c. and 25 c/s a.c. for ringing purposes.

The main features of the two new cordless P.M.B.X. switchboards are as follows:

- (a) Lamp signalling for exchange lines and extensions.
- (b) A transmission and signalling limit of 500 ohms for extension circuits and of 935 ohms for exchange-to-extension connexions when connected to an exchange equipped for 1,000-ohm lines.
- (c) Press-button recall on extension-to-extension calls and extension-to-exchange calls, under all conditions.
- (d) Individual clearing on extension-to-extension calls.
- (e) Automatic holding of exchange calls.
- (f) Follow-on-call trap on incoming exchange calls.
- (g) Connexion of private circuits and inter-switchboard circuits without modification to the permanent wiring of the switchboard.
- (h) Connexion between cabling and the switchboard by a flexible cord and connector.
- (i) Arrangements for the provision of a headset in addition to the operator's handset telephone.
- (j) Space for the provision of subscriber-trunk-dialling (S.T.D.) trip meters on the switchboard.

The following additional facilities are provided only on the larger switchboard:

- (k) An "overcall" circuit to enable the operator to answer exchange and extension lines when all connecting links are engaged.
- (l) Lamp signals to indicate the next free connecting-link circuit available.

PHYSICAL DESIGN

P.M.B.X.s No. 2/3A and 2/4A are similar in design and are shown in Fig. 1 and 2. The switchboards are



FIG. 1—P.M.B.X. No. 2/3A

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FIG. 2—P.M.B.X. No. 2/4A

supplied in two-tone grey with matching Telephones No. 706 as the operating instruments.

Both switchboards have a metal chassis and a plastic cover. The P.M.B.X. No. 2/3A is approximately 17 in. wide by 8 in. high by 13 in. deep and weighs 33 lb; the P.M.B.X. No. 2/4A is approximately 22 in. wide by 9 in. high by 15 in. deep and weighs 56 lb.

The thermoplastic French-grey covers are made by injection moulding using a co-polymer plastic material that is both economical and attractive in appearance. The leading edge of the cover fits under the front of the face panel, and adjustable plates on the side of the panel form dust seals.

The face panel is finished in elephant-grey stoved p.v.c. (organosol) that provides a durable surface with a leather-grain appearance. The marking required on the face panel is applied by hot stamping into the layer of stoved p.v.c. and the characters are white.

If it is desired to use a headset as the operator's instrument, the Telephone No. 706 is changed for a Telephone No. 710 and a headset jack is provided on the switchboard. The change-over from handset to headset is arranged by providing auxiliary spring-sets in the Telephone No. 710 so that when the handset is on the rest the receiver and transmitter of the headset are brought into circuit. When the handset is lifted the transmission path is automatically switched back to the handset. Under these conditions the normal gravity-switch spring-sets are short-circuited and the connexion of the operator's telephone depends entirely on the operator's telephone key.

The miniature 1,000-type key⁴ has been used instead of the standard lever key. The key handles are coloured light ivory for the exchange lines and operator's keys, and, alternately, light ivory with black inserts and French-grey with black inserts on the extension positions to assist in identifying the keys associated with a particular circuit. The ALARM ON/NIGHT SERVICE key is light ivory with a red insert.

The keys, lamp jacks and circuit-designation label-strips are mounted on the panel in such a manner that all screw heads are concealed. When the lamp cover-strip is removed the lamp-jack screw heads are exposed; by releasing these screws, the lamp jack may be drawn forward to permit lamps to be changed without the use of a lamp extractor or the removal of the switchboard cover.

Arrangements have been made for the provision of subscribers' private trip-meters. These are used on S.T.D. calls and are fitted, as required, in the key panel of the switchboard in line with the appropriate exchange-line keys. For this reason the exchange-line connecting-circuit keys are more widely spaced than the extension keys. The removal of the exchange-line designation strip uncovers a cut-out portion of the panel provided to accommodate the meters; if meters are provided a narrower type of designation strip is used. The meters can be provided on the basis of one meter per exchange line or one meter that can be switched to any of the exchange lines.

When the cover of the switchboard is removed the metal chassis, consisting of three sections, is exposed. The front and rear panels and the base plate form a triangular section when the chassis is closed, as shown for the P.M.B.X. No. 2/3A in Fig. 3. By releasing the screws at the apex, the hinged panels can be opened outwards to permit inspection of the wiring and components. The P.M.B.X. No. 2/4A is similar except that it contains more equipment.

The front panel carries the keys and lamps, and the relays are mounted on the rear panel under a dust cover;

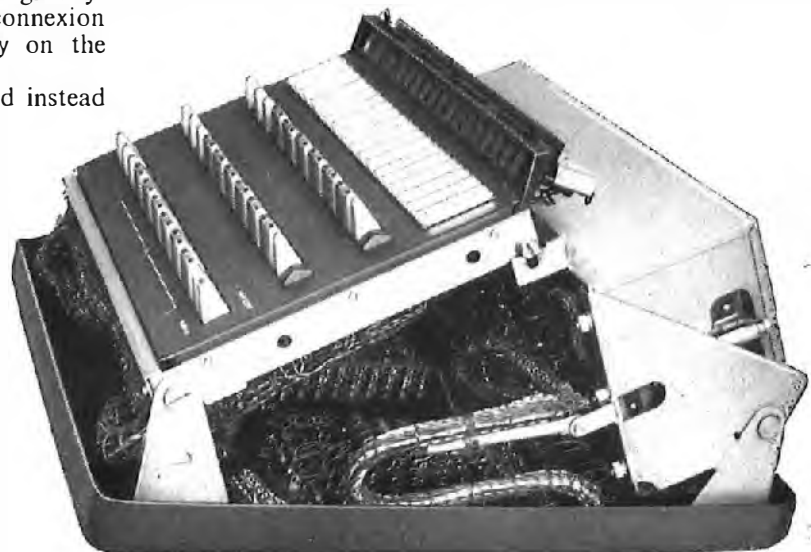


FIG. 3—CHASSIS OF P.M.B.X. No. 2/3A

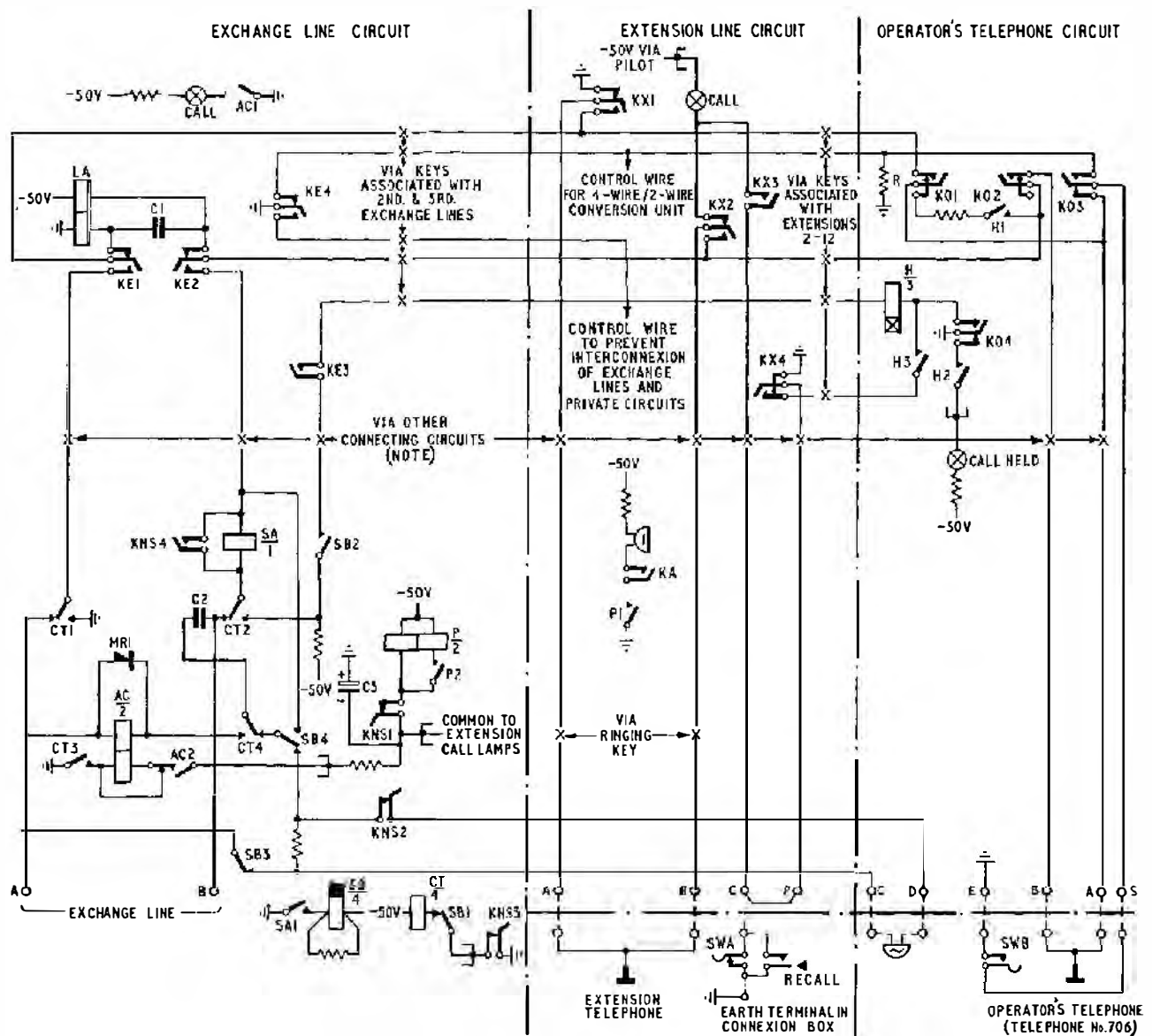
some static components are mounted on the base together with the connexion blocks. One type of connexion block has soldered connexions that can be re-arranged to provide, for example, barring of the connexion of private circuits to exchange lines; the other type is equipped with screw terminals and is used for the connexion of the operator's telephone and the line-circuits. Screw terminals are also provided to permit re-arrangement of the straps and cords when 2-wire extensions, private circuits or inter-switchboard extensions are required.

The switchboard is supplied with a multi-way cord already connected, and with the free end terminated on small connectors that plug into a wall-mounting jack assembly cabled to the connexion box. The P.M.B.X. No. 2/3A is equipped with a 68-way cord and P.M.B.X. No. 2/4A with a 100-way cord.

ELECTRICAL DESIGN

For economic reasons a parallel-feed transmission bridge has been adopted for extension-to-extension calls. The bridge is of the new 50-volt design (used on P.M.B.X. No. 2/2A) and consists of a $300 + 300$ -ohm coil with an $0.1\mu\text{F}$ capacitor across the output to give improved side-tone balance. This combination is suitable for all extension-to-extension calls up to a signalling limit of 500 ohms, with either 300-type or 700-type telephones. Non-removable relay shields fitted to the transmission-bridge relays increase the crosstalk attenuation between circuits to at least 75 db.

A new lamp (Lamp No. 2, 45 volts) has been developed for use on these switchboards. It has a reasonably flat lumens/resistance response over the range 0-500 ohms for the line-plus-telephone loop resistance and its use has obviated the need for a line-signalling relay.



Note: There are five connecting circuits.

FIG. 4—SIMPLIFIED CIRCUIT OF P.M.B.X. No. 2/3A

No hand generator is fitted; the ringing supply is derived from a frequency-dividing mains-operated unit producing a 25 c/s a.c. output.

The switchboard circuits have been designed to operate from a nominal 50-volt d.c. supply, but are capable of operating from a supply in the range 45–55 volts, and this has enabled economies to be made in the design of the power units. Under full-load conditions the current consumption of the P.M.B.X. No. 2/3A is 1 amp and that of the P.M.B.X. No. 2/4A is 2 amp. If auxiliary units are associated with the switchboard, the power consumption is increased and the power units are changed to 2-amp and 4-amp types, respectively. Arrangements have been made to ensure that exchange calls in progress are maintained if a mains failure occurs. For normal installations it is recognized and accepted that extension-to-extension and inter-switchboard calls will fail if the mains supply ceases, but at installations where such a break in service could not be tolerated the switchboard will be operated from a floated-battery system.

CIRCUIT DESCRIPTION AND OPERATION

The 4-wire extension principle is used on all internal extensions and can be applied to external extensions within the curtilage of the subscriber's premises. For external extensions connected via the local-line network it will generally be desirable and more economical to use a 4-wire/2-wire conversion unit. For extensions not requiring a conversion unit the exchange-to-extension transmission and signalling limit is 935 ohms in exchange areas equipped for 1,000-ohm line working, 65 ohms being required for the supervisory relays. On external extensions for which conversion units are required this limit is reduced to 850 ohms, the difference being due to the resistance of the signalling relays in the conversion unit.

Two additional facilities are provided by the circuit of the larger switchboard, the P.M.B.X. No. 2/4A. The first enables a free connecting link to be selected rapidly by means of a free-link signalling system. The second facility, known as overcall, enables the operator to answer a call when all seven connecting links are engaged.

A simplified circuit diagram of the P.M. B.X. No. 2/3A is shown in Fig. 4.

Extension-to-Extension Calls

When a call is originated at an extension by lifting the telephone handset, earth via contact KX1, the telephone loop, contact KX2 and the calling lamp, operates the pilot relay, P, which is connected to –50 volts, and the extension calling lamp glows. Contact P2 connects the low-resistance coil of the P relay in parallel with the high-resistance coil. This prevents the voltage drop across the pilot relay becoming excessive when a number of lamps are glowing simultaneously. Contact P1 causes an audible alarm to be given if the ALARM ON key, KA, is operated. If more than one extension is calling the switchboard, overhearing between the extensions is suppressed by capacitor C3. The call is answered by operating the OPERATOR'S TELEPHONE key, KO, associated with the chosen connecting circuit and the appropriate CONNECT EXTENSION key, KX, and by lifting the handset of the operator's telephone. The transmission-bridge relay, LA, feeds transmitter current to both telephones.

If connexion to another extension is required, the operator checks that the extension is disengaged by observation of the keys, and calls the extension by the operation of the appropriate ringing key. When the called extension answers, the calling lamp glows and the KX key associated with the extension is operated to complete the connexion. The operator then restores key KO and replaces the handset. Either extension can recall the switchboard by depressing the recall button on the extension telephone. An earth (on the fourth wire from the connexion box) is then extended to the C wire (the third wire) and the calling lamp glows while the recall button is pressed. When the call is completed and the extension handset is replaced, earth potential is extended via the auxiliary gravity-switch spring-set, SWA, to the C wire to give a clearing signal on the calling lamp via key contact KX3.

Extension-to-Exchange Calls

If the calling extension requests connexion to an exchange line the CONNECT EXCHANGE key, KE, of a free exchange line is operated. This disconnects the local 50-volt supply from the connecting circuit at contacts KE1 and KE2 and extends the extension to the exchange-line circuit. As relay CT is normally operated, earth via contacts CT1, KE1 and KX1, the extension-telephone loop, contacts KX2 and KE2, relay SA and contact CT2 operates relay SA to –50 volts. Contact SA1 operates relay SB and contact SB1 releases relay CT. Contacts CT1 and CT2 extend the circuit through to the exchange line. Capacitor C2 is connected across relay SA to provide a low-impedance speech path. The exchange-line connecting keys are arranged to prevent any exchange lines being connected together.

Incoming Call on an Exchange Line

Incoming ringing current on an exchange line will operate relay AC over one coil, via contact CT4 operated. Contact AC1 lights the calling lamp and contact AC2 completes a holding circuit for relay AC from an earth via contact CT3 (to provide a locked calling signal on the exchange line until the operator answers) and also operates the pilot relay, P. The circuit is arranged to ensure that, provided the ALARM ON key, KA, is operated, an audible alarm is given at the P.M.B.X. even if the exchange-line calling lamp becomes disconnected. The operation of relay AC is delayed by the short-circuit maintained across the hold coil by contact AC2. This avoids false operation due to line surges when switching takes place. False operation of relay AC can, however, occur under certain conditions if the A and B wires of the exchange line are reversed.

Specific safeguards have also been incorporated to avoid the possibility of lost calls due to misoperation of the switchboard keys. A calling signal is not extinguished (except when a headset is also provided) until the operator's handset has been lifted and both the KE and KO keys have been operated. When the call is answered by the operator, relay SA operates. Relay SA then operates relay SB, which releases relay CT. Contacts CT1 and CT2 extend the operator's telephone loop to the exchange line to trip the ringing if the incoming call is from an automatic exchange. Contact CT3 disconnects the holding circuit for relay AC, and contact AC1 extinguishes the calling lamp. The exchange call can

then be extended to an extension, as already described, or automatic holding conditions can be applied.

Automatic Holding of Exchange-Line Calls

When a call is answered, relay SB is operated by relay contact SA1; -50 volts, via contacts SB2 and KE3 operated, operates relay H to earth at contact KO4. Relay H locks to earth via contacts H3 and KX4 or to earth at the auxiliary gravity-switch, SWA, of the extension telephone if the extension key has been operated. Contact H1 prepares the holding loop across the exchange line, the loop being completed by contact KO1 when the operator restores the KO key to normal. Contact H2 lights the CALL HELD lamp. This lamp remains as a visual reminder to the operator that supervision of the switchboard is still required. If the line has been switched to an extension the holding circuit is released when the extension answers the call by the auxiliary gravity-switch contacts, SWA, opening. When the holding circuit is removed the CALL HELD lamp is also extinguished. The CALL HELD lamp is common to all connecting circuits.

If the operator wishes to release an exchange call without connecting it to an extension, the holding circuit to relay H is released at contact KE3 when the exchange key is restored. Although relay H is shown in Fig. 4 as a slow-to-operate relay, advantage is taken of its slow release, and in so doing further economy and space saving has been achieved by using 600-type relays instead of 3,000-type relays. The slow release of relay H is particularly important when the automatic holding circuit is used on circuits where line surges are prevalent.

Call Trap

When an exchange-extension call is completed the clearing signal is given on the extension calling lamp only when the extension telephone is replaced. Relay SA then releases and contact SA1 releases relay SB. Contact SB1 restoring to normal permits relay CT, the call-trap relay, to re-operate. Contact CT4 re-connects relay AC and capacitor C2 across the A and B wires of the exchange line, while contacts CT1 and CT2 disconnect the exchange line from the connecting circuit. Thus a follow-on incoming call will be trapped on relay AC and will not ring the extension telephone bell if the call has not been cleared-down at the switchboard.

Free-Link Signalling

A free-link signalling system, similar to the well-known free-line signal (F.L.S.) used on manual switchboards in main exchanges, has been provided to increase the speed of answer. This is particularly important with the P.M.B.X. No. 2/4A as there are 88 circuit keys to scan before selecting a free connecting link. The free-link signals are given by small amber-coloured lamps situated down the left-hand side of the face panel. Two lamps are provided for each row of keys, one for the upward movement and one for the downward movement. The circuit arrangement is shown in Fig. 5. Normally, all lamps are extinguished in the idle condition. As soon as an incoming call is received pilot relay P operates. Contact P1 lights lamp LPA and the operator answers the call using the A connecting link. When the A connecting link is taken into use the relay contacts LA1 and LA2 of the transmission-bridge relay operate and

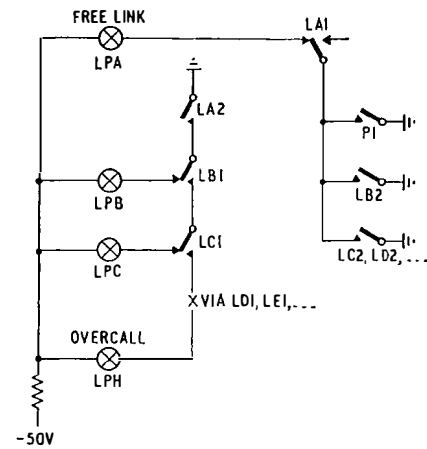


FIG. 5—FREE-LINK-SIGNALLING CIRCUIT ELEMENT

step the free-link signal on to lamp LPB to indicate that the B connecting link should be used for the next call.

The sequence is always the same, but if any link is taken into use out of turn the remaining lamps still glow in the same order, excluding the circuit taken out of sequence if it is still in use. When a circuit becomes disengaged the free-link lamp glows again if it is the first free link in the sequence. On exchange calls arrangements are made to operate the appropriate transmission-bridge relay although it is not used to provide the transmission feed. When all seven connecting links are engaged the eighth lamp, the OVERCALL lamp (LPH), glows. This indicates that all connecting circuits are engaged. Should any exchange or extension call then be received at the switchboard it can be answered on the overflow or overcall circuit.

Overcall

As mentioned above, overcall enables the operator to answer a call when all seven connecting links are engaged. The circuit is shown in Fig. 6. To answer an extension

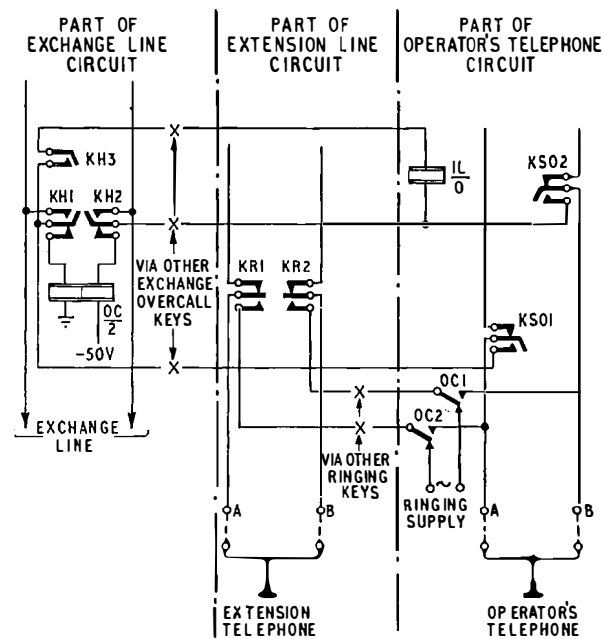


FIG. 6—OVERCALL CIRCUIT ELEMENT

call under these conditions the SPEAK ON OVERCALL key, KSO, is operated and relay OC feeds transmission current to the operator's telephone via contacts KH1 and KSO2, and contacts KSO1 and KH2. Relay OC operates, and contacts OC1 and OC2 changing over disconnect the ringing supply and extend the operator's telephone to the extension RING key, KR. The operator can now speak to the calling extension by holding operated the appropriate KR key. The KSO key must be restored before answering a normal call.

An exchange call is answered by operating the KSO key and the appropriate EXCHANGE OVERCALL key, KH, which locks in the operated position. Contacts KH1 and KH2 disconnect relay OC and connect the exchange line to the operator's circuit. The transmission feed for the operator's telephone is now supplied by the public exchange and contact KH3 connects bridging coil IL to provide a holding condition. This permits the operator to leave the circuit and offer the call to an engaged extension and then, if required, breakdown the connexion and extend the exchange call to the extension. When the call has been dealt with, keys KH and KSO are restored.

Mains Failure

As the switchboard has been designed to work from a mains-operated 50-volt d.c. power-supply unit, the circuits have been arranged so that the exchange-line service is maintained under mains-failure conditions. If a mains failure occurs, relay CT (Fig. 4) releases and contact CT4 connects the bell of the operator's telephone to the first exchange line so as to give an audible indication of an incoming call. The operator can answer the exchange call under mains-failure conditions by operation of the appropriate KE and KO connecting keys and by removing the handset from the operator's telephone. Outgoing exchange calls can also be originated by the operator in the normal manner. The operating instructions for these switchboards will advise the subscriber to connect the remaining exchange lines to selected extensions (as for night-service working) if a mains failure should occur, and the selected extensions will then have direct access to these exchange lines.

Press-Button Recall

Each extension telephone is provided with a press-button key (a make contact in parallel with the auxiliary gravity-switch spring-set) for recall purposes. Operation of the button connects earth potential (on the fourth wire) to the C wire (the third wire). Recall is available on all extension and exchange calls.

Night Service

Night-service arrangements are provided by the NIGHT SERVICE key, KNS, and relief relays that disconnect the pilot relay and the extension calling-lamps.

Key contact KNS3 releases relay CT, which disconnects the AC relay of each exchange line thus rendering the call-trap circuit ineffective. Selected extensions can be connected to the exchange lines by operating the appropriate KE and KX keys as required.

Two-Wire Extensions, Inter-switchboard Extensions and Private Circuits

Additional terminations have been provided on extensions 7-12 of the P.M.B.X. No. 2/3A and on extensions 10-18 of the P.M.B.X. No. 2/4A so that by suitable inter-connexions these extensions can be used for 2-wire extensions, inter-switchboard extensions or private circuits, without alteration to the permanent wiring of the switchboard.

When any of these facilities are required the connexions are made so that the switchboard controls the switching relays in the various auxiliary apparatus units to provide for automatic hold on 2-wire extensions and inter-switchboard extensions, or prohibition of exchange-line connexion to private circuits.

Provision is also made to control the relays in the 4-wire/2-wire conversion unit in order to provide through-dialling facilities on exchange calls. Should the operator enter the circuit on this type of connexion, spring-set SWB on the operator's telephone short-circuits resistor R on the control wire and operates a relay to provide transmission feed from the conversion unit to the extension. On extension-to-extension calls the divided transmission-feed arrangements are applied by earth from contact KE4 normal short-circuiting resistor R.

CONCLUSION

The P.M.B.X.s No. 2/3A and 2/4A incorporate new circuit design, provide better facilities, and should give greater reliability and ease of maintenance. These advantages, coupled with their improved appearance, should make them welcome substitutes for the switchboards they supersede.

ACKNOWLEDGEMENT

The authors wish to thank Ericsson Telephones, Ltd., who, as the liaison manufacturers, worked in close co-operation with the Post Office on these developments.

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