PRIVATE MANUAL BRANCH EXCHANGES

CONTENTS

[Figs. 14, 20, 21, 22, 23, 26 and 28 are appended to this pamphlet]

INTRODUCTION

Subscribers' installations involving a main instrument and several extensions are dealt with in E.P. Draft Series TELEPHONES 1/2. Where, however, the number of extensions exceeds one or two and particularly when intercommunication is required between the extensions it is necessary to install at the subscriber's premises either

(1) A House Exchange System

or (2) A Private Branch Exchange (P.B.X.)

(1) The House Exchange System, which is described in E.P. Draft Series TELEPHONES 1/3, caters for subscribers' installations having a maximum of two exchange lines and ten extension lines.

(2) A Private Branch Exchange (P.B.X.) may be a small local automatic system, or alternatively may consist of a manually operated switchboard. To differentiate between the two types, automatic installations are referred to as P.A.B.X's. i.e. Private Automatic Branch Exchanges (these are described in E.P. Draft Series TELEPHONES 1/5) whilst purely manual switchboards are known as P.M.B.X's. (Private Manual Branch Exchanges).

This pamphlet deals with the main types of P.M.B.X's. which are, at present, in use in the B.P.O.

P.M.B.X's. may be classified under three main headings, namely:-

(a) Cordless switchboards. These are small switchboards where switching is effected by means of keys. The boards are designed for installation on a table and are ideal for small offices where up to three exchange lines and nine extensions only are required.

(b) Cord type Non-multiple switchboards. These are large switchboards employing jacks and cord circuits. They are designed for installation on the floor. The smaller types requiring attachment to a wall, but the larger type are free standing.

(c) Cord type Multiple switchboards. These are boards for very large installations where three or more operating positions are required.

The types of circuit connected to a P.M.B.X. switchboard are as follows.

(a) Exchange lines. Lines terminated on a public exchange.

(b) Extension lines. Lines terminated on extension telephones either within the same building or in a remote building.

(c) Inter-switchboard extensions. Lines to another P.M.B.X. over which incoming exchange calls may be extended.

(d) Private wires. Lines, terminated on telephones, from which access to exchange lines is barred by electrical means. They may, however, be connected to other circuits on the switchboard.

(e) Inter-switchboard private wire. Lines between switchboards designed to carry traffic from private wires and extensions on one switchboard to similar circuits on the other switchboard. Access to exchange lines is barred electrically.

EXCHANGE LINE TRAFFIC

Incoming Calls

Normally, the exchange lines rented by a P.B.X. subscriber have consecutive numbers, and the first telephone number of the group is quoted in the telephone directory against a P.B.X. subscriber's name. At manual main exchanges the first exchange line of the group serving the P.B.X. is connected to the jack bearing this number on the subscriber's multiple, and the remaining lines in the group are connected to successive adjacent jacks numbered consecutively so that they form a complete group of lines. The fact that these jacks serve the same P.B.X. is indicated to the operators by means of a continuous distinctively coloured line painted immediately underneath the series. On receiving a call for a P.B.X. number, the operator tests along the group of jacks and connects to the first disengaged line. Where the main exchange is automatic this process of selection of a free line is done by a P.B.X. final selector.

When the connexion at the exchange has been made as described, a ringing current is sent to line, which operates an indicator on the branch exchange switchboard. The P.B.X. operator connects her telephone to the particular exchange line, speaks to the caller, and obtains from him the name of the person, the department, or the number of the extension with which he wishes to communicate. Having obtained this information, she makes the desired connexion and rings the extension.

Outgoing Calls

When the subscriber wishes to make a call from one of the extensions, it is only necessary to lift the receiver off the rest in order to signal the P.M.B.X. operator. The latter answers the call, and makes the connexion either to another extension or to an exchange line, as required.

SUPERVISORY SIGNALS

Positive and Negative Clearing

Double supervision is desirable, i.e., a separate signal for each subscriber connected, and whenever possible these signals should be positive in action, that is, the intimation should be conveyed to the operator by the appearance of a previously invisible signal, not by the disappearance of a previously visible one this is known as negative clearing.

Positive clearing is used on all smaller type switchboards where constant attention may not be possible, the supervisory signals are also connected to an audible alarm thus facilitating prompt disconnexion of finished calls.

Through Clearing

All modern P.M.B.X's. are arranged to give "through clearing" from the extension to the exchange i.e. on an exchange call when an extension replaces his receiver a clearing signal is given both to the P.M.B.X. operator and to the public exchange. This is essential for the proper timing of trunk calls (when the P.M.B.X. originates the call) as the automatic timing devices at the public exchange are controlled by the P.M.B.X. extension's telephone switch springs.

POWER SUPPLY

The smaller P.M.B.X's. are designed to operate with a power supply at a minimum voltage of 12 volts. The larger type of P.M.B.X. (P.M.B.X. No. 1A) works at a power supply voltage of 24 volts. The usual methods of providing power are as follows:-

(a) Power lead. This consists of one or more bunched pairs connected to the main exchange battery via counter-e.m.f. cells. The return is by an earth connexion at the P.M.B.X.

(b) Accumulators floated from a power lead. This method is more economical in the use of cable pairs as the lead has only to supply the average instead of the peak current.

(c) Accumulators floated by a rectifier from a.c. mains.

(d) Primary cells.

Ringing supply

Ringing current to enable the P.M.B.X. operator to call the extension can be supplied by one of the following methods,

(a) a hand generator fixed on the switchboard,

(b) a feed from the main exchange over a circuit known as a 'ringing lead',

(c) a static ringing converter, this is a circuit arrangement for producing ringing current at a frequency of 25 c/s from the 50 c/s public mains supply,

(d) a ringing current generating machine driven either by the public mains supply or the power supply of the P.M.B.X.

The method employed depends on the size and type of the P.M.B.X. and the volume of the traffic handled. In any case, a hand generator is provided on the switchboard as a standby.

TRANSMISSION BRIDGE

The transmission bridge on smaller type P.M.B.X's. consists of battery and earth which is supplied via a two winding impedance coil and is used only on extension to extension calls. Such a bridge is only suitable for use where the extension lines connected are of approximately the same resistance, (as they are in the case of a small P.M.B.X.) otherwise the low resistance line would take a large current at the expense of the high resistance one. A higher standard of transmission than that obtained with this arrangement is required for extension to exchange calls. To this end, the connecting circuits are so arranged that an extension station connected through to an exchange line draws current for exciting its transmitter direct from the transmission bridge at the main exchange.

NIGHT SWITCHING

All P.M.B.X's. provide facilities for extending selected extensions to the exchange lines during the night time and weekends when the P.M.B.X. switchboard is not staffed. Under normal conditions, if a call is already set up then a clearing signal is given at the P.M.B.X. when the handset of an extension is replaced on the rest. In the event of an extension being switched through to the exchange for these pre-determined periods, then during the times when the extension handset is on its rest the associated supervisory indicator will be operated. This is unnecessary and undesirable (from a power wastage point of view) and keys known as night service keys are provided which, when operated, disconnect the supervisory indicators and local transmission bridge under these conditions.

SWITCHBOARD DESIGNATION

In the B.P.O., non-multiple type switchboards are designated by a fractional index indicating

(1) the number of exchange lines

(2) the number of wired extensions

(3) the ultimate number of lines (exchange and extension) which could be fitted

$$\text{eg. } \frac{3+7}{12} = \frac{\text{equipment for 3 exchange lines + 7 extensions}}{\text{ultimate capacity of 12 lines (exchange + extensions)}}$$

CORDLESS TYPE SWITCHBOARDS

GENERAL

There are four standard cordless type switchboards namely $\frac{1+3}{4}$, $\frac{2+4}{6}$, $\frac{3+7}{12}$ and $\frac{3+9}{12}$. They are all of the same appearance and differ only in the number of lines and connecting links. Fig. 1 illustrates the $\frac{3+7}{12}$ type switchboard.

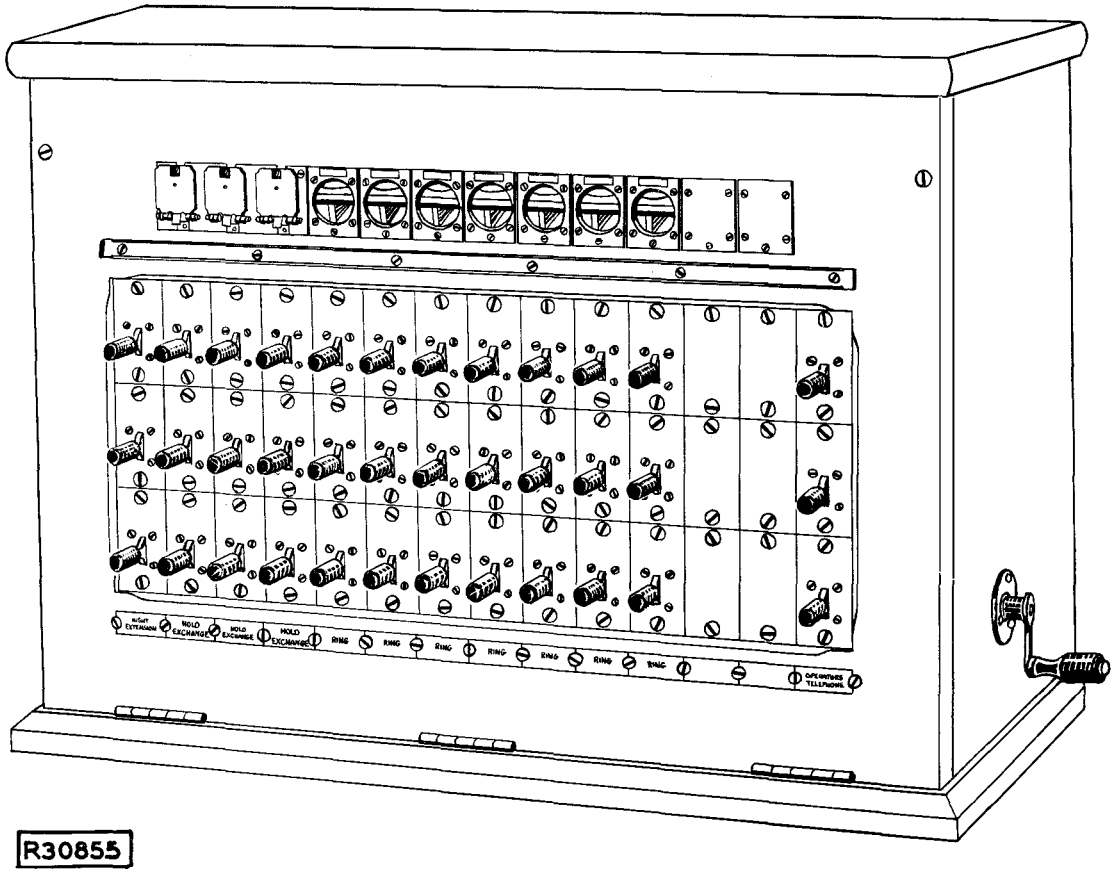


Fig. 1

Operating features - Each line is connected to an indicator and to a number of keys in a vertical column below the indicator. The operating telephone is also connected to a similar column of keys on the extreme right of the switchboard.

The keys in the bottom horizontal row are individual ringing keys for the extensions and holding keys for the exchange lines. The keys in the other rows are commoned horizontally to form separate connecting circuits for each row; consequently the movement in the same direction of any two keys in the same row connects together the two lines concerned.

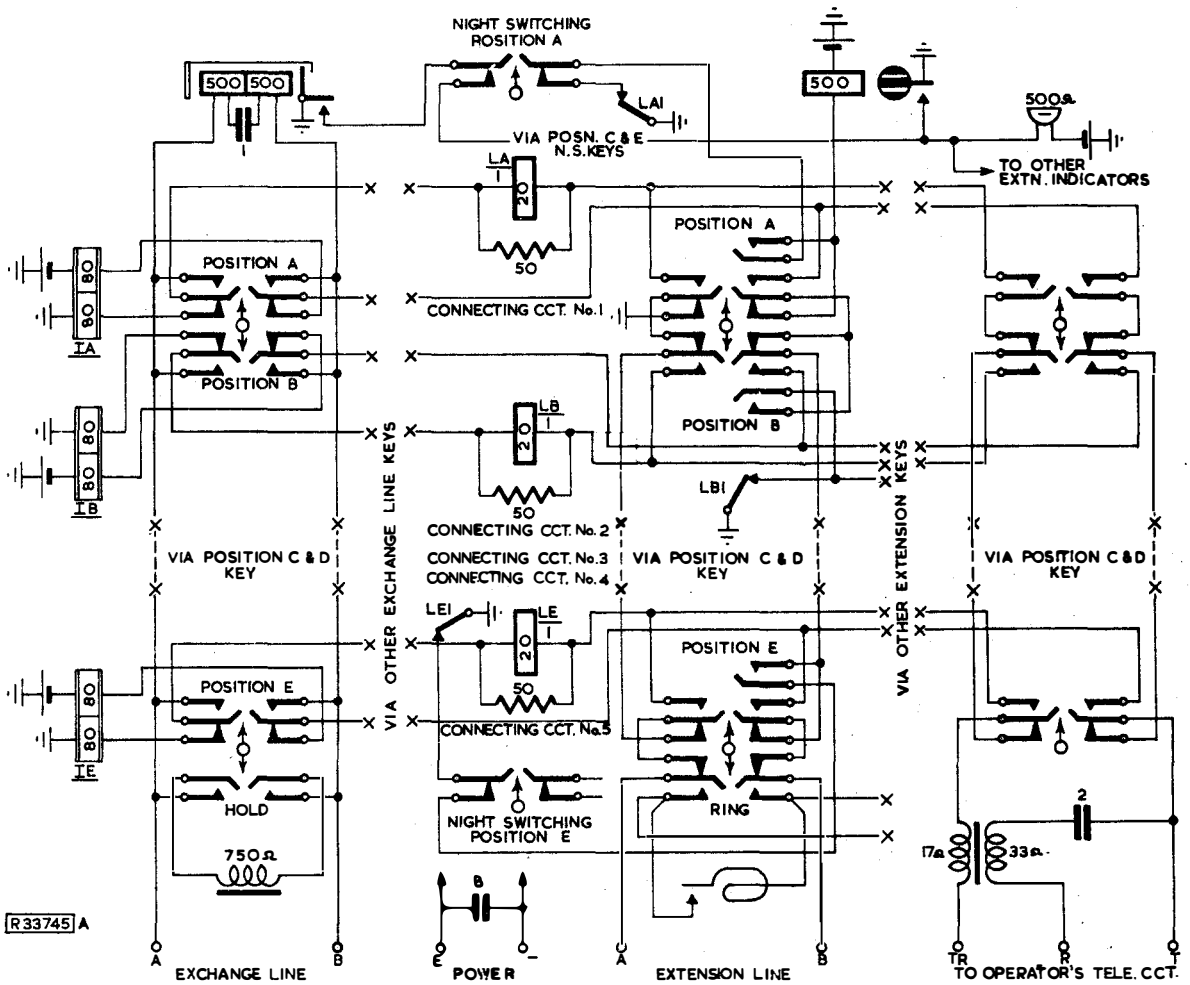
When a connexion is established, positive supervisory signals with an audible alarm are provided by the relevant extension indicators. On an extension to extension connexion the clearing signal is given only when the handsets of both extensions are replaced. On an extension to exchange connexion, the clearing signal is given on the extension indicator at the P.M.B.X. and at the main exchange simultaneously.

Night service - On certain of the connecting circuits, NIGHT SWITCHING keys are provided which disconnect the local circuits of the supervisory relays and cut the audible alarm from the exchange line indicators. The operation of one of these keys enables the corresponding connecting circuit to be used for connecting any extension to any exchange line for night service. In C.B. manual areas no special apparatus or connexions are necessary on extensions with night service, but, in an automatic area, a dial is necessary on each extension requiring direct night service to the main exchange.

CIRCUIT DESCRIPTION

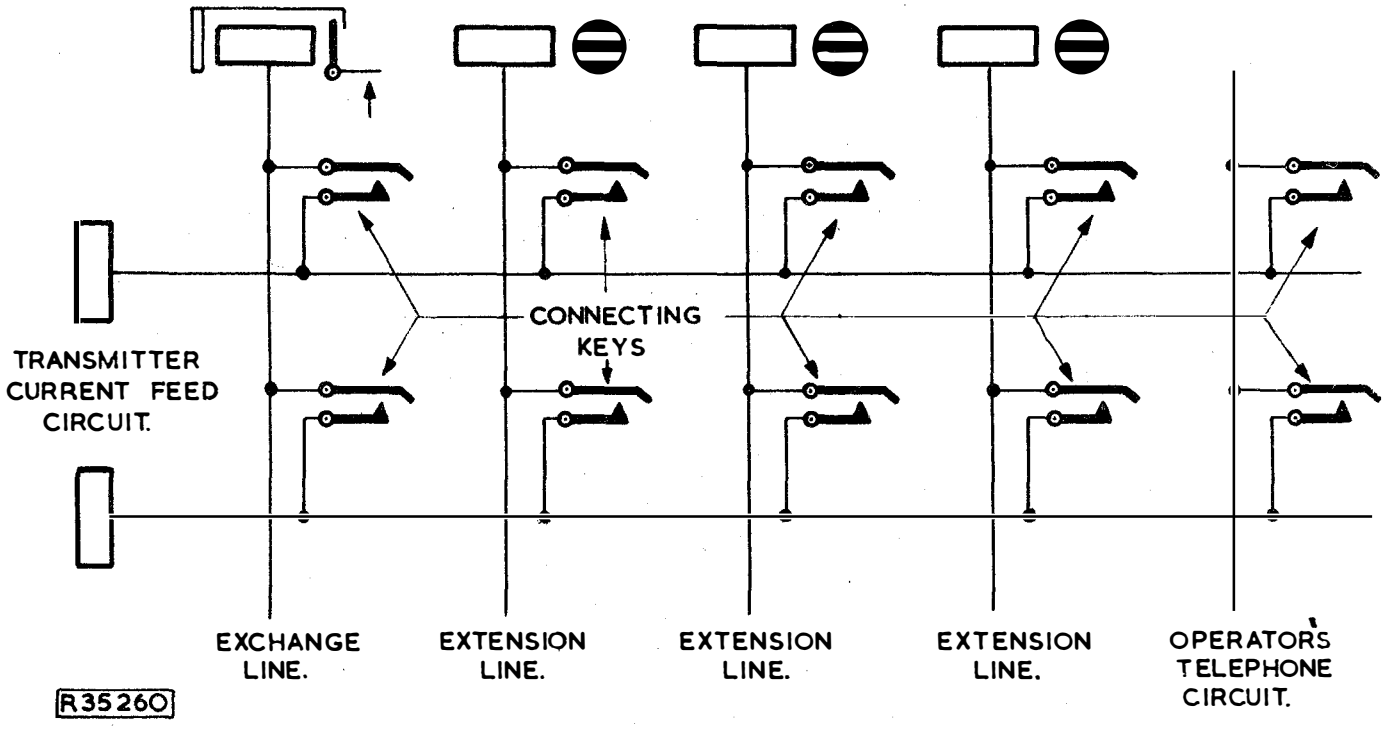
The cordless switchboards described in this section are suitable for use in C.B. or automatic areas. No description is given of similar switchboards used in local battery areas i.e. C.B.S. and Magneto.

The circuit arrangement of a $\frac{3+7}{12}$ or $\frac{3+9}{12}$ P.M.B.X. cordless switchboard is shown in Fig. 2(a). Provision is made for five simultaneous connexions, three of which, have night service facilities (these keys can be seen in Fig. 1). The $\frac{1+3}{4}$ and $\frac{2+4}{6}$ switchboard circuit arrangements are similar but only 2 and 3 connecting circuits with the corresponding number of key positions, are provided respectively.



(a)
Fig. 2

The 80 + 80Ω retard coils in each link circuit provide the simple transmission bridge for extension to extension calls. The circuit is so arranged that the operation of any exchange line key cuts off the transmission bridge from the link.



(b)

Fig. 2

A simple trunking diagram of a $\frac{1+3}{4}$ cordless type switchboard is shown in Fig. 2(b). This should give the reader an appreciation of the circuit layout of this type of switchboard which is given fully in Fig. 2(a). Operation of a key merely connects that particular extension or exchange line to a common pair of wires to which any other extension or operator's telephone may be connected.

Extension to Extension Calls

An extension calls the switchboard by the removal of the handset from its rest extending a loop through the various connecting keys to the earth and battery (see Fig. 3), a current thus flows in the completed circuit which, energizes the

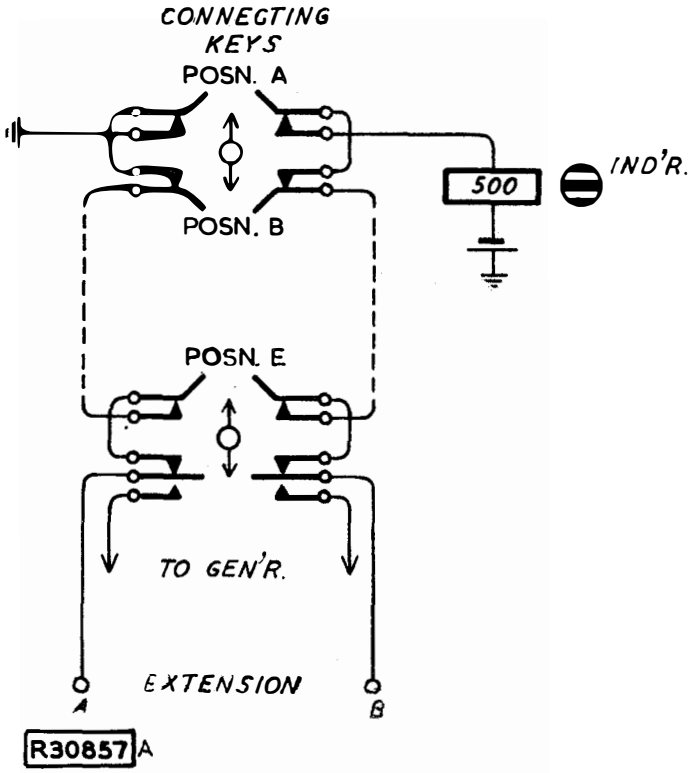


Fig. 3

calling indicator. The P.M.B.X. operator answers the call by throwing the appropriate extension key and corresponding operator's telephone key in the same direction. The required extension is then rung by depressing the non-locking key (associated with the extension) in the bottom row of keys and turning the hand generator. When the called extension answers, the applied loop causes the operation of the extension indicator on the switchboard and the operator throws the corresponding extension key in the same direction as that of the calling extension. This disconnects the indicator which releases and the two extensions are able to converse. The 80 + 80Ω retard coil provides the transmission bridge as previously mentioned. The circuit conditions when the extensions are switched through to each other are shown in Fig. 4. The operation of either extension line indicator is under the control of the supervisory relay contact LA1 and consequently, a positive supervisory signal is given only when the handsets of both extension telephones have been replaced. From this it follows that it is not possible for one of the extensions to flash the P.M.B.X. operator.

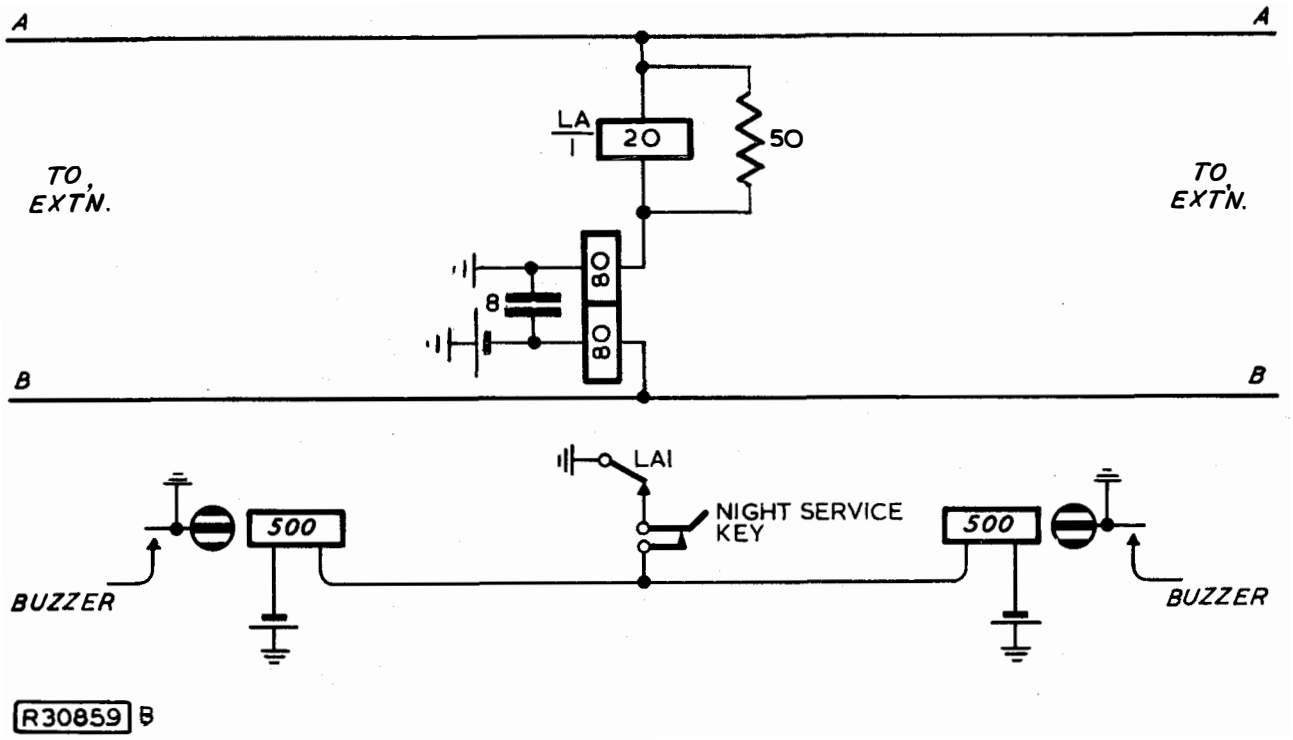


Fig. 4

Extension to Exchange Calls

An extension calls the switchboard in the normal manner and the P.M.B.X. switchboard operator obtains the required number by using the operator's telephone circuit. The calling extension is then switched through to the exchange line by throwing the corresponding exchange line key in the same direction as the extension line key. Alternatively the operator may switch the extension straight through to the exchange line allowing the extension to obtain the required call himself.

For incoming calls, ringing current is received over the exchange line which is terminated by a drop type indicator in series with a capacitor (see Fig. 1). The flap of the indicator drops, attracting the attention of the operator. The required extension is rung and connected in the same manner as previously described. Fig. 5 shows the circuit conditions of an extension connected through to the exchange. The P.M.B.X. transmission bridge is disconnected at the exchange line key, the current for energising the extension telephone transmitter is drawn from the main exchange battery.

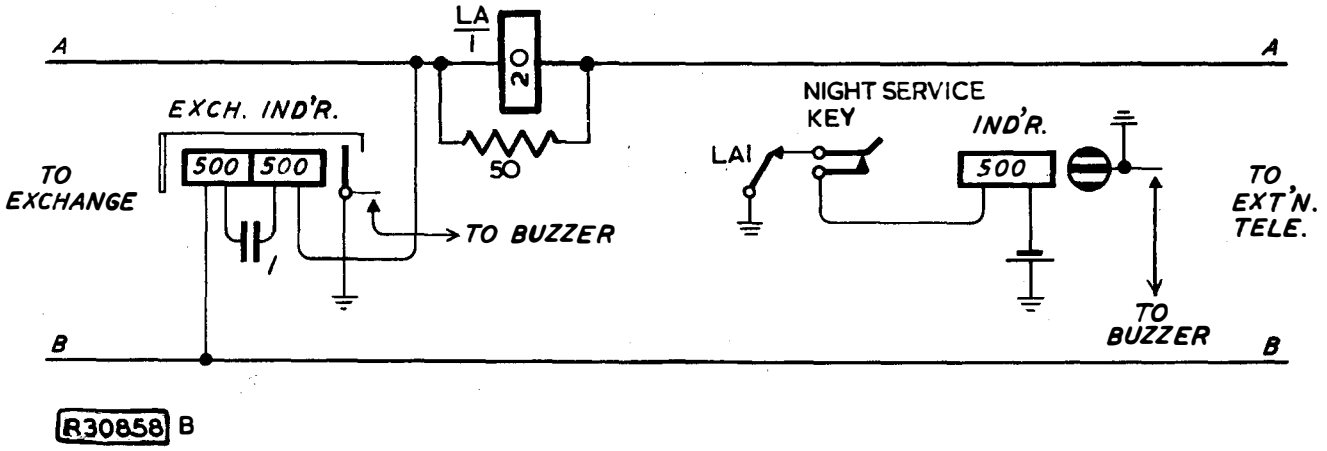


Fig. 5

It will be seen that the supervisory relay is connected in series with the A-wire of the connecting circuit. When the extension handset is replaced, the circuit for this supervisory relay is broken and the relay releases. Contact LA1, on releasing, operates the extension indicator and thus gives a clearing signal to the P.M.B.X. operator. At the same time the disconnexion gives the necessary, supervisory signal to the main exchange equipment.

Power Supply

As mentioned previously the cordless type board is designed to operate at a busbar voltage of 12 V. This is obtained by either a battery of primary cells or a power lead from the exchange. Both these sources present a considerable impedance at speech frequencies and for this reason it is usual to connect a large value of capacitance across the P.M.B.X. busbars to prevent overhearing (see Fig. 2).

NON-MULTIPLE CORD TYPE SWITCHBOARDS

The largest cordless type board is the $\frac{3+9}{12}$ - the advantages of a larger type board of this type are far outweighed by the complication involved in design. For larger installations cord type boards are installed. The following cord type boards are the standard sizes which are used by the B.P.O.

$$\frac{5+20}{25},\quad \frac{10+30}{65},\quad \frac{10+50}{65},\quad \frac{10+60}{180}$$

For larger P.M.B.X's the standard switchboard now installed is the P.M.B.X. No. 1A; this type of switchboard supersedes the C.B. Multiple No. 9 of which there are still a considerable number in existence thus warranting their description in this pamphlet.

SWITCHBOARD $\frac{5+20}{25}$

General

A picture of a $\frac{5+20}{25}$ switchboard is shown in Fig. 6. The switchboard is intended to be fixed against a wall and fixing plates are fitted, as shown, at the top of the board. The front of the switchboard is hinged on the left hand side and is divided in two to provide access to the interior.

The 25 extension indicators are of the 'dolls eye' type and the 5 exchange line indicators are of the drop type.

The circuit arrangements are very similar to those of the cordless board with positive clearing on the line indicators, i.e. the extension calling signals are also used as supervisory signals when an extension is connected. This feature is an advantage, since a board of this size may not warrant the undivided attention of the operator, and all the signals, being in the face of the board, can be seen from a distance. The figure shows the operator's handset resting on a switchook on the left hand side of the front of the switchboard. The contacts of the switchook complete the night alarm circuit when the handset is on the switchook (see Fig. 7). The night switching keys are fitted immediately above the indicator panel as shown.

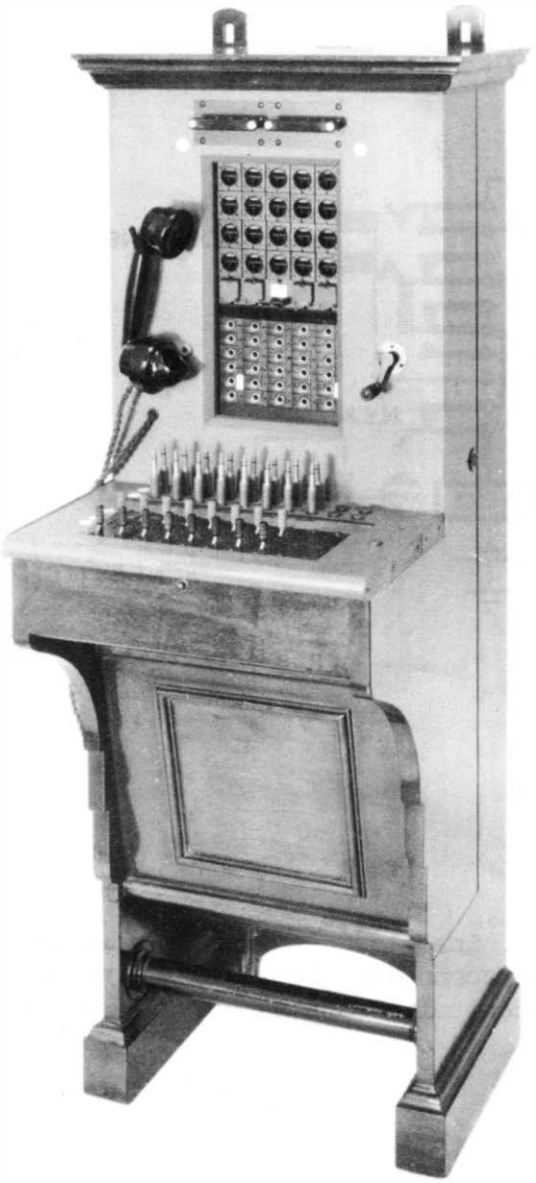


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Fig. 6

CIRCUIT DESCRIPTION

Extension to Extension Calls

The extension line circuit is shown in Fig. 7. When the handset is removed at the extension the telephone loop completes a circuit to operate the calling indicator as follows.

Earth - jack springs - supervisory relay A - telephone loop - jack springs - night service key - calling indicator - battery.

The extension indicator contact, when operated, connects an earth to operate the night alarm bell if the P.M.B.X. operator's handset is on the receiver rest.

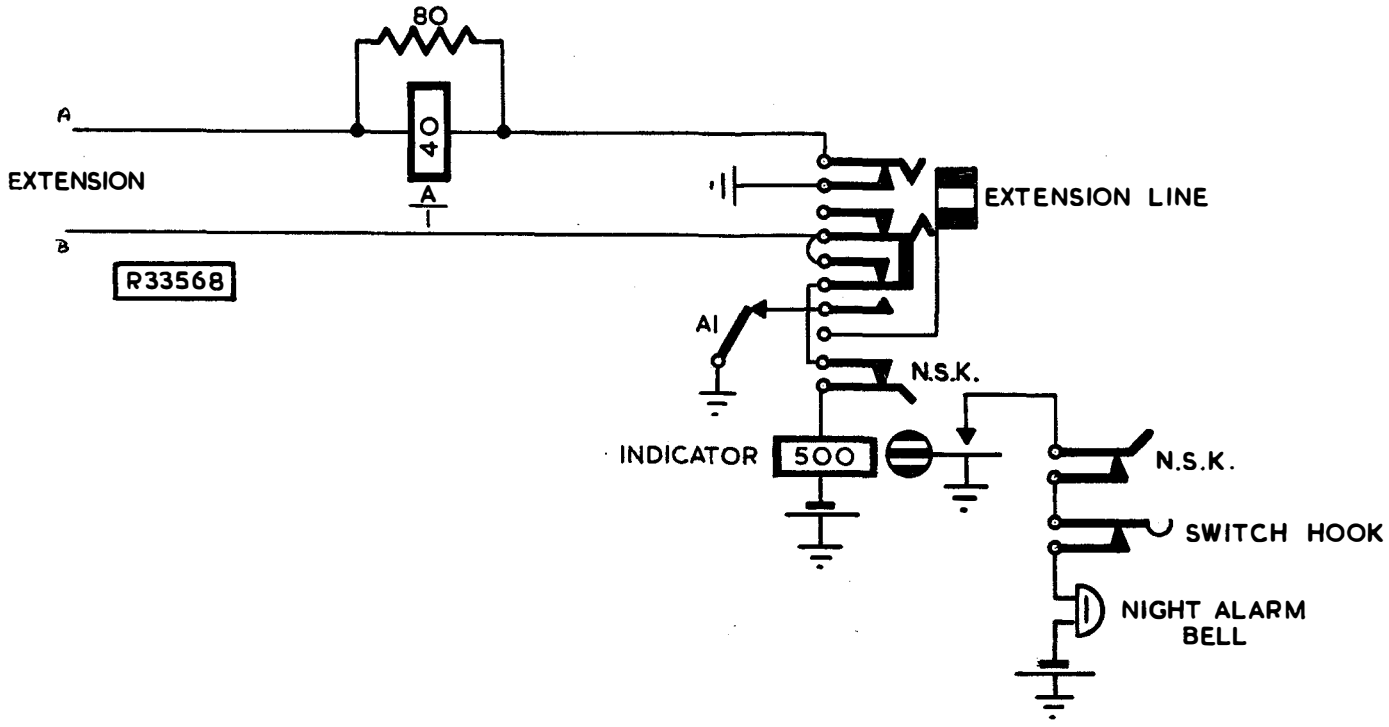

Fig. 7

On answering the call, the P.M.B.X. operator, inserts an answering cord into the corresponding extension jack. This action disconnects the indicator which releases, at the same time placing it under the control of the supervisory relay contact A1.

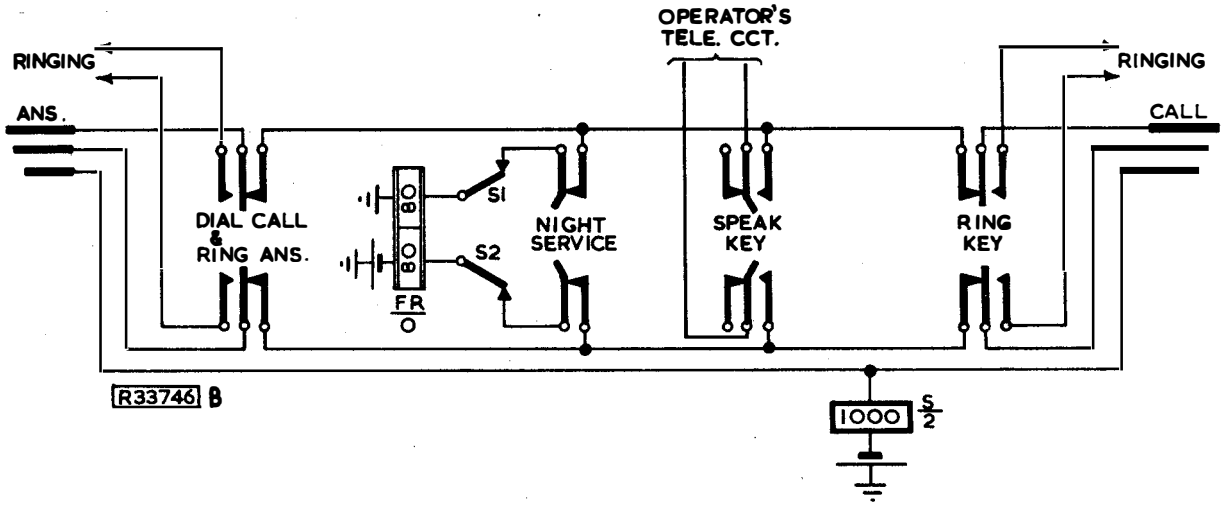

Fig. 8

Fig. 8 shows a diagram of the cord circuit in use on this type of switchboard. On extension to extension calls relay S does not operate. Earth and battery are fed via the impedance coil FR and S1 and S2 respectively to the tip and ring of the answering and calling cords, thus providing the transmission bridge. The calling cord is then inserted into the required extension's jack, and the extension rung by operation of the ring key and turning the generator handle. The insertion of the calling cord causes the operation of that extension line indicator (the line indicators give the supervisory signals) via earth - contact A1 (normal) - jack springs - night switching key - line indicator - battery. When the called extension answers, relay A in the required extension's line circuit operates to the telephone loop and contact A1 will disconnect the circuit of the indicator which restores.

Exchange to Extension Calls

If an extension requires an exchange line call then the calling cord is inserted into an exchange line jack. The circuit of the exchange line termination is shown in Fig. 9.

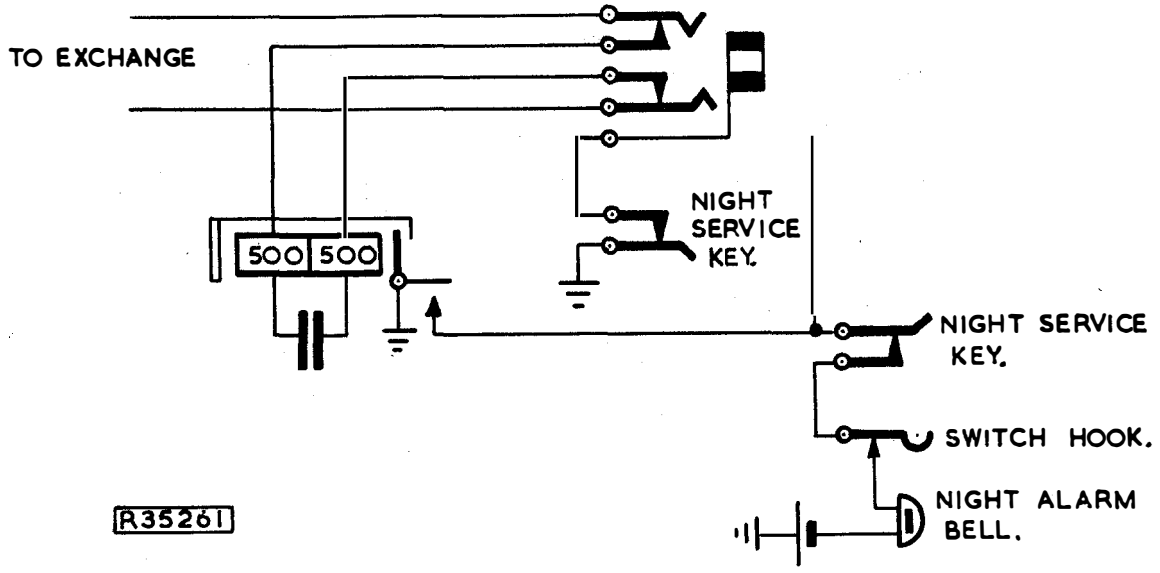

Fig. 9

The bush of the exchange line jack is connected to earth via the night switching key and thus a circuit is completed for relay S which operates. Contacts S1 and S2 disconnect the local transmission bridge as speaking current is provided by the main exchange. When the P.M.B.X. extension clears, the disconnexion of the telephone loop releases the supervisory relay A and A1, in restoring, energises the extension calling indicator thus giving a supervisory signal to the P.M.B.X. operator. At the same time the disconnexion of the extension telephone loop releases the automatic equipment at the exchange or in the case of a manual exchange releases the supervisory relay thus giving a clear to the operator.

The circuit operation of an incoming exchange line call is similar, with respect to supervisory conditions, to that previously described except that the answering cord is inserted into the exchange line jack and the calling cord is inserted into the extension jack. In this case when the extension clears the disconnexion of the loop releases the supervisory relay in the final selector at the main exchange giving a C.S.H. condition (auto) or causing the calling cord supervisory lamp to glow (manual).

Night Service

Night switching keys are mounted above the extension line indicators as seen in Fig. 6. These keys are thrown when any chosen extension is left connected to any exchange line for night service by means of a pair of cords. Examination of the diagrams show that the operation of the night switching key results in disconnexion of the:-

(1) Extension indicator.

(2) Earth on the bush of all exchange line jacks.

(3) Audible alarm bell.

(4) Local transmission bridge from all cord circuits and

(5) P.M.B.X. operator's telephone circuit.

Operator's Circuit

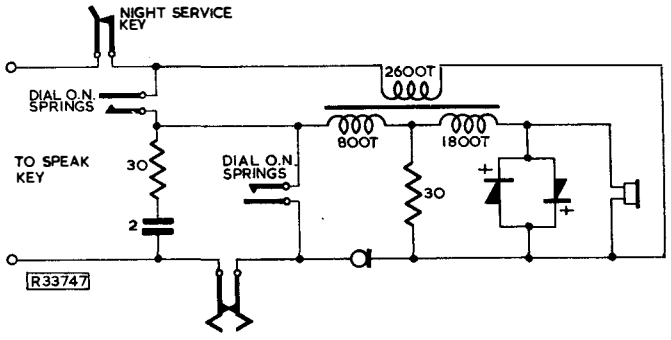

Fig. 10

Fig. 10 shows the circuitry of the operator's telephone circuit. The rectifiers across the receiver are to prevent the operator receiving acoustic shocks. The dial circuit is rather unusual in that the dial off-normal springs are connected in series with the pulsing springs while pulsing is taking place. It will also be observed that before dialling can take place the SPEAK key, the DIAL CALL and RING ANSWER key have to be operated. The operation of this latter key, which is non-locking, disconnects the answering cord thus preventing the calling extension telephone loop from shunting the dialled pulses. Further examination of the cord circuit diagram shows that dialling can only take place from the calling cord.

Power Supply

Either secondary cells or primary cells may be used as a source of power for this type of board. The board is designed to work at a minimum battery busbar voltage of 12 volts. If primary cells are used then 15 cells are provided. A trickle charge plant is installed if secondary cells are used.

DOUBLE CORD BOARDS $\frac{10 + 30}{65}$, $\frac{10 + 50}{65}$ and $\frac{10 + 60}{180}$

General

A larger type of floor pattern non-multiple switchboard is available when the traffic requirements are such that a $\frac{5 + 20}{25}$ would be too small for satisfactory

working. There are three sizes namely $\frac{10 + 30}{65}$, $\frac{10 + 50}{65}$ and $\frac{10 + 60}{180}$. The first two have an ultimate capacity of fifteen exchange lines and fifty extensions. The latter type has a maximum capacity of twenty exchange lines and 160 extensions. Access to the interior of these boards, for maintenance purposes, is obtained through the removable rear panel; it is essential therefore to leave a space behind the switchboard for the purpose of accessibility. There is no projecting apparatus on either side of any of these switchboards and it is therefore possible to install two sections in a continuous line Fig. 11 gives a picture of a $\frac{10 + 30}{65}$ switchboard, the $\frac{10 + 50}{65}$ is similar but has two additional rows of extension indicators and jacks.

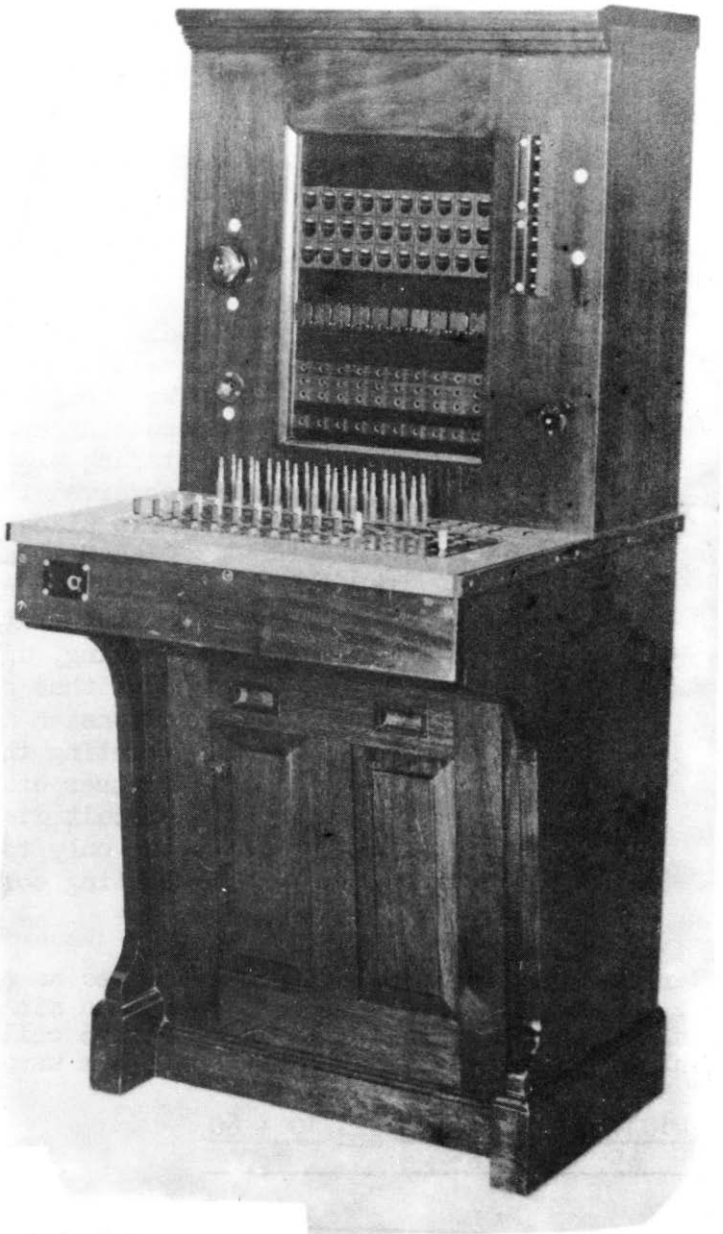

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Fig. 11

On the $\frac{10 + 60}{180}$ switchboard, the position of the extension and exchange line jacks are reversed and the strip of jacks associated with the exchange lines is fitted above the extension jacks and immediately below the corresponding exchange line indicators.

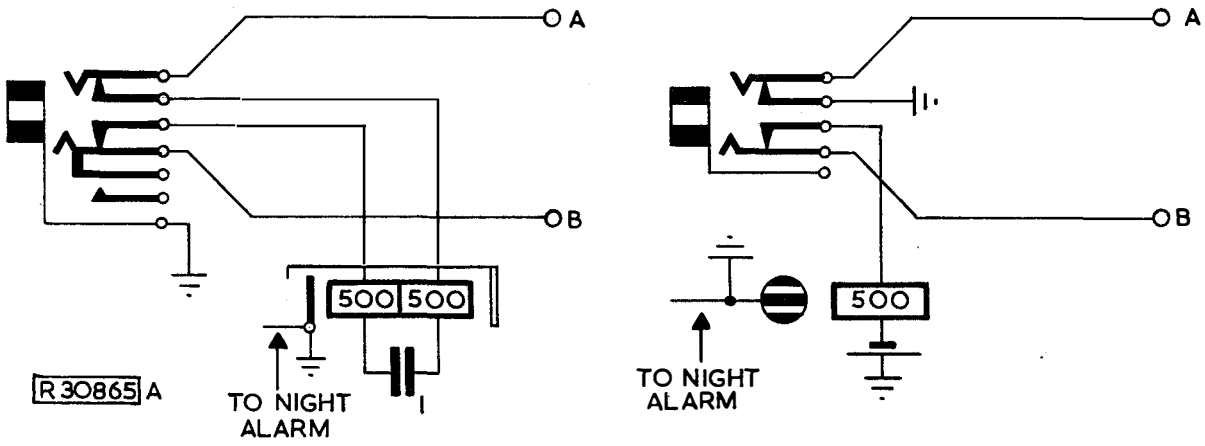
The main difference between these larger capacity switchboards and the $\frac{5 + 20}{25}$ and cordless switchboards is the arrangements for supervisory signals. On these larger type switchboards separate supervisory indicators are provided for both answering and calling cords of each cord circuit and are fitted in the space between the speak keys and the cords. The supervisory signals are "negative" in operation - this means that the indicator flaps are visible whilst a call is in progress and disappear at the termination of a call. This is the reverse of the normal supervisory signals used by the B.P.O. i.e. as used on the cordless and 25 line switchboards. The negative type of signal is employed to avoid the provision of additional apparatus which the provision of a "positive" signal would involve on these boards.

The extension and exchange line indicators are of the doll's eye and drop type respectively and the usual speak ring and ring back/dial keys are provided.

CIRCUIT DESCRIPTION

The circuitry for all three types of switchboard is identical in most respects and only one circuit description is given in the following paragraphs.

The exchange line and extension circuit terminations are shown in Fig. 12.



EXCHANGE LINE CIRCUIT EXTENSION CIRCUIT

Fig. 12

Loop calling is used between extension and P.M.B.X. and on incoming exchange line calls ringing current is fed through the indicator via the capacitor. Extension and exchange line signalling is thus identical to the smaller type boards.

Fig. 13 shows the diagram of the cord circuit used on this type of board.

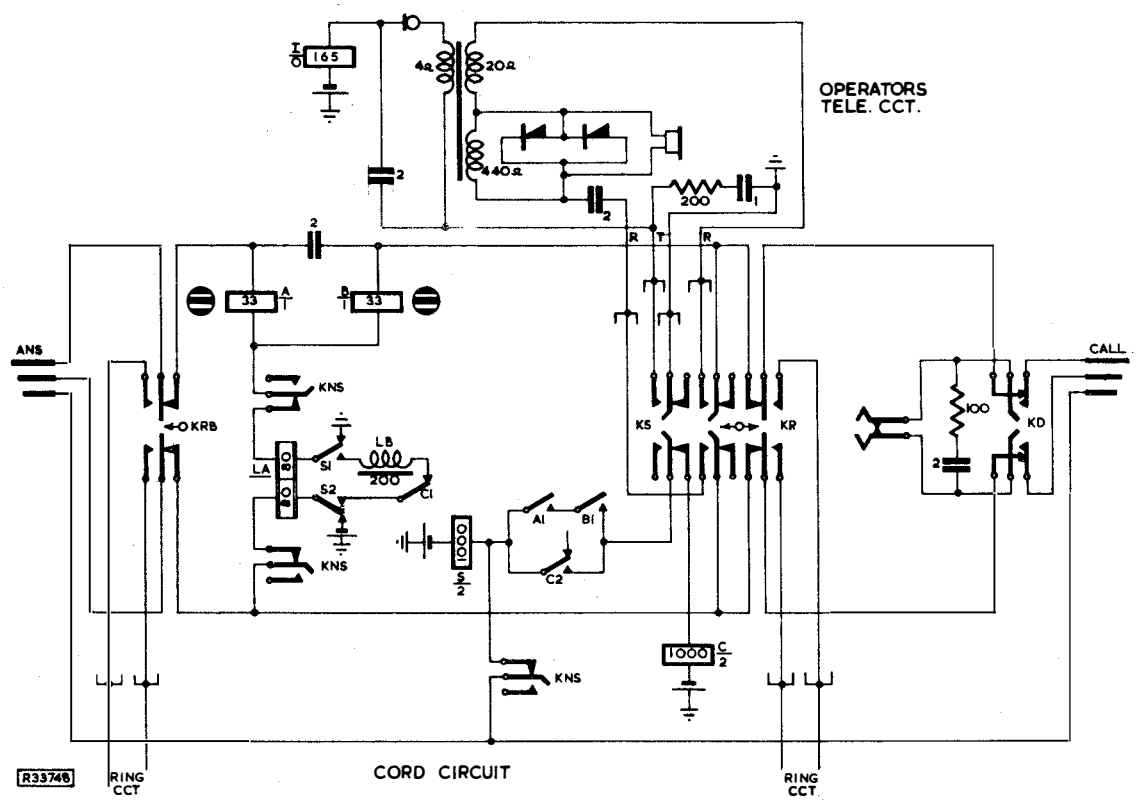


Fig. 13

Extension to Extension Calls

As mentioned previously an extension signals the P.M.B.X. switchboard by removing his handset and extending his telephone loop to the earth and battery of the extension termination thus operating the line indicator. The insertion of the answering cord into the extension jack disconnects the indicator which releases. After ascertaining the extension required, the calling cord is inserted into that jack, and the ring key is operated. Relay S remains unoperated and the local transmission bridge of the cord circuit is used via S1 and S2 contacts normal. With both extensions in conversation, supervisory indicators A and B are both operated by the respective telephone loops so that both indicator flaps will be showing. When both extensions replace their handset, both indicators release and the operator removes the cords. The 2 μF capacitor provides a path for speech currents across the two high impedance supervisory indicators.

Extension to Exchange Calls

When either the answering or the calling plug is inserted into an exchange line jack the sleeve relay S is operated. Contacts S1 and S2 remove the earth and battery from the tip and ring connexions of the plugs and substitute a loop via C1 and the 200 ohm bridging coil LB.

When the call is in progress, current from the main exchange flows through the two supervisory indicators. When the latter are both operated, contacts A1 and B1 complete a circuit for relay C. Contact C2 provides a holding circuit for C and C1 disconnects the 200 ohm bridging coil from the tip and ring of the cord circuit. The operation of the SPEAK key KS disconnects relay C so that the line is bridged by the 200 ohm coil when the operator is in circuit.

From the above it will be seen that on exchange calls:-

(a) The speaking current is obtained from the main exchange.

(b) A loop is maintained across the line from the time the cord is inserted at the P.M.B.X. until the extension clears.

(c) The called (or calling) extension controls both supervisory indicators at the P.M.B.X. and also the supervisory at the main exchange.

Night Service

The night switching keys are mounted by the side of the extension line indicators as shown in Fig. 11. The arrangements for night switching are the same as those for a $\frac{5 + 20}{25}$ switchboard i.e. the night switching keys disconnecting

(1) the local transmission bridge

(2) operator's telephone circuit

(3) the sleeve circuit of the cord circuit.

It should be noticed that in this type of board, for normal working, there is no audible alarm for exchange and extension line indicators. Such an alarm is only provided by means of a tumbler switch (fitted on the left hand side of the front of the board). There is no audible alarm provided on the supervisory indicators.

Operator's Circuit

The operator's circuit is shown in conjunction with the cord circuit in Fig. 13. The telephone circuit is of modern design. The 1 μF capacitor and 200Ω resistor provide a spark quench circuit for the speak key contacts. It will be observed that the operator's transmitter circuit is completed only when a speak key is thrown this providing an economy in power consumption.

A dial key KD is incorporated with the ring back key KRB - the locking position gives dialling facilities and the non-locking position gives ringing facilities on the answering cord.

The insertion of the calling cord into an exchange line jack extends a loop forward to the main exchange equipment in the normal way. The operation of the DIAL key KD disconnects the calling cord from the cord circuit and extends it to the dial pulse contacts. Make before break contacts are fitted on the dial key so that the throwing of the key does not cause a momentary disconnexion on the exchange line thus giving a false pulse to the selector.

Power Supply

The power supply details are similar to those of the $\frac{5 + 20}{25}$ switchboard. The board is designed to work at a minimum battery busbar voltage of 12 volts. Primary or secondary cells may be installed but if primary cells are provided, two sets of 15 cells are connected in parallel. If secondary cells are used the usual trickle charge plant is fitted.

MULTIPLE-TYPE CORD SWITCHBOARDS

As mentioned previously there are two types in general use namely the C.B. Multiple No. 9 and the P.M.B.X. No. 1A the latter now supersedes the former for all new work but in view of the number of C.B. Multiple No. 9 switchboards still in existence a short description is given in this pamphlet.

C.B. MULTIPLE NO. 9 SWITCHBOARD

General

As the title suggests this is a multiple type switchboard, the complete switchboard being made up of one position sections placed in line forming a continuous multiple field.

There are no local jacks as usually understood, all calls being answered from the multiple. No I.D.F. is provided, and it is necessary, therefore, to arrange the calling signals initially in a suitable manner for the traffic needs. The calling signals are fitted above the jack multiple, the usual arrangement of the switchboard face equipment is shown in Fig. 14 (appended).

The extension line jacks, in strips of 20, are the lowest on the jack panels and are multipled every fourth panel. Above these are the exchange line jacks in strips of 10, multipled similarly. Fitted above the jacks are the extension calling signals in strips of 20. Finally, above these, are the exchange line calling indicators in strips of 10. Doll's-eye type indicators are used for the extension calling signals and for the exchange line signals.

The calling equipment is usually arranged so that the jack multiples occur on the same section as the calling signals. Cables are run from the main frame to the first multiple jacks, thence jack to jack, and are terminated on tags at the rear of the last (or last two) sections. The calling equipment is cabled to tags on the appropriate sections. The tags are connected together by cable according to the traffic requirements, in blocks of strips of calling signals. Individual line jumpering is not necessary as no separate answering jacks are fitted. For tie lines and private wires, exchange line jacks and calling equipments are generally utilized. On the keyboard, capacity exists for 17 sets of cord circuits. The cord circuit relays, retardation coils, etc., are fitted in the rear of the sections. Extra equipment for long lines, tie lines, private wires, etc., as necessary, is fitted on a separate relay rack.

CIRCUIT DESCRIPTION

The extension line circuit, cord circuit and exchange line circuit are shown in Figs. 15, 16 and 17. Signalling on extension and exchange lines is the same as on the $\frac{10 + 50}{65}$ P.M.B.X's previously described.

It will be observed that the cord circuit is very similar to the one shown in Fig. 13 and that negative clearing is again adopted.

Extension to Extension Calls

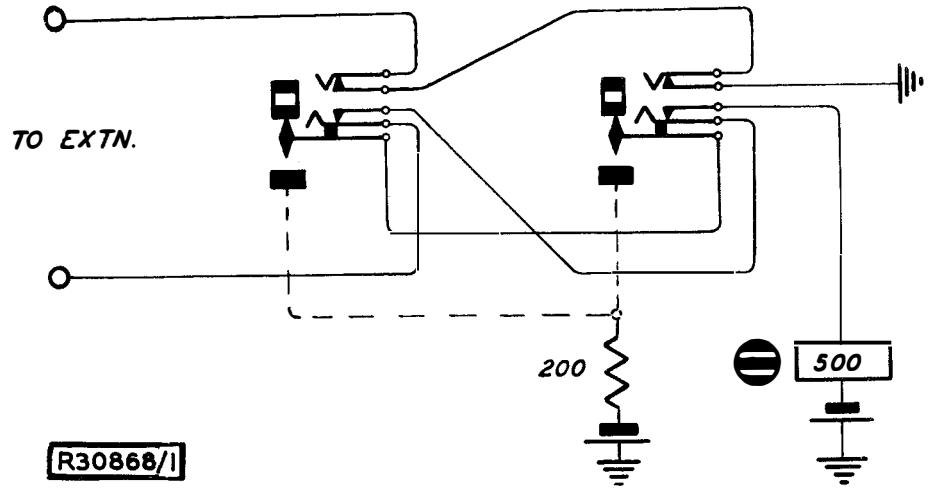


Fig. 15

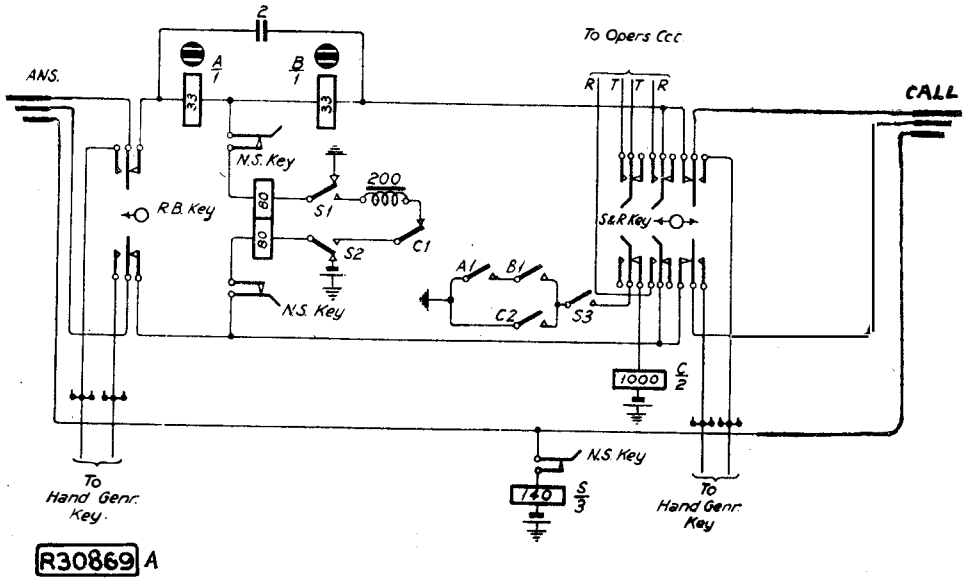


Fig. 16

The extension calls the P.M.B.X. operator by extending his telephone loop to the earth and battery fed A and B wires. This completes the circuit for the doll's eye indicator and the latter operates. Insertion of the answering cord into the jack disconnects the circuit of the indicator which releases. The calling cord is inserted into the required extension jack (after making the 'engaged' test) and the ringing key operated to connect ringing current to ring the extension's bell. The sleeve relay S is not operated and battery and earth is supplied to both the answering and calling cords via the normal contacts of relay S and 80 + 80Ω retardation coil. The two supervisory indicators, A and B, which are in series with the tip connexions of the answering and calling cords respectively are controlled independently by the respective extension telephone loops.

Extension to Exchange Calls

Fig. 17 shows a diagram of the exchange line termination.

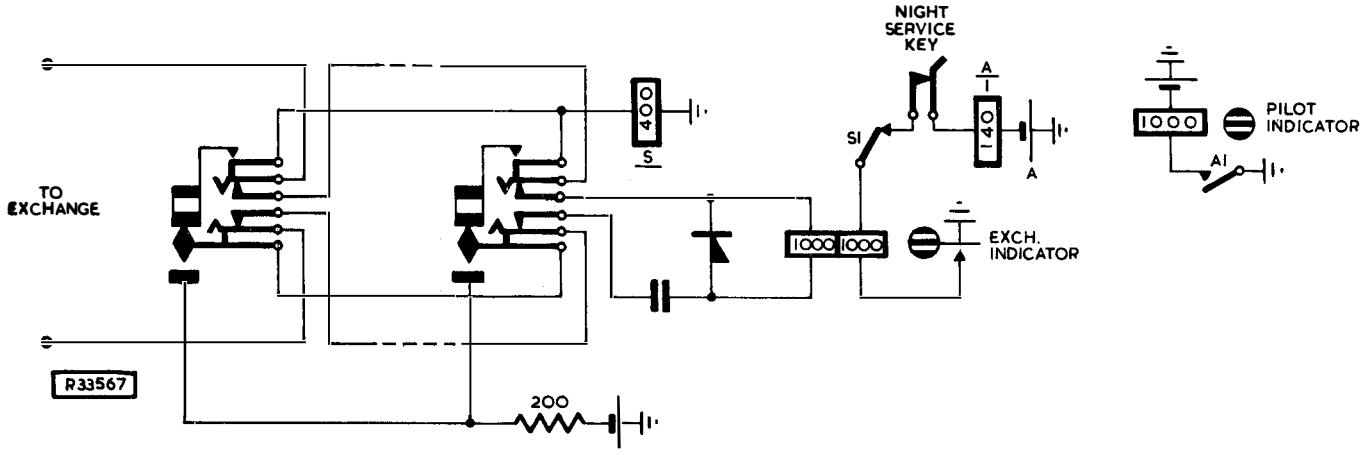


Fig. 17

As mentioned previously the exchange line indicator is of the doll's-eye type having two 1000 ohm coils. Each position is equipped with exchange line indicators and a pilot indicator is fitted on the front of the switchboard between the extension indicators and the answering jack field. The pilot indicator which is also of the doll's-eye type, operates whenever any exchange line indicator on the same position is operated.

On an incoming call, ringing current passes through the capacitor and one coil of the indicator; this coil is shunted by a half wave rectifier thus enabling the indicator to operate to ringing current. When operated, the indicator contact completes a locking circuit via its second coil in series with relay A which operates. Contact A1 operates the pilot indicator. When the operator answers, the insertion of an answering plug into the line jack causes the operation of relay S to the battery on the sleeve of the plug. Contact S1 releases the calling indicator. The call is extended to whichever extension is required by means of the calling cord, the local transmission bridge being disconnected (relay S being operated in the cord circuit) and contacts S1 and S2 providing a 200Ω loop via contact C1.

When the call is in progress both supervisory indicators A and B are operated. Contacts A1 and B1 operate relay C via contact S3 (operated). Contact C1 disconnects the 200Ω loop and the operation of both the local supervisory indicators and the supervisory at the main exchange depends upon the loop of the required extension. Contact C2 holds relay C.

When the operator throws the SPEAK key, S, relay C releases; thus when the operator is on the line relay C at C1 provides a holding loop.

It will be seen therefore, that on exchange calls:-

(a) The speaking current is obtained from the main exchange.

(b) A loop is maintained across the line from the time the cord is inserted at the P.M.B.X. until the extension clears.

(c) The extension controls the supervisories at the P.M.B.X. and the supervisory at the main exchange.

As with the cord circuit for the $\frac{10 + 30}{65}$ switchboards a capacitor is placed across the indicators to by-pass the speech currents.

Engaged Test

In order to provide an engaged test on both exchange and extension line circuits, the multiple jacks are of the 7-point type with an auxiliary spring and contact, the latter being common to a strip of jacks. All auxiliary springs for one circuit are in parallel and normally rest on, and are in contact with, their jack bushes. Negative potential is connected to the contact. With a plug in a jack the auxiliary spring of that jack is pressed against the contact thereby connecting negative potential to the rest of the springs of the circuit multiple and thence to the jack bushes. A 200 ohm resistor (one per group of 20 lines) is shown in the circuit of the engaged test battery. This resistor prevents excessive current passing and reduces the potential sufficiently to provide a reasonable "click" in the receiver when the operator is tapping the bush of the jack during the engaged test.

Night Service

To enable extensions to be switched through on exchange lines during the night period and week-ends, cord circuits are used and keys are provided which disconnect the earth and battery feeds from the tip and ring of all cord circuits and the S relay from the sleeve of the same circuit. Contacts of the same key also disconnect the hold coil circuit of the exchange line indicator.

Operator's Circuit

The operator's telephone circuit is the same as that used for the $\frac{10 + 30}{65}$ switchboard and no further description is considered necessary. Similarly the dialling circuit is identical and for the same reason no description is given.

Private Wires

Private wires which terminate on the switchboard are allowed access to all extensions but must be barred from connexion to an exchange line. To achieve this an additional unit is fitted which consists essentially of a relay which is connected to the bush of the private wire jack. The principle is shown in Fig. 18.

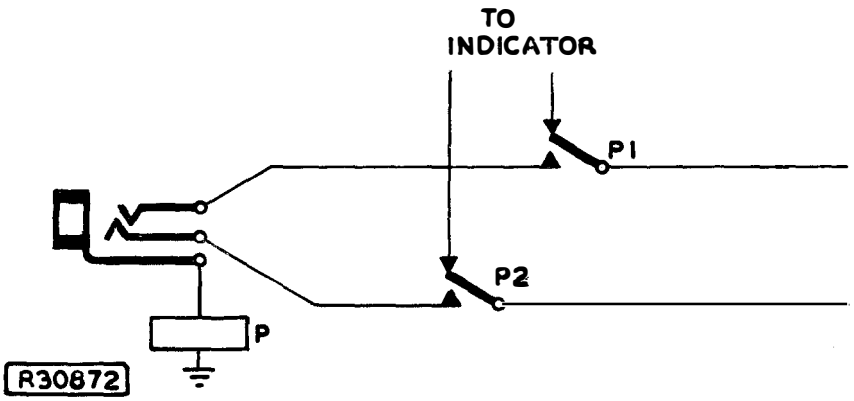


Fig. 18

When a signal is received over the private wire the insertion of an answering cord into the jack completes the circuit for relay P via the battery connected S relay on the sleeve of the cord circuit. Relay P operates and contacts P1 and P2 extend the line through to the operator. If the calling cord is now inserted into an exchange line jack the earth connected to the bush of the jack short circuits relay P thus disconnecting the private wire at contacts P1 and P2. Relay P is often referred to as a prohibition relay.

Power Supply

In view of the fairly heavy load that a board of this type would place on its source of power supply, primary cells are not an economic proposition. Sufficient secondary cells are, therefore, provided to give a minimum busbar voltage of 16 V. The cells are trickle charged from a rectifier thus maintaining them in good condition.

LONG EXTENSIONS

In the switchboards which have been described, the type of transmission bridge employed is such that the transmitter current fed to two inter-connected extensions passes through common impedances and then divides in inverse proportion to the resistances of the two circuits. The shunting effect of a short extension, when connected through to a long extension, may be such that insufficient current passes to the long extension for satisfactory operation of the supervisory relays. Arrangements are therefore made, in the case of double cord switchboards, to provide long extensions with individual transmitter feed current by the inclusion of auxiliary apparatus in the line circuit. The circuit elements of this equipment are shown in Fig. 19.

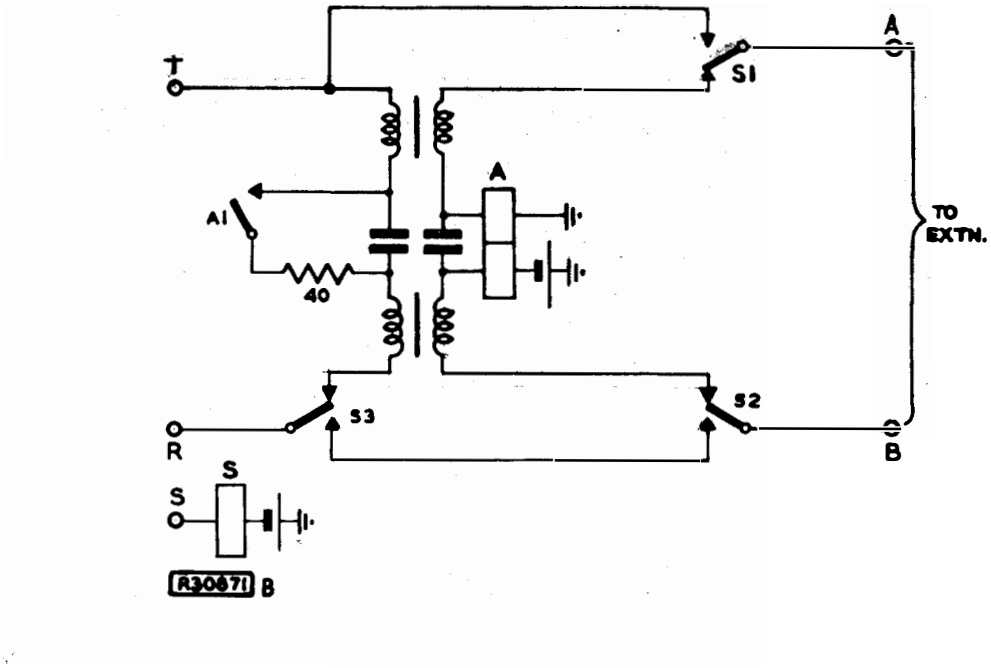


Fig. 19

Current for transmitter excitation is fed to the extension via the coils of relay A and A1 contact provides for calling and supervisory signals.

On exchange to extension calls relay S is operated by earth from the sleeve circuit of the exchange-line jack via the connecting cord and S contacts cut out the auxiliary equipment.

Ringing current passes to the extension via the transformer included in the auxiliary apparatus.

P.M.B.X. No. 1A

General

The P.M.B.X. No. 1A is now the current standard switchboard for subscribers' installations where more than two positions are required. It supersedes the C.B. No. 9 type switchboard described in the previous section. It is a multiple

switchboard of the lamp signalling type having a capacity of 800 extensions and 160 exchange (or inter-switchboard) lines.

Facilities

The P.M.B.X. No. 1A provides the following facilities:-

1. Positive clearing is adopted on all cord circuits.

2. Separate battery feed is given to the calling and called lines on extension to extension calls. This enables extension lines of considerable difference in resistance to be connected to one another without any adverse effect on the transmission performance.

3. Standard ringing and dialling facilities are provided on the calling cord with the ring back facility on the answering cord.

4. The standard "click" engaged test is provided.

5. Through clearing from extension to public exchange is standard and both supervisory lamps glow on the P.M.B.X. switchboard when the extension clears.

6. Press button operator recall can be provided when required.

7. When an incoming exchange call is required before the operator clears the previous connexion the supervisory lamps will flash and the incoming ring is prevented from calling the extension.

8. Night service conditions can be set up without the use of separate cords or night service keys.

Face Equipment

A photograph showing the face equipment of a typical switchboard is shown in Fig. 20 (appended). The switchboard, which is 4 ft. 8 in. high, is of the 2-panel type. Each panel has room for 40 exchange lines and 200 extensions. Keys, for bringing the hand generator into use if power-ringing fails and for coupling the cord-circuits to the operator's circuit of the next position on the right when the original position is unattended, are accommodated in the right-hand panel at the top of the multiple-field. A cord-test jack and position pilot lamp are fitted in the pilot rail below the multiple-field.

Keyshelf

A photograph giving a close-up of the keyshelf is shown in Fig. 21 (appended). Examination of the photograph shows that space is provided for 16 cord circuits but normally only 12 are equipped. The dial is fitted, if required, on the right hand side of the keyshelf. Two supervisory lamps and two keys are provided per cord circuit. The facilities provided by the keys, the cords and supervisory lamps are clearly marked by engraved labels countersunk into the switchboard. The operator's instrument jack and the hand generator are fitted on the left and right-hand sides respectively of the keyshelf. A pilot lamp for each position is situated below the multiple field and to the right of the centre stile.

Apparatus Racks

Apparatus officially known as a "P.M.B.X. Equipment No. 1" is shown in the centre of Fig. 22 (appended) and on the right hand side of this figure other apparatus known officially as "P.M.B.X. Equipment No. 1/35" is fitted. All apparatus except that for the cord and position circuits is accommodated outside the switchboards on these racks. Exchange line and interswitchboard line apparatus is made up in the form of relay sets. As well as the relay sets, the apparatus racks carry the rest of the equipment necessary for an installation.

The P.M.B.X. Equipment No. 1 accommodates the apparatus for 5 positions, 250 extensions, 30 exchange lines or 15 interswitchboard lines. Where large numbers of interswitchboard lines are required, a P.M.B.X. Equipment No. 1/35 is provided. This apparatus rack caters for 35 interswitchboard line relay sets only.

Line Circuits

Exchange line calling lamps and jacks are fitted below the extension multiple; they may be multipled as required. No home jacks are provided for the extensions, calling lamps being in the multiple. Normally ebonized blanks are inserted between the multiple jack strips, but at one of the multiple appearances this blank is replaced by a strip of calling lamps above the multiple jacks. The switchboard does not provide multiple answering facilities for extension lines, there being only one calling lamp per circuit. The distribution of calling signals is normally determined at the design stage by traffic requirements and it is usual to arrange for the calling lamps of each group of twenty extensions to appear on one specified panel. No I.D.F. is provided but flexibility may be obtained by providing a second lamp strip at another multiple appearance so that individual calling lamps may be transferred from one answering position to another to equalize the operators' loads.

A series multiple is employed for the extension circuits in order to avoid the provision of a cut-off relay per line. Extension calling lamps are lit directly by current passing round the extension loop and amber lamp caps are fitted in order to reduce the apparent difference in glow between the lamps of long and short lines. On very long lines lamp relays can be fitted.

CIRCUIT DESCRIPTION

Diagrams of the cord circuit and extension line circuit are shown in Figs. 23 (appended) and 24 respectively.

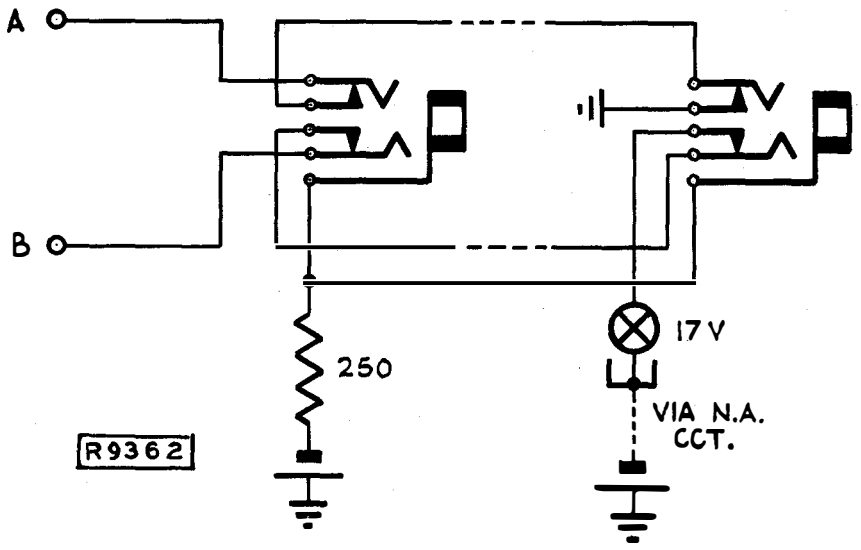


Fig. 24

Extension to Extension Calls

To call the P.M.B.X., an extension lifts his receiver thus extending a loop and completing a circuit for the operation of the calling lamp. The operator answers by inserting an answering plug into one of the multiple jacks associated with the calling extension. /Normally, the operator will plug into the jack directly associated with the lamp, but there is no reason why she should not use any multiple jack for the purpose/. Insertion of the plug disconnects the lamp circuit at the break jacks and the lamp is extinguished. The operator now throws her speak key which causes the operation of relay SK (see Fig. 23). Contact SK1 operates relay SKR. Contact SK3 operates relay AS to the battery on the bush of the jack and contacts AS3 and AS6 complete the circuit of the local transmission bridge. Relay LA operates to the calling subscriber's loop and the operation of contact LA1 extinguishes the supervisory lamp.

After making the normal engaged test the operator inserts the calling plug into the required extension jack and operates the ring key. The insertion of the plug into the jack causes the operation of relay CS and contacts CS3 and CS6 complete the calling side of the local transmission bridge. When the called extension answers, relay LC operates and contact LC1 operates and extinguishes the calling supervisory lamp.

The conditions of an extension-to-extension call is shown in circuit element form in Fig. 25.

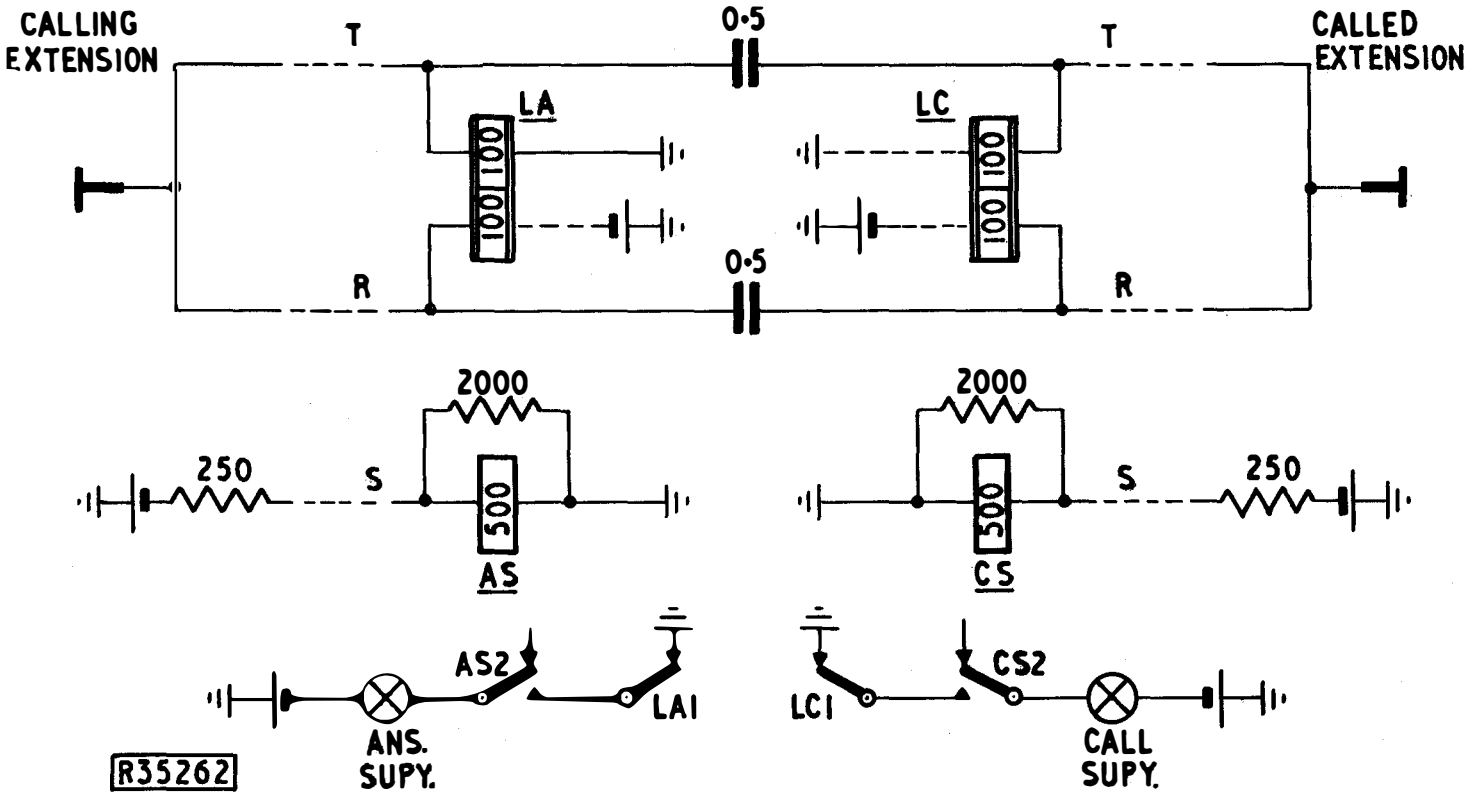


Fig. 25

Restoration of the speak key leaves the release of relay SK under the control of contacts AS5 and CS4. When either extension replaces his handset at the end of a call relay LA or LC releases and LA1 or LC1 completes the circuit for the local supervisory lamp.

Extension to Exchange (Outgoing Call)

The exchange line circuit is shown in Fig. 26 (appended).

When the operator inserts the calling plug into an exchange line jack the bush of the jack is earthed via contacts LR3, AC2 and the auxiliary springs (operated) of the jack. In consequence relay CS does not operate and with contact CS3 normal, and the speak key operated contacts SKR3 and SKR5 apply the LC relay loop to the line which operates relay LG, relay LC itself does not operate. Contact LG1 repeats the loop to the exchange and the current in this loop operates relay L. The differential relay D does not operate. Contact L1, in turn, removes the short circuit from relay LR and contacts LR2 and LR4 extend the exchange line to the cord circuit. Relay LG now releases after a lag period and removes the temporary loop at contact LG1; at the same time the loop via relay LC in the cord circuit is now extended through the differential relays D and L to the exchange. Relay LC now operates and at Contact LC2 releases relay SK which in turn releases relay SKR. Contacts SKR1, SKR3, SKR4 and SKR5 disconnect relays LA and LC (which release) and connect the exchange right through to the extension. Contacts SK2 and SK5 connect both supervisory lamps in parallel with the sleeve of the calling cord, the resistance of the sleeve circuit is, however too high for them to glow at this time. When the calling extension replaces his handset, the removal of the loop releases relay L in the termination thus short circuiting relay LR at contact L1. The

consequent release of relay LR short circuits the 500 ohm resistor on the bush of the jack, thus applying full earth to the sleeve to light both supervisory lamps.

Exchange to Extension (Incoming Call)

Alternating current received over the exchange line passes via the rectifier shunted coil of relay AC and the 2 µF capacitor. Contact AC1 lights the calling lamp whilst relay AC holds via its second coil and contact AC3. Contact AC2 extends a 500Ω earth to the bush of the jack to give an engaged signal to any operator attempting to use the line for an outgoing call.

The operator plugs in after throwing the speak key thus operating relays SK and SKR as before. Insertion of the plug disconnects the hold circuit of relay AC which then releases. The supervisory lamps are disconnected at SK3 and the same contact applies relay AS to the sleeve circuit but the relay does not operate due to the absence of battery in the circuit. A loop is thus extended via relay LA to the line at contact AS3 to operate relay LG (relay LA does not operate). Contact LG1 provides a loop back to the main exchange and relay L operates but the differential relay D remains normal. Contact L1 operates relay LR. As before contacts LR2 and LR4 disconnect relay LG and extend relay LA to the main exchange. Relay LG releases and relay LA operates to the main exchange battery.

The operator having ascertained the extension required calls it in the usual way. Relays CS and LC operate and on restoration of the speak key relays SK and SKR release thus disconnecting relays LA and LC in the cord circuit and leaving the exchange line right through to the extension loop. When the extension clears the removal of the telephone loop releases relay L, contact L1 short circuits relay LR which releases and contact LR3 short circuits the 500Ω resistor thus extending full earth to the sleeve to light both supervisory lamps.

Fig. 27 gives a circuit element of the conditions on an extension-to-exchange call.

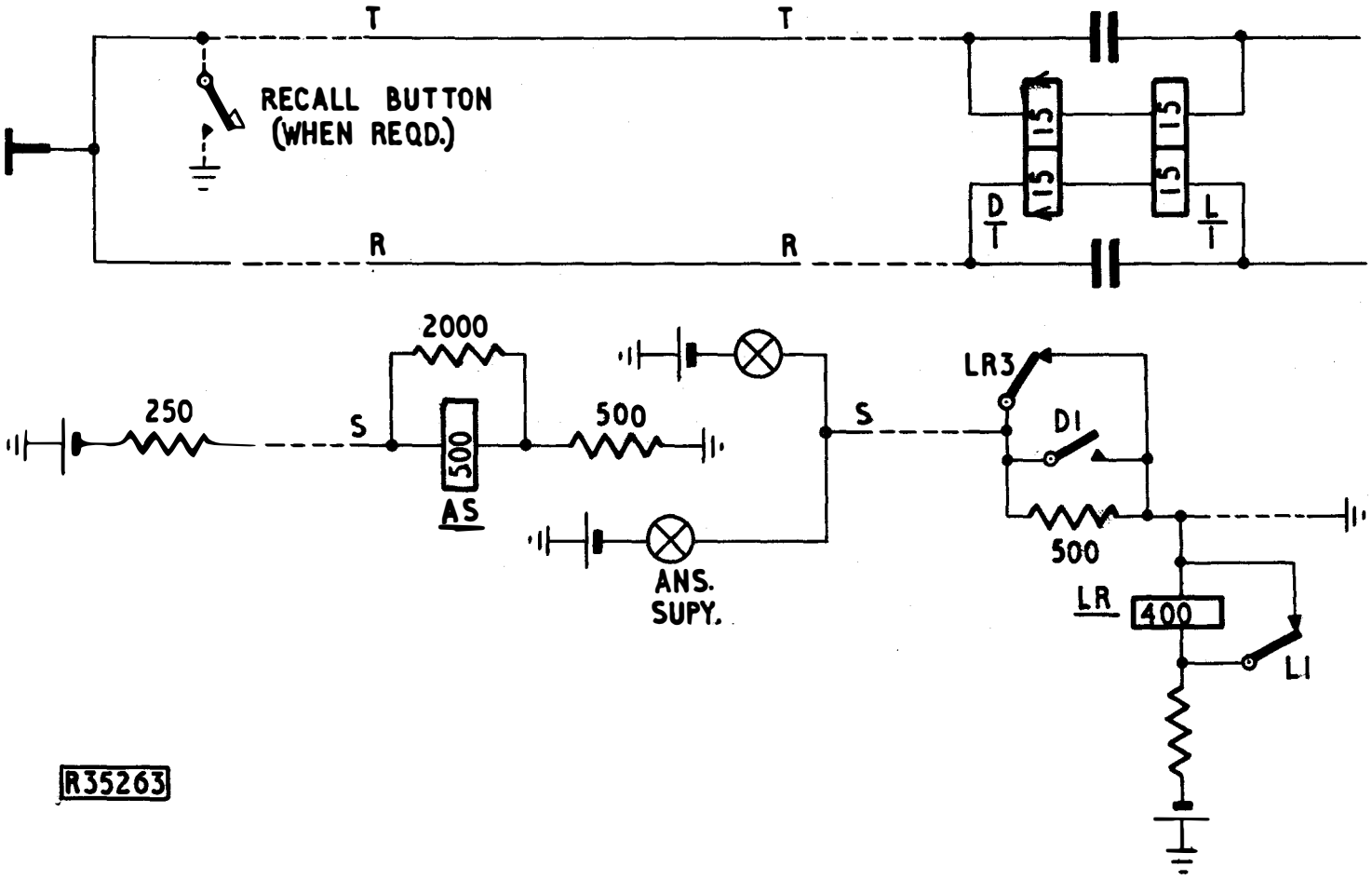


Fig. 27

Operating procedure

In operating a board of this type, the standard procedure is to throw the SPEAK key before inserting the plug in the jack. (On other boards it is immaterial whether the SPEAK key is thrown before or after inserting the plug). The reason for the procedure will not be readily apparent from the foregoing description as it only has an effect on private wire or inter-switchboard extension working. In this case the calling lamp is not extinguished until the operation of relay S in the termination via the sleeve circuit and contact SK3 (operated). Where the lines are multipled it would thus be possible for a second operator to answer the same call during the time taken by the first operator between plugging in and throwing the SPEAK key.

Operator recall facility

This facility can be effected by slowly depressing and releasing the extension instrument receiver rest on the following types of call:-

(a) Incoming from and outgoing to manual exchange.

(b) Incoming from automatic exchange.

(c) On calls via auto-manual switchboard with manual hold facilities.

In these cases operation of the receiver rest disconnects the loop thus releasing L in the termination and lighting both supervisory lamps as for a normal clearing signal. In this way depression and release of the receiver rest causes the supervisory lamps to flash.

On calls outgoing to an automatic exchange depression of the receiver rest would release the connexion. A separate press-button is therefore fitted at each extension where this facility is required. Depression of the button earths the loop thus reducing the current to zero in one line and doubling it in the other. Relay A at the exchange and relay L in the termination thus hold over one coil, but the differential relay D, being now unbalanced, operates. Contact D1 earths the sleeve to light both supervisory lamps. Thus depression and release of the button causes the P.M.B.X. supervisory lamps to flash.

Follow-on Call Trap

After an exchange line call has finished, it is possible that the main exchange operator may clear the line before the P.M.B.X. operator has removed the cords on the P.M.B.X. switchboard. An incoming call may then be received over the same line and will neither light the exchange calling lamp nor ring the extension's telephone bell. The circuit is designed, however, so that the attention of the operator is drawn to the existence of conditions of this nature and the circuit operation will now be considered.

The incoming ringing current operates relay AC but because the plug is already inserted in the exchange line jack the earth is disconnected from the hold circuit of relay AC and in consequence this relay fails to hold. The operation of relay AC to the intervals of ringing current causes periodic removal of the short circuit of the 500 ohm resistor in the bush of the jack thus causing both supervisory lamps to be dimmed with each operation of contact AC2. The attention of the operator is thus drawn to the flashing supervisory lamps, the plugs are withdrawn and on the next operation of relay AC to ringing current the relay locks via the earth on the jack springs. The call is then dealt with in the normal way.

Night Service

A break jack with the bush disconnected is inserted in each exchange circuit between the line and the relay set. These jacks are the night service exchange jacks. The insertion of a cord circuit plug into one of these jacks cuts off the exchange calling equipment and the insertion of the associated cord circuit plug into an extension jack joins the exchange line straight through to the extension.

Private Wires

The P.M.B.X. No. 1A caters for the termination of private wires which may use any type of signalling method. Two types of relay set can be obtained. The first type is designed primarily for d.c. signalling only, whilst the second is a universal relay set which can be arranged to work with any of the usual combinations of d.c. and generator signalling.

Power Supply

The normal battery supply is a single 24 V battery floated from a.c. mains by a rectifier. If a.c. mains are not available then a double battery scheme would be used. The average load for a reasonably busy installation is 10 ampere hours per section per day. Where a rectifier is used, a mains failure alarm is fitted in the cable turning section of the suite. This gives immediate advice that the battery has ceased to charge and the operator can report the trouble to the maintenance staff before the battery has been discharged to any extent. As is normal the battery capacity is arranged to give a 24 hour standby on a mains failure.

RECENT DEVELOPMENTS IN SWITCHBOARD DESIGN

General

The main development which has taken place in the last few years has been in the field of cordless switchboards. The three existing types of cordless boards - the $\frac{1+3}{4}$, $\frac{2+4}{6}$ and $\frac{3+9}{12}$ are unduly bulky in appearance and much in need of modernization. Design of a successor to the $\frac{2+4}{6}$ has been completed and preparations are being made for its production. The new switchboard, which is to be designated 2 + 6 i.e. two exchange lines and six extensions will officially be known as the P.M.B.X. 2/2A. It will have a grey plastic case and despite the fact that it will provide two more extensions than its predecessor it is considerably smaller. Fig. 28 (appended) shows a photograph of the board.

A feature of this new switchboard is the 'four wire extension', each extension line consisting of three wires and an earth lead. The third wire and the earth connexion are used for supervisory purposes. It has been found that the additional cost of wiring is more than off set by a reduction in the number and cost of components in the switchboard. Only in the case where external extensions terminate on the switchboard is the economic advantage lost.

The principle of the system is shown in Fig. 29.

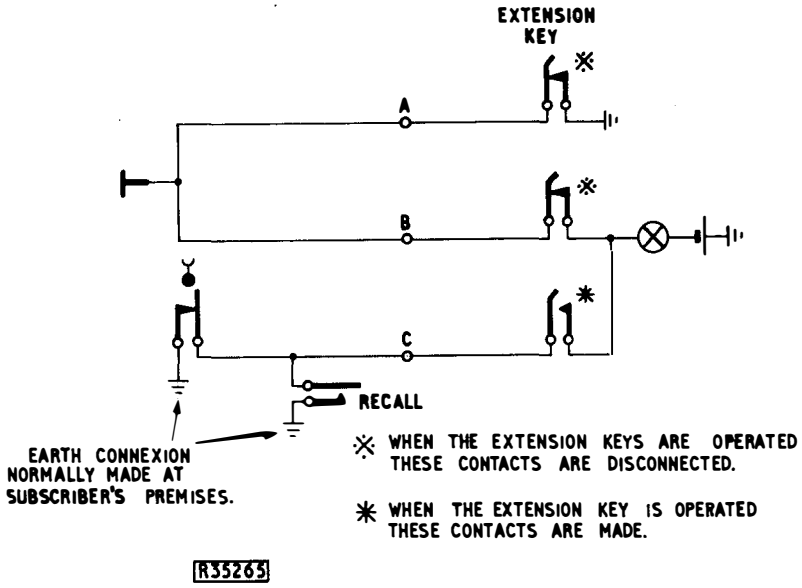


Fig. 29

Brief Circuit Notes

Lamp signalling is employed and a telephone loop placed across the A and B wires of the extension causes illumination of the calling lamp. Operation of the extension key disconnects the calling lamp which is then extinguished. At the end of the call the extension replaces his handset and completes a circuit for the calling lamp via auxiliary contacts of the tele-switch springs, a positive clearing signal is thus given to the operator who then restores the keys. Should the extension wish to attract the attention of the operator during the call then by depressing and releasing a reset button a circuit is completed and disconnected respectively for the calling lamp this attracting the attention of the operator.

As mentioned earlier, where an external extension is provided it may be uneconomic to use extra wires for signalling purposes in the main exchange local line network and in these cases a comparatively expensive relay set for converting the extension from four wire to conventional two wire circuitry is fitted at the P.M.B.X. end of the extension. Special arrangements also have to be made to provide certain plan numbers off the extension telephones. However these disadvantages are more than offset by the economic advantage to be gained at any average installation.

A similar design is proposed for the new 3 + 12, to be officially known as the P.M.B.X. No. 2/3A, which replaces the existing $\frac{3+9}{12}$ switchboard, but this will have in addition a new facility for automatically holding exchange line calls thus obviating the need for the operator to throw a hold key. There is also a follow on call trap facility provided on each exchange line.

Power Supply

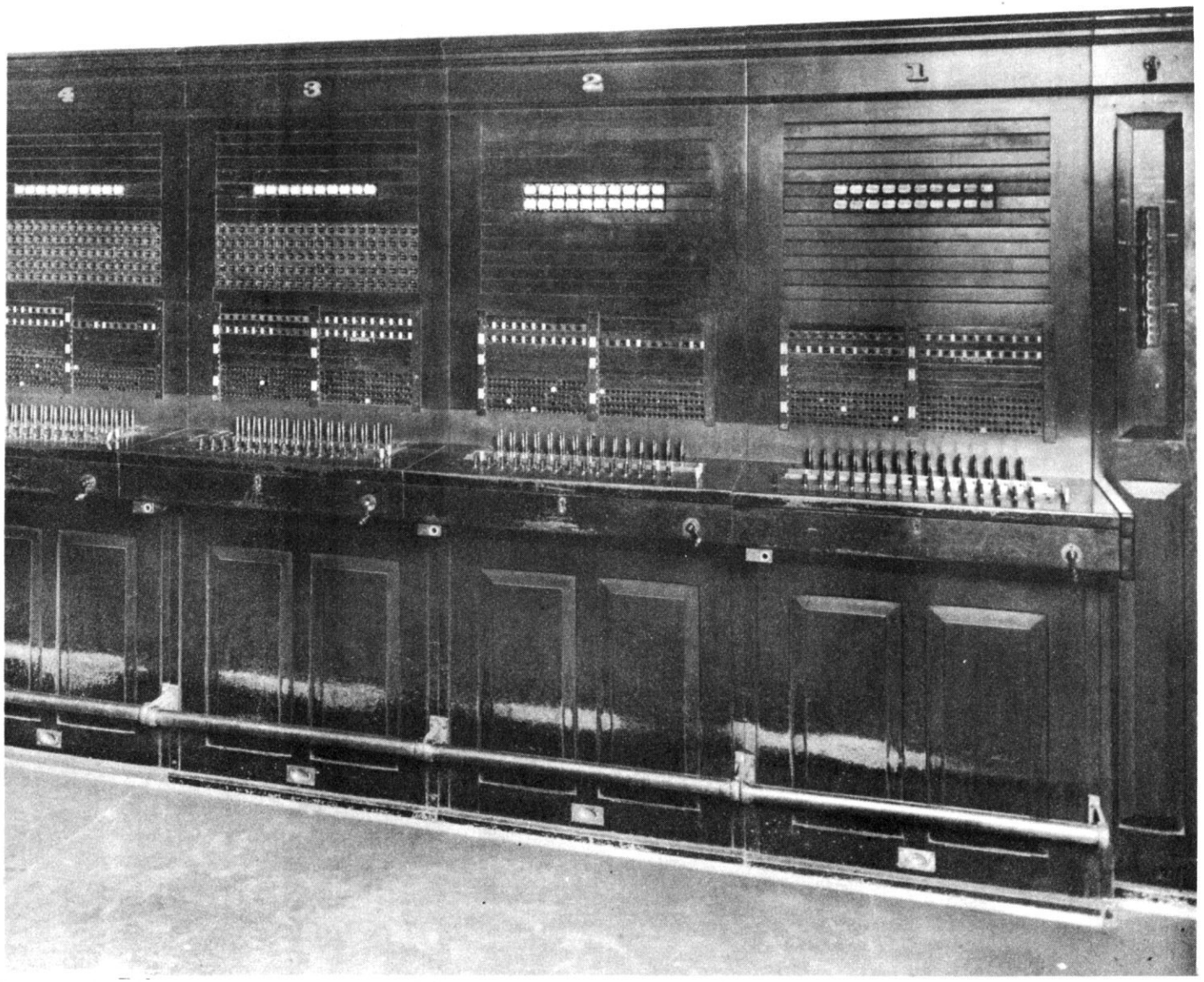
The power supply for these new switchboards is obtained from a mains driven unit instead of a battery. The busbar voltage is 50 V. A ringing supply of frequency 25 c/s is also obtained from a mains unit. Should a mains failure occur there is no reserve battery to maintain 100% service. Arrangements are made however for an indication to be given to the operator in that the first incoming exchange line call received after the failure is arranged to ring a bell wired in the operator's telephone circuit. Arrangements are then made perhaps switching each exchange line through to a selected extension on a night switching basis. Under these circumstances no extension to extension traffic is possible. This is a departure from previous practice but in view of the present day reliability of the mains supply, it is considered a justifiable economic saving.

Summing up, the design of the new cordless type P.M.B.X. has the big advantages of cheapness and simplicity. The switchboard can be installed at a large majority of subscribers' installations; more expensive units are only to be fitted in those cases of absolute necessity thus effecting an overall saving in cost.

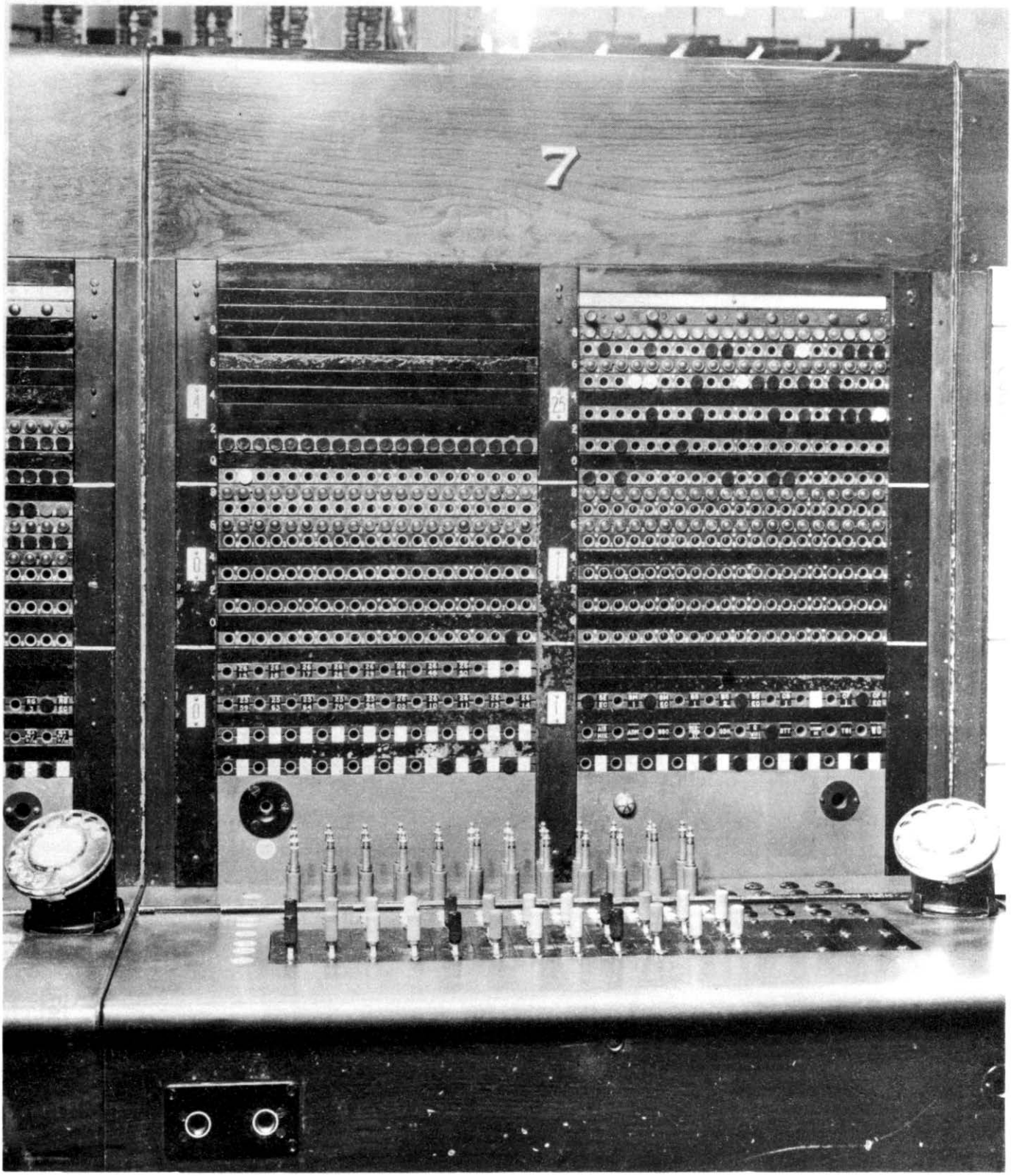
END

References

Educational Pamphlet - Draft Series TELEPHONES 1/2, 1/3, and 1/5



Typical suite of sections C.B. Multiple No. 9 P.M.B.X.
Fig. 14



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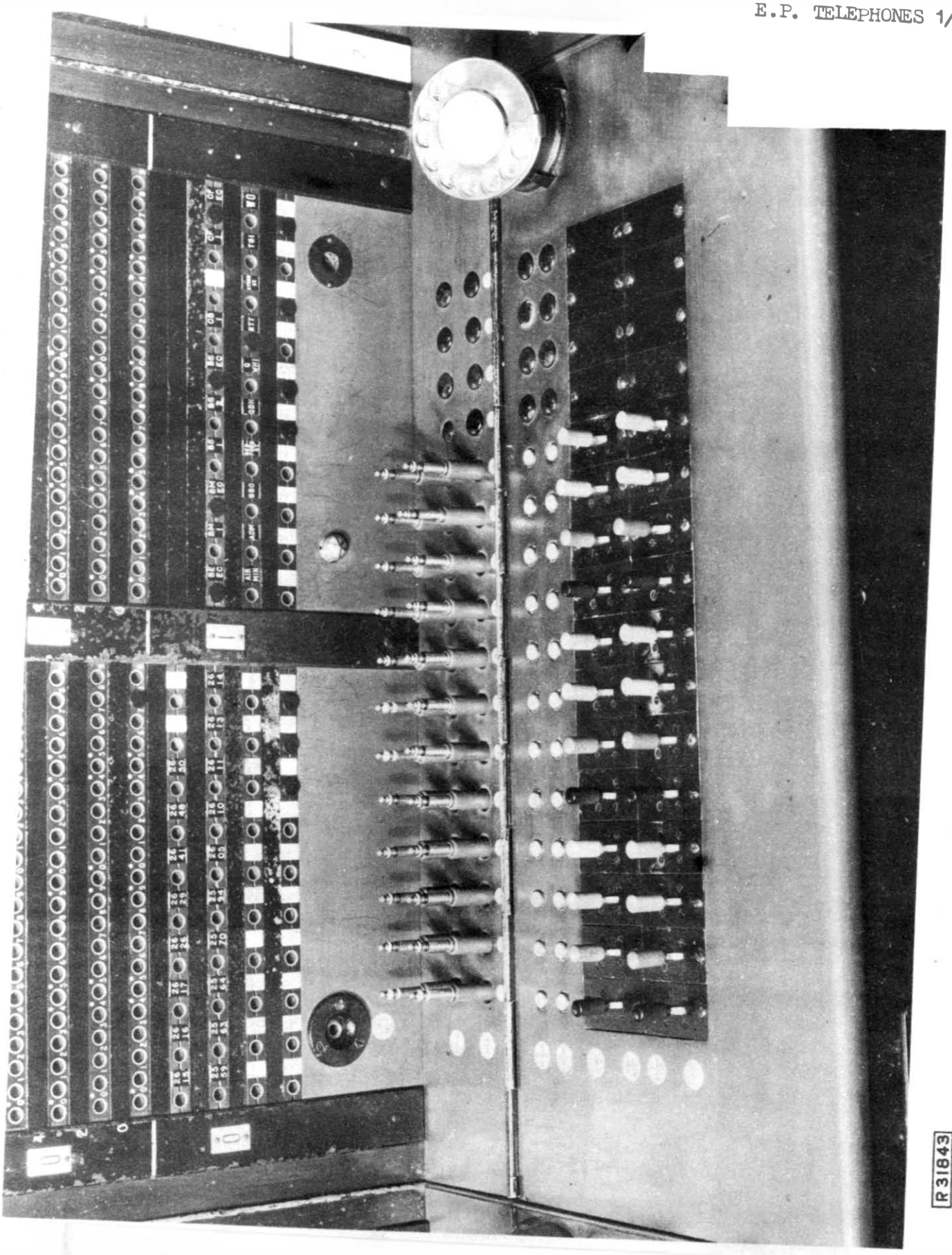
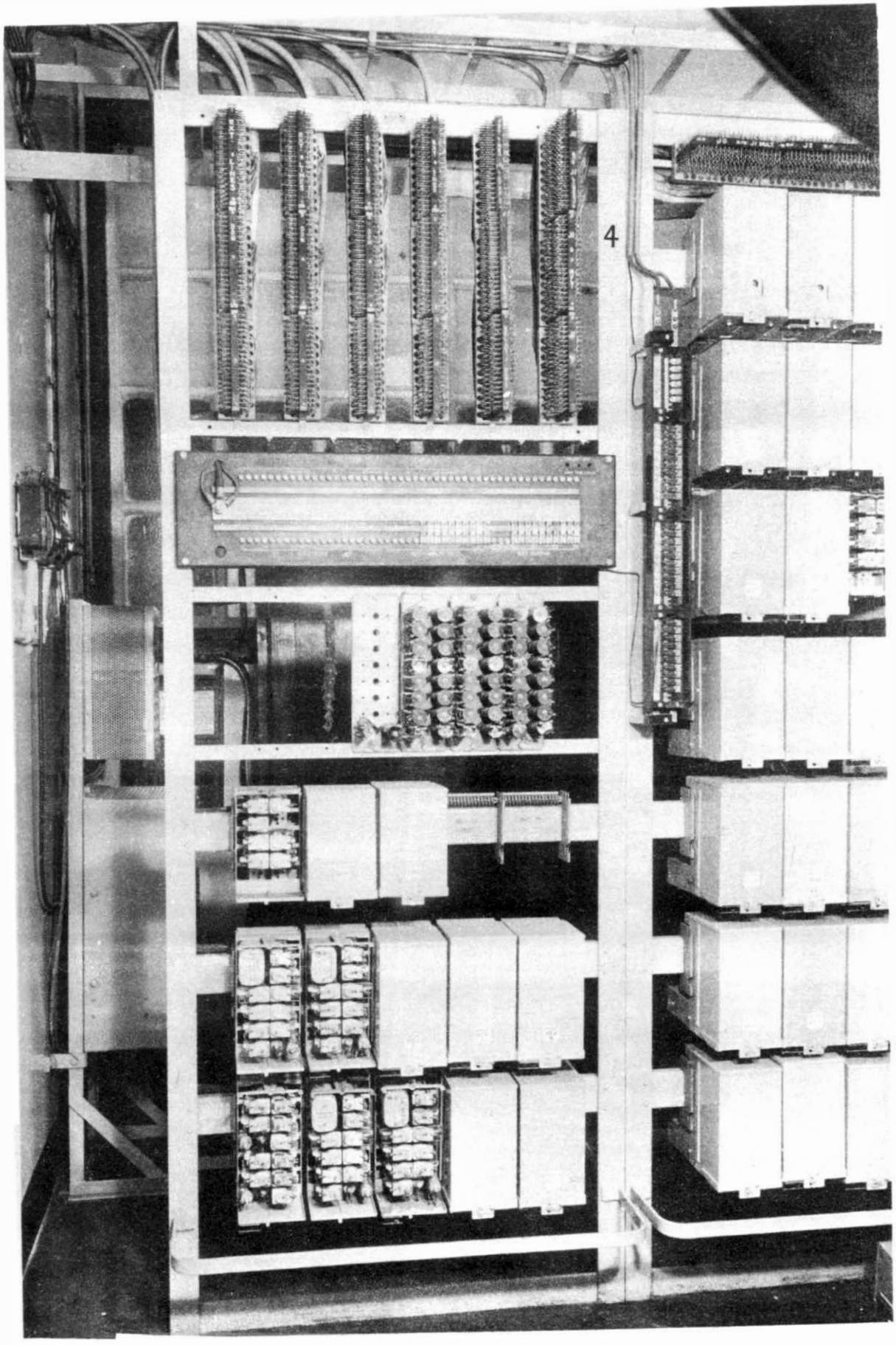
Face equipment P.M.B.X. No. 1A
Fig. 20



Keyshelf P.M.B.X. No. 1A
Fig. 21



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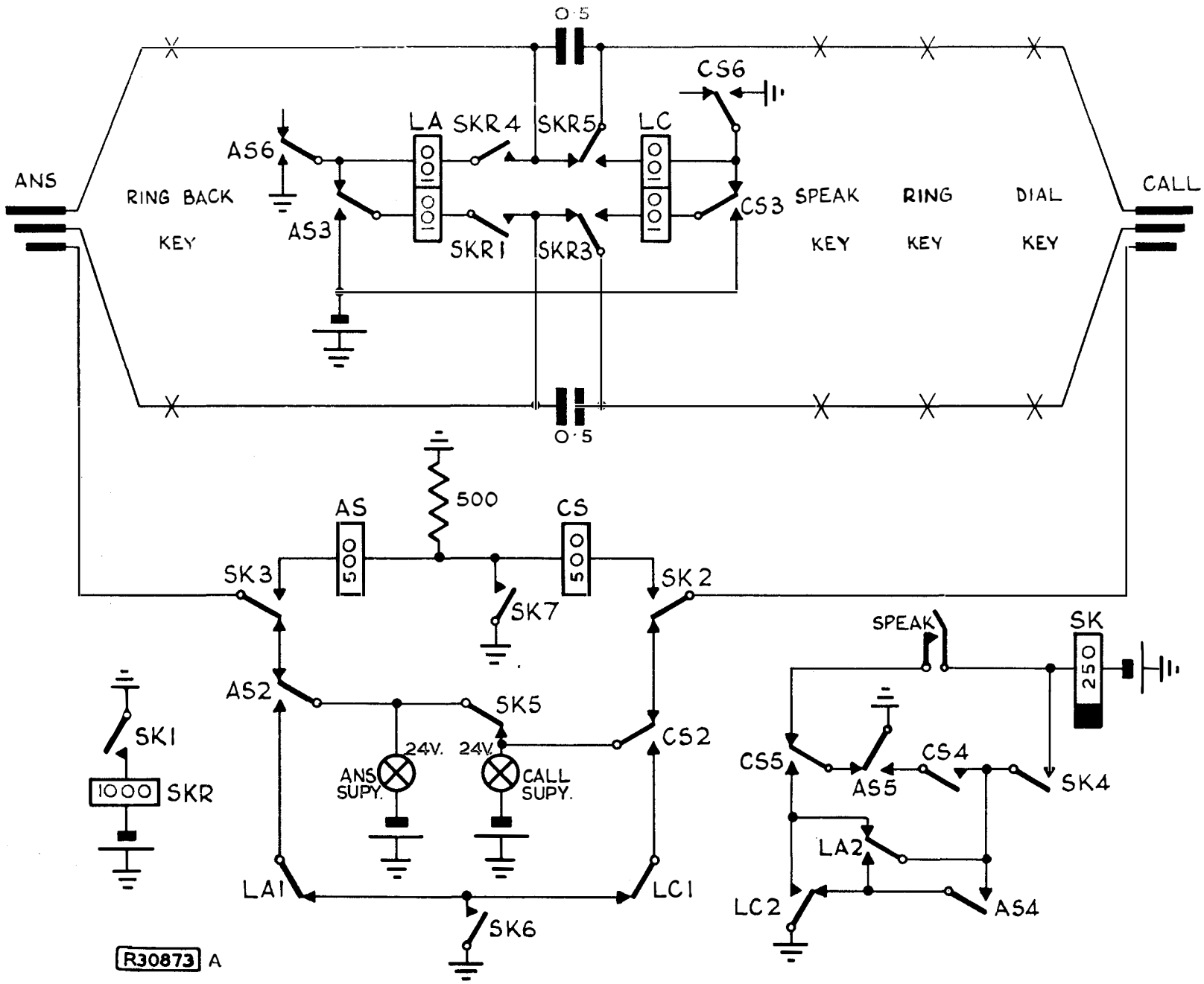
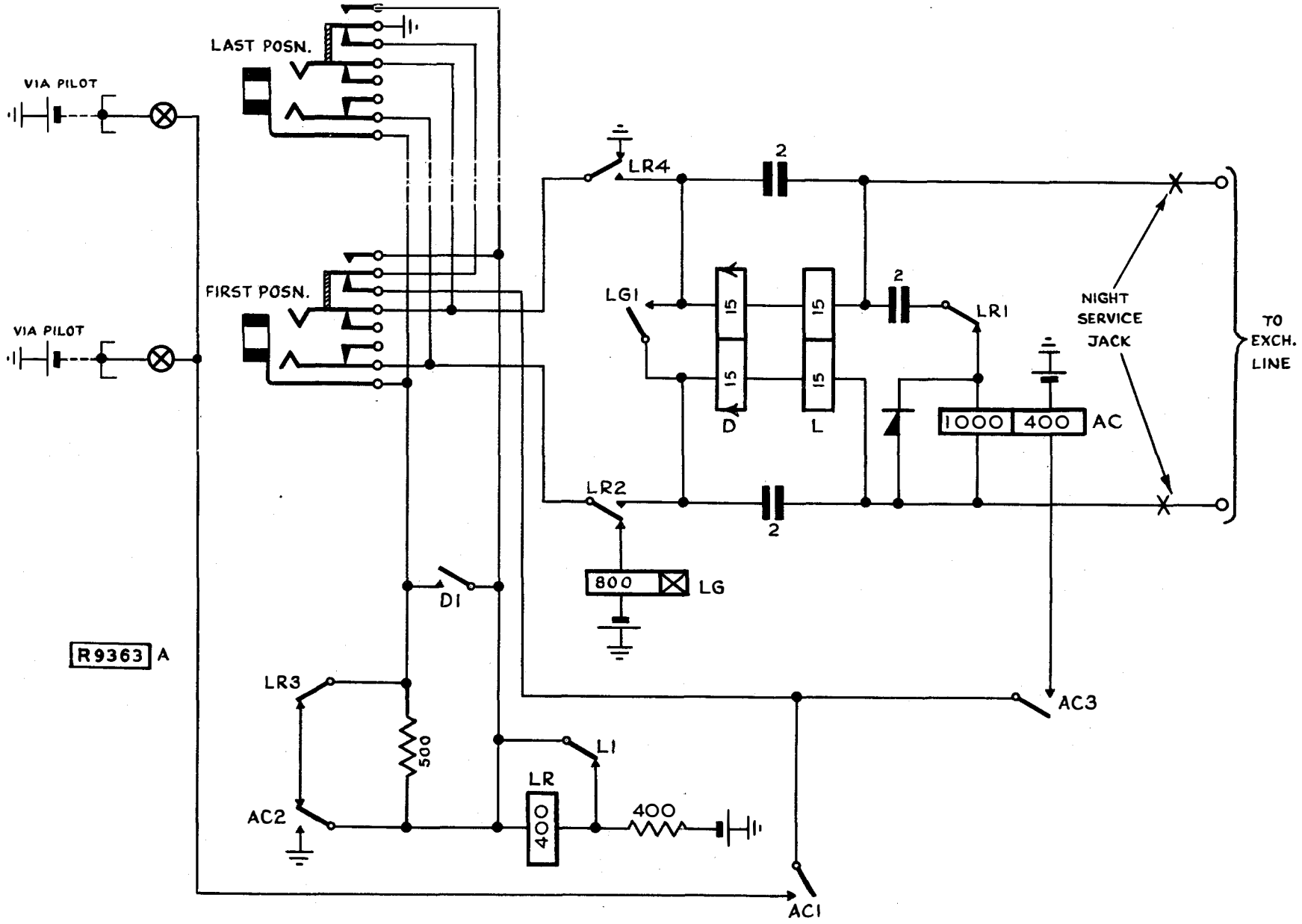
Apparatus rack P.M.B.X. No. 1A
Fig. 22



Cord Circuit P.M.B.X. No. 1A
Fig. 23



Exchange Line Termination P.M.B.X. No. 1A
Fig. 26

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The new 2 + 6 switchboard
Fig. 28