

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

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Part 4

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THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

Vol. 46

January 1954

Part 4

Post Office Standard P.A.B.X.s

J. J. ROCHE†

Part 1.—General review of new types and details of P.A.B.X. No. 1

U.D.C. 621.395.24

During the past few years much work has been done on the standardisation of P.A.B.X.s and this article, to be published in two parts, describes the developments so far completed. Part 1 introduces the subject, outlines the various types of standard P.A.B.X. now available and covers in some detail the P.A.B.X. No. 1 and its associated cordless manual board. Part 2 will describe the P.A.B.X.s Nos. 2 and 3.

INTRODUCTION

ALTHOUGH the Post Office is concerned primarily with telephone communication on a national basis, the private branch exchange is becoming an increasingly important feature of the general scheme of communications. Indeed, the growing tendency towards the formation of large commercial and industrial groups, together with a greater appreciation of the value of efficient internal communications, is, in many cases, changing the P.B.X. outlook from one of serving as a dispersal point of the main exchange call, to a field of its own, providing an essential self-contained network of communications separate from, but dovetailing into, the main national network.

The private manual branch exchange (P.M.B.X.) has, in the past, been widely used. This may well be continued in the future, particularly for the smaller unit, but with the increasing demand for rapid and efficient 24-hour service and the high cost and scarcity of switchboard operators, the private automatic branch exchange (P.A.B.X.) is being used to a much greater extent than formerly.

Until recently the design of P.A.B.X. equipment was left to the individual manufacturer concerned, with the result that several differing types of equipment have been provided throughout the country. As the number of installations increased it was decided that it would be to the advantage of all concerned and in the interests of efficiency to evolve standard designs.

The development of standard equipment was commenced on the following broad terms:—

- (1) The facilities to be given should be as comprehensive as possible, based upon the past experience of earlier designs.
- (2) For all types of P.A.B.X., both cord- and cordless-type manual boards should be available.
- (3) Up to 50 extension lines the equipment should be designed as a self-contained unit. Above 50 extension lines design would follow main exchange practice.
- (4) Post Office standard components only should be used.
- (5) Equipment up to a size of 1,200 extension lines should be held as a stock item.

Development of the "under 50 lines" type with cordless and cord switchboards, and the "over 50 lines" with cord switchboards, has been completed and equipments are in service. No development has as yet been done on the cordless "over 50 lines" P.A.B.X.

The P.A.B.X.s have been titled as follows:—

P.A.B.X. No. 1—maximum capacity, 10 exchange lines, 49 extensions. Cordless manual board (referred to as "attendant's cabinet").

P.A.B.X. No. 2—maximum capacity, 10 exchange lines, 49 automatic extensions, with an additional 30 "manual only" extensions. Cord-type manual board.

P.A.B.X. No. 3—50 extension lines and over, with cord-type manual board.

The original objective of making P.A.B.X. No. 3 up to 1,200 lines a stock item has had to be abandoned and complete standardisation has not been realised. P.A.B.X.s of this type will continue to be supplied and installed by direct arrangement between the manufacturer and subscriber, standardisation being limited to circuits and components. This means that, while there may be slight variations in layout of equipment between one installation and another, there will be no fundamental differences between them.

GENERAL DESCRIPTION OF P.A.B.X. NO. 1

The Automatic Equipment.

The automatic equipment is manufactured in four sizes having capacities as shown in Table 1.

TABLE 1

Apparatus	Sizes of Equipment			
	4 + 15	5 + 24	7 + 35	10 + 49
Exchange line circuits	4	5	7	10
Extension line circuits	15	24	35	49
Manual Extension line circuits	2	2	4	4
Inter-Switchboard line circuits	2	2	3	3
Connecting circuits	3	4	6	7
"0" level circuits	2	2	2	2
Enquiry circuits	1	1	1	1

The equipment is enclosed in a cabinet and Figs. 1 and 2 show the arrangement for the 10 + 49 size; the others are similar, except that for the two smallest the cabinet width is reduced. No provision is made for the extension of the smaller sizes; they will be replaced when necessary with a larger unit.

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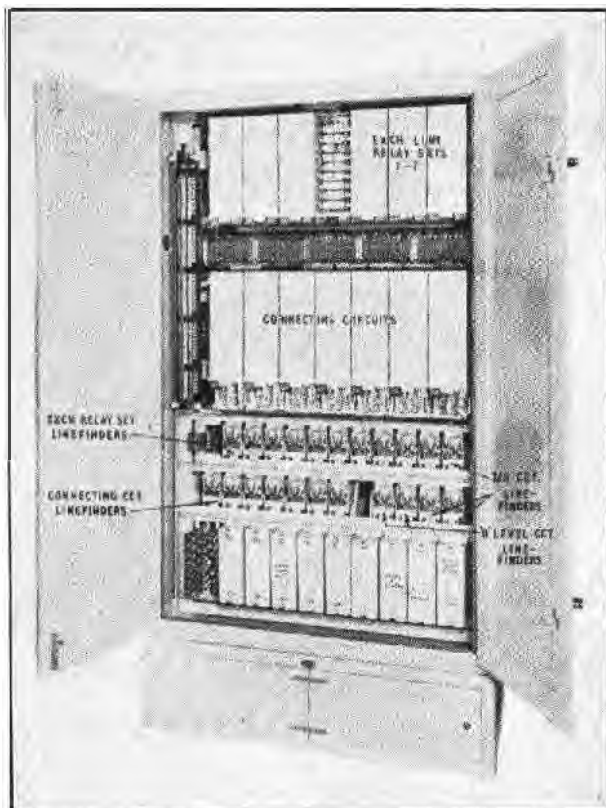


FIG. 1.—FRONT VIEW OF AUTO EQUIPMENT FOR 10 + 49 LINES P.A.B.X. No. 1.

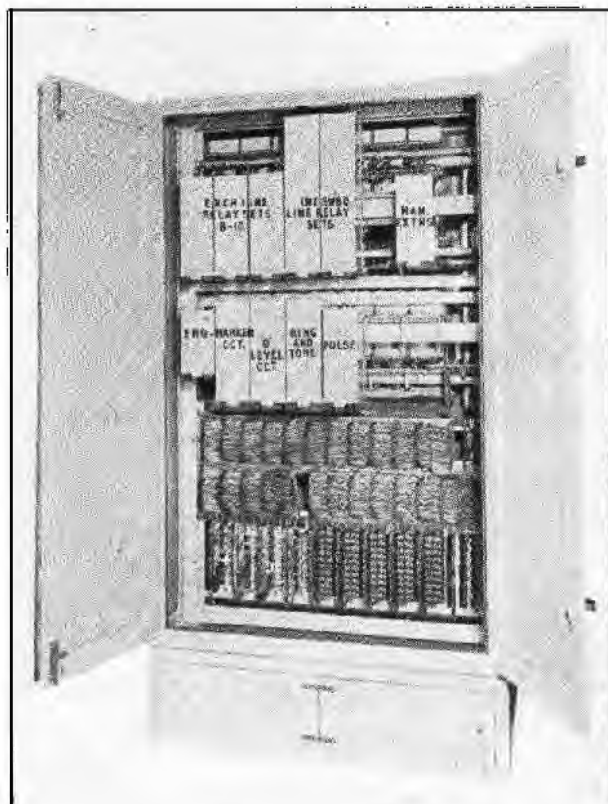


FIG. 2.—REAR VIEW OF AUTO EQUIPMENT FOR 10 + 49 LINES P.A.B.X. No. 1.

The Cordless Switchboard.

The cordless switchboard shown in Fig. 3 is common to all sizes. Exchange circuits appear on the first five keys and lamps, two circuits per key. The next key and associated



FIG. 3.—THE CORDLESS SWITCHBOARD.

lamps accommodate two inter-switchboard circuits. (A third can be added at the expense of the 10th exchange line.) Four manual extension circuits, and two "0" level circuits, complete the row of keys. A common group of keys and lamps is provided to give the usual operating and miscellaneous facilities required. The dial is used primarily for outgoing calls made by the operator. The digit keys are used for the connection of incoming calls to extensions.

Principles of Design.

Much of the design and circuit operation follows conventional practice and will be referred to only in outline. The main departure from previous designs is to be found in cordless working and the inclusion of special features such as enquiry, transfer, ring when free, dial "8" night service etc., which will be dealt with more fully later. The general principles followed are interconnection between extensions by means of connecting circuits consisting of 2,000-type two-motion selectors with associated 50-point uniselectors of the P.O. standard type, as line-finders. Other types of connections are made via the appropriate relay set and line-finder, using the connecting circuit as a selecting device only during the setting up of the call.

Numbering Scheme.

The extensions are numbered 21 to 69, level 1 being left spare. Single-code digits are used as follows:—

- 7—Direct access to inter-switchboard lines.
- 8—Night service access to incoming exchange and inter-switchboard calls.
- 9—Direct access to main exchange, outgoing calls.
- 0—Operator.

OUTLINE OF OPERATION

A brief description of the operation of the equipment can be given by considering in turn the following classes of call:—

- (a) Extension to extension.
- (b) Outgoing, direct access by dialling.
- (c) Outgoing via manual board.
- (d) Incoming via manual board.
- (e) Incoming direct into auto equipment.

A trunking diagram of the P.A.B.X. is given in Fig. 4 and will be referred to in the explanatory outline in the paragraphs which follow.

Extension-to-Extension Calls.

The operation of the line relay in the extension line circuit causes a start signal to be given, via the common start circuit, to a free connecting circuit. The calling extension is found by the associated line-finder (LF) and dialling tone is returned from the connecting circuit. The

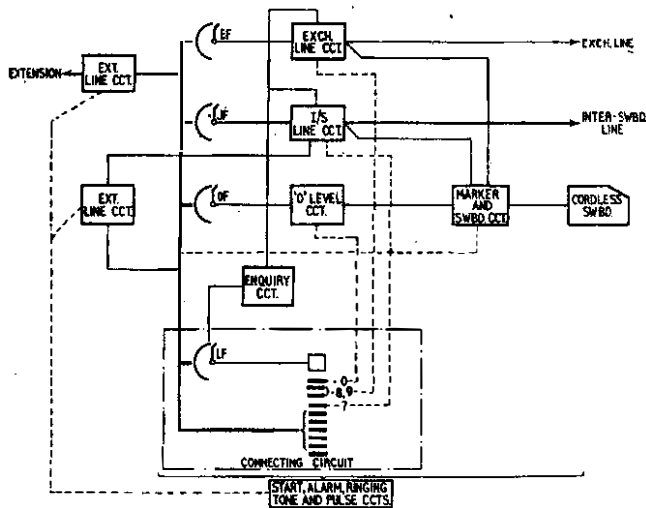


FIG. 4.—TRUNKING ARRANGEMENTS OF P.A.B.X. NO. 1.

required extension is obtained by dialling into the connecting circuit selector, connection being established over the extension line multiple connected to levels 2-6.

Outgoing Calls, Direct Access by Dialling.

Two classes of call are concerned: to the exchange or to another P.B.X. To obtain the exchange, code digit 9 is dialled into the connecting circuit which acts as a "discriminator," causing a free exchange circuit finder (EF) to find the calling extension. The connecting circuit is then released. The caller is thus switched through directly to the exchange and may continue setting up the call as appropriate. The procedure of obtaining access to another P.B.X. over an inter-switchboard line is similar except that code digit 7 is dialled and the call routed via line-finder JF and the inter-switchboard line circuit.

Outgoing via Manual Board.

While it is intended that all types of call should, as far as possible, be completed automatically, facilities are provided whereby the operator can set up the call. Access to the operator is obtained by dialling "0," and the connecting circuit is used to select the "0" level circuit, connection to the manual board being ultimately established via the finder OF and the "0" level circuit. A flicker calling signal is connected to the "0" level line lamp on the switchboard and the operator answers by operating the associated speak key. If the extension requires an exchange or inter-switchboard call, the operator may set up the call using an exchange or inter-switchboard line circuit and then key it to the extension. The circuit switches to the extension and releases the "0" level circuit if this is still held by the extension. Should the caller have replaced his receiver he is automatically rung by the exchange or inter-switchboard line circuit in the normal manner.

Incoming via Manual Board.

All incoming exchange calls are received at the manual board. Inter-switchboard and private circuits where automatic signalling or dialling cannot be used are similarly connected.

When an incoming call occurs, a calling signal is given on the associated line lamp on the switchboard. The operator answers the call by operating the speak key and, after ascertaining the extension required, depresses the digit keys corresponding to the number of the extension required. The exchange line circuit line-finder (EF) is driven to the position corresponding to the extension and, if the extension is free, ringing conditions are applied to the line. If the

extension is engaged, busy flash is given on the line lamp. In either case the operator may retire from the circuit, leaving the call to be automatically connected when the extension becomes free or answers.

Incoming Calls Direct into Auto-Equipment.

This type of connection can only be made over an inter-switchboard circuit. Referring to Fig. 4, an extension line circuit is shown associated with the inter-switchboard circuit. An incoming call over an inter-switchboard line will be connected initially via this extension circuit to a connecting circuit. The wanted extension will be dialled and upon the receipt of the two digits the connecting circuit will cause the line-finder (JF) to find the required number. The connecting circuit will then be released.

OUTLINE OF CIRCUIT OPERATION

It will have been realised from the general description given in the preceding section that, because of the method used in setting up the various classes of connection, the circuits concerned are very closely related and to a large extent functionally inter-dependent on common control equipment.

For automatic calls the connecting circuit provides a discriminating point and controls the routing of the call, taking into account its point of origin and the level and contact dialled. The manual call needs no discrimination because the circuit will be selected by the operator, but such connections are ultimately routed entirely through the automatic equipment, the switchboard having a controlling function only; arrangements must, therefore, be made to enable the operator to exercise such control.

Common-Start Arrangements.

Fig. 5 shows the circuit element of the start connections between line circuits and connecting circuits; the common

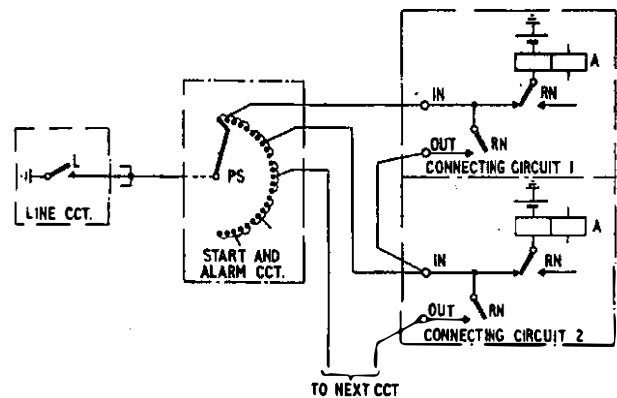


FIG. 5.—START CHAIN BETWEEN LINE AND CONNECTING CIRCUITS.

start circuit connections are shown in outline in Fig. 6. Referring to Fig. 5, a connecting circuit is seized by the operation of its A relay and, when engaged, the operation of RN will cause the common start wire to be connected to the next circuit, and so on. Normally, therefore, the first free circuit will be seized, but the first choice is continually changed by the action of the pulse switch (PS). This switch is non-homing and is provided primarily for the distribution of pulses throughout the equipment. It steps at about 0.4 sec. intervals during the establishment of any connection. Spare arcs are, however, available and wiring the start commons through these, as shown, ensures rotation of the first-choice circuit, thus preventing a faulty circuit being repeatedly picked up during slack periods.

Extension Marking and Discrimination by the Connecting Circuit.

Fig. 6 shows the multiple connections between the line-finders and connecting circuit selectors, excluding the speaking connections. It is over wires HF, BD, H and J that marking and discrimination is done. For the ordinary extension-to-extension call the HF wire and H wire from the selector have functions similar to those of the private circuit in automatic exchange practice.

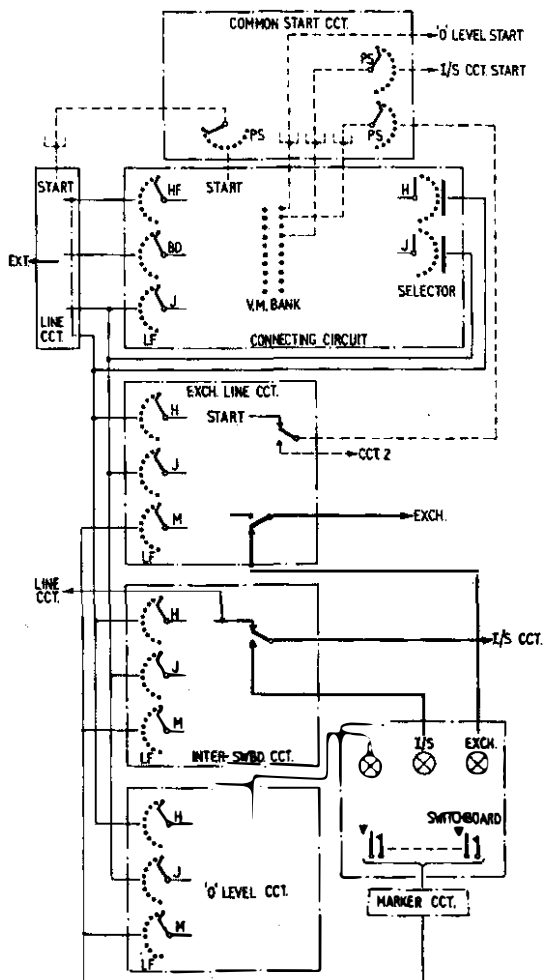


FIG. 6. ARRANGEMENT OF MARKING AND CONTROL CONNECTIONS BETWEEN CIRCUITS.

When an extension call sets up an exchange call, "9" is dialled into the connecting circuit. The BD connection is used to discriminate whether or not the extension is allowed direct access to the exchange. If allowed, an earth will be extended from the line circuit over this wire and, as a result, the connecting selector will, over the 9th level of the vertical marking bank, apply a start condition to the line-finder of a free exchange circuit via the start chain. At the same time the J wire of the line-finder multiple will be marked with a battery condition by the connecting circuit and this will be found by the exchange circuit line-finder. The exchange line circuit will take over the connection, and, by connecting an earth to the H wire and thence to the HF wire, will not only guard the circuit but also cause the release of the connecting circuit. The extension is thus connected directly to the exchange line.

"0" level and outgoing inter-switchboard calls are similarly switched when "0" or "7" is dialled. On an incoming inter-switchboard call, however, the inter-switchboard circuit is connected, upon seizure, to its own line circuit and thence to a connecting circuit. On the

J wire to the connecting circuit line-finder a condition will be applied which will inform the connecting circuit that the call originates from an inter-switchboard circuit and, as a result, when the extension number has been dialled, the connecting circuit selector will return a marking condition on the J wire of the selector bank. At the same time, over the BD wire, the connecting circuit will return a battery condition which will cause the inter-switchboard line-finder to rotate, find the called extension and release the connecting circuit from the connection. If "0" is dialled over the inter-switchboard circuit an earth condition will be returned from the connecting circuit over the BD wire and this will cause the line lamp on the switchboard to be lit and the connecting circuit to be released. The operation of the associated speaking key will connect the inter-switchboard line direct to the switchboard.

Control by the Operator.

Exchange line and inter-switchboard circuits are not wired through the switchboard; they are connected to the switchboard and marker circuit over common-access wires by operating the appropriate speaking key. Fig. 7 shows the

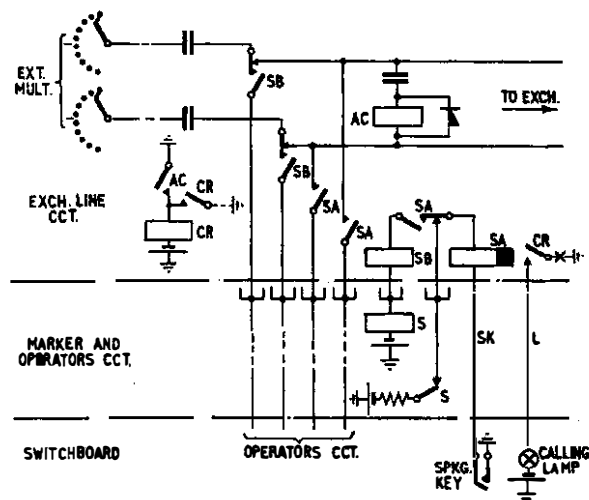


FIG. 7.—CONNECTION OF EXCHANGE LINE CIRCUIT TO OPERATOR.

method of connecting the exchange line circuit to the switchboard, other circuits being similar. It will be noticed that the only permanent connections to the switchboard are the L and SK wires. The operator obtains control of the circuit by operating the speaking key which, assuming no other speaking key is operated, operates the access relays SA and SB. Fig. 7 also shows how the speaking connections are switched, but there are other wires similarly switched to enable the operator to obtain full control. The supervisory conditions given to the operator on the calling lamp are:—

- | | |
|--------------------------|-------------------------------|
| (a) incoming call | — int. earth 0.4 sec. on/off, |
| (b) extension engaged | — busy flash, |
| (c) extension being rung | — steady glow, |
| (d) speaking condition | — lamp out. |

Access to the extension circuits is obtained over the exchange, inter-switchboard and "0" level circuits by keying the required extension number. How this is done will be shown by the help of Fig. 8. The operation of the speaking key operates relays SA and SB as previously mentioned, and the drive circuit of the exchange circuit line-finder is brought under the control of the marker circuit. The operator keys the first digit and it is stored in the "tens" storage group. The digit keys are switched to the "units" storage group by the switching relay RX, and the units digit is keyed.

The storage relays and their associated contact arrangement for marking purposes follow conventional lines and have not been shown in Fig. 8. There is, however, one point

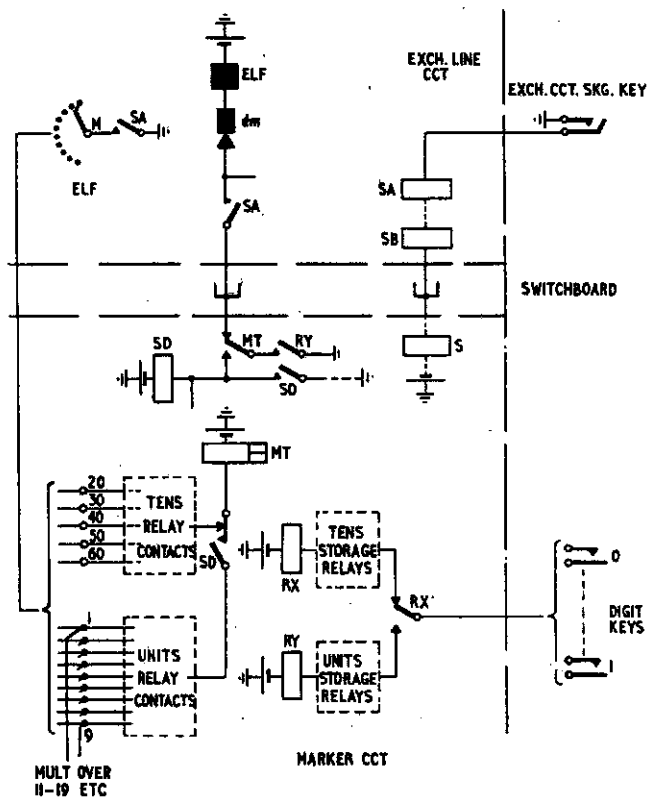


FIG. 8.—MARKING ARRANGEMENTS FROM SWITCHBOARD.

of interest in that the coding chosen differs from that normally used. It is arranged so that as far as possible, on all sizes of the P.A.B.X., keying an unused tens digit will operate a cut-off relay and not result in a wrong number. The operator will be apprised of incorrect keying by the retention of the calling signal on the calling lamp.

The exchange circuit finder (ELF) is set in motion when the units digit is stored, i.e., when relay RY operates. Design economics dictate that the units marking should be common and thus the line-finder must first be positioned on the first contact of the units group concerned. The tens marking is therefore wired to contacts 20, 30, etc., and the operation of the cut-drive relay, MT, will arrest the line-finder on the first contact of the group required. Relay SD will then operate and MT will be connected in turn to the units digit marking. The line-finder will be restarted and will find the units digit. The extension will be rung from the exchange line relay set and the operator releases the marker and position circuit from the connection by the restoration of the speaking key. Alternatively she may fully supervise the call by keeping the speaking key operated until conversation commences.

SPECIAL FACILITIES

When a subscriber makes a call to a P.B.X. further progress of the call is under the control of the P.B.X. operator. The difficulties in recalling the P.B.X. operator for the purpose of transferring the call to another extension, or correcting a mis-routed call, often make it necessary for the calling subscriber to originate a second exchange call to re-establish connection to the P.B.X. operator. As far as possible, the P.A.B.X. No. 1 removes these difficulties. Firstly, an automatic "ring when free" facility is provided and, secondly, enquiry and transfer facilities under the control of the extension user are available on incoming and outgoing exchange, and inter-switchboard calls. Apart from the service advantages gained, the inclusion of these facilities, together with automatic clearing, which is

fundamental to cordless working, does meet a main design objective—that of minimising the switchboard operator's duties.

"Ring When Free."

When an engaged extension is "keyed" by the operator the supervisory lamp of the exchange or inter-switchboard line concerned will flash. If the caller waits, restoration of the speaking key causes the connection to remain set up continually testing the engaged extension circuit and making connection when it becomes free.

The facility is given by arranging for the testing circuit to be continually applied to the engaged circuit as illustrated in Fig. 9. Relays ET and H will not operate when an

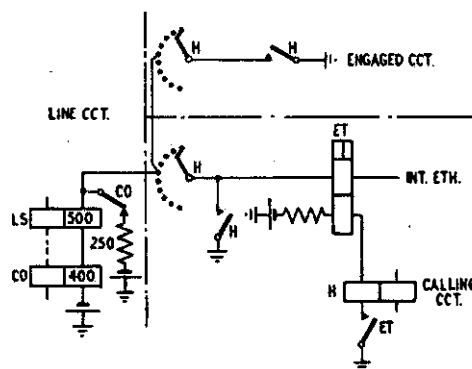


FIG. 9.—"RING WHEN FREE" FACILITY.

engaged condition exists on the H wire and busy flash will be returned to the operator. The testing relay ET is, however, continuously applied and as soon as the circuit becomes free the caller will be connected. Earth pulses 0.4 sec. every 10 sec., are connected to ET because a continuous earth condition would not allow relays LS and CO in the line circuit to release and the 200-ohm testing battery, essential to the operation of ET, would not be reconnected to the H wire.

Enquiry and Transfer.

When connected to an exchange or inter-switchboard circuit an extension user may:—

- (a) Make another call on the same telephone for the purpose of making an enquiry, the original connection being held.
- (b) Return to the original connection or, alternatively, transfer it to another extension.
- (c) Call in the operator.

Each extension instrument is provided with a press button the depression of which will send a discriminating signal into the automatic equipment so that the necessary switching can take place. The sequence of operations can be described with the aid of Fig. 10.

Assuming that extension A is engaged upon an exchange call, depression of A's button will cause the exchange circuit to be held and at the same time seize the enquiry circuit. This enquiry circuit is connected to the first contact of the LF multiple (which is why the P.A.B.X. has a capacity of only 49 and not 50 extensions). A start condition is applied to a free connecting circuit, the enquiry circuit will be found, and A will thus be connected to a connecting circuit. Extension B may be called and, at the conclusion of the conversation, a further depression of A's button will re-establish the original exchange connection. Should A, however, wish to transfer the exchange call to B, A will replace the receiver without depressing the button and this will cause the exchange circuit line-finder to be set in motion, find, and connect to B. Should A require to speak

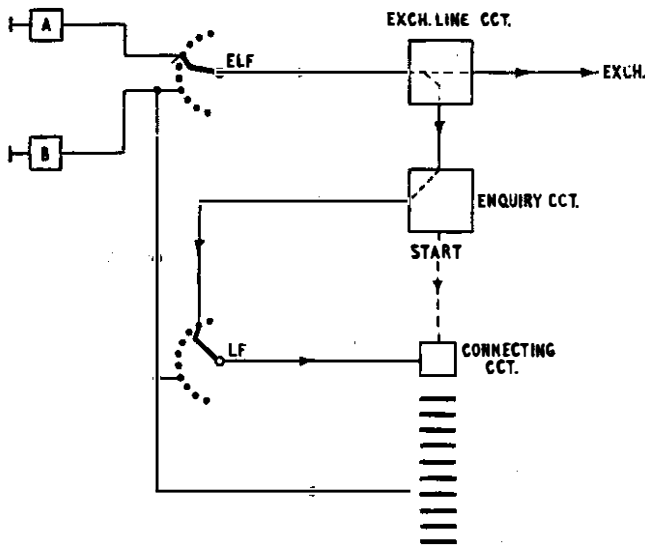


FIG. 10.—ROUTING OF ENQUIRY CALL.

to the operator, a second depression of the button after the enquiry circuit has been seized, i.e., prior to dialling, will cause flicker earth to be connected to the exchange connection switchboard lamp, thus attracting the operator's attention.

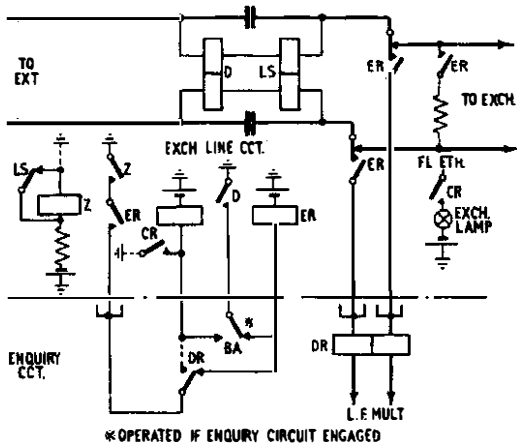


FIG. 11.—CONNECTION TO ENQUIRY CIRCUIT.

Fig. 11 shows the main circuit elements. Essentially the control is vested in the three relays, D and LS in the line circuit and DR in the enquiry circuit. Relay LS remains operated during the call because of the current flowing around the extension loop, but D and DR are differentially connected, operating only when the line is unbalanced by the depression of the telephone press button, which connects both wires to earth.

The following operations are possible:—

(a) *Seizure of enquiry circuit*—operation of relay D, which in turn operates ER and connects the exchange connection to the enquiry circuit. Alternatively, if the enquiry circuit is engaged the lamp on the switchboard is flashed and the operator may take over.

(b) *Call operator*—operation of DR (second depression of push button prior to dialling). Again the call is reverted to the P.A.B.X. operator and the enquiry circuit released.

(c) *Restore to original call after enquiry*—operation of DR releases the enquiry circuit and restores the original connection.

(d) *Transfer original call*—receiver replaced and LS releases. The exchange circuit line-finder rotates to find the

extension called. A marking condition is applied to the LF multiple from the enquiry circuit via the connecting circuit as set up by the extension making the enquiry (this is somewhat involved and is not shown in the circuit element in Fig. 11).

Disconnect-Clearing Equipment.

As the facility of direct dialling to the public exchange is available, it is desirable that the exchange line is entirely free of all connections before it is seized by a P.A.B.X. extension dialling "9". It is possible otherwise for an extension user when making a call to the public exchange either to re-seize the main exchange line before the switching equipment has released from a previous call or if the previous call is controlled by an operator, to seize the line before the operator clears the connection.

Normally the electrical conditions for the free and engaged line condition presented from the main exchange are similar. It is necessary, therefore, to provide equipment at the main exchange, known as "Disconnect-Clearing Equipment," which will give a 600-mS disconnection of the line when the exchange equipment releases. This disconnection is detected at the P.A.B.X. by introducing a high resistance relay MH across the line when the P.A.B.X. extension user clears.

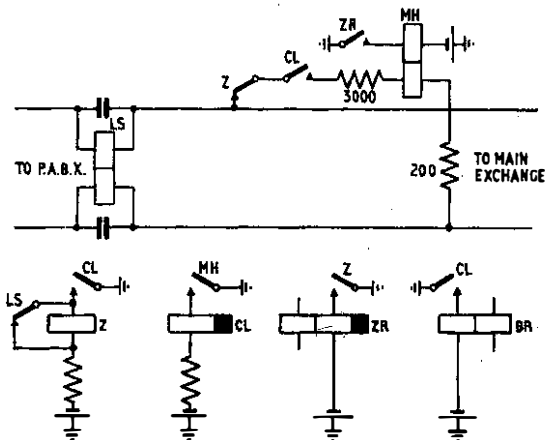


FIG. 12.—ARRANGEMENT FOR BUSYING P.A.B.X. EXCHANGE LINE RELAY SET UNTIL MAIN EXCHANGE EQUIPMENT CLEARS.

The circuit element is shown in Fig. 12. Relay MH is connected across the — and + lines and, when relays L and Z release, MH will hold until the main exchange equipment releases, thus busying the exchange line relay set at the P.A.B.X.

Night Service.

Service at night (or more correctly, service when P.B.X. switchboard is unattended) is normally given by connecting the exchange lines to selected extensions. This is known as "direct extension night service" and the extensions concerned operate as direct exchange lines, all P.B.X. switching facilities being lost. The limited communication provided by such means adequately meets the need of many subscribers because their business is such that international communication is rarely required after office hours.

A subscriber may well justify the additional cost of P.A.B.X. because he requires inter-communication to be available throughout the 24 hours. Further, it is a particular advantage of the cordless P.A.B.X. that operating attention is reduced to a minimum, an advantage which would be lost

if the retention of an operator was necessary to obtain full continuous service. It is arranged therefore to retain the essential switching facilities during night service conditions without the necessity for an operator.

It is because of the existence of the enquiry and transfer facilities that these night service arrangements are possible. The operation of the night service key on the switchboard brings into operation a bell or number of bells, placed at convenient points, which will ring when an incoming exchange or inter-switchboard call is received. Dialling "8" from an extension will cause the incoming call to be switched to that extension. It can then be dealt with and transferred to another extension as required.

It might well be asked why this arrangement cannot be made a permanent feature and an operator dispensed with entirely. The reason is, of course, that this method of dealing with incoming calls can only be used to handle a limited amount of traffic and can only be operated during slack periods. It may be of interest to mention that some telephone administrations do offer "subscriber attended" P.A.B.X.s, but up to the moment the Post Office has regarded the provision of a switchboard as essential.

Miscellaneous.

Apart from routine visits, P.A.B.X.s are maintained on a fault-reporting basis and essential alarms are, therefore, extended to the switchboards. Mains failure alarm is provided as in standard P.B.X. practice. Automatic equipment release alarms are given in a similar manner to main exchange practice, the alarm lamp being fitted on the switchboard.

A P.G. alarm is also provided to warn the operator when an extension circuit is continuously held, either because of fault conditions or failure to replace the hand-set. A common P.G. pilot alarm lamp is provided on the cordless switchboard, but the operator may locate the extension concerned by using an "0" line circuit and keying extensions in succession. When the faulty circuit is reached, it is indicated by the P.G. pilot and "0" line lamp being extinguished together.

If there is more than one P.G. condition the "0" line lamp only is extinguished and the operator continues to key the remaining extension lines until all P.G. lines have been located.

(To be continued)