

# A Modern Cordless P.A.B.X.

G.E.C. Type : PB.4200

B.P.O. Reference : GEC.4.



124 ✓

Figure 1. Desk console

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(Retracted) ✓

*In this age of high-speed communication, the telephone has become an integral part of, rather than a subsidiary aid to, the functioning of an organisation. As a result, the requirements for speedy intercommunication have become far more exacting than hitherto. This article describes a private automatic branch exchange in which the role of the operator is that of assistant primarily concerned with routing incoming calls to a required extension. A normal system can cater for up to 150 circuits to the operator's console, divided between public exchange, interswitchboard, extension access, and operator access lines. The exchange can accommodate a virtually unlimited number of extension lines. Direct access to exchange lines for extensions, together with full automatic enquiry and transfer facilities, are provided. The equipment can also be used as a tandem exchange between interswitchboard lines.*

A private branch exchange takes one of three forms. Firstly, there is the all-manual system (p.m.b.x.) whereby all calls, internal and external, are routed via the operator. Secondly, there is the manual external system working side by side with an automatic internal system (p.m.b.x. + p.a.x.). This second form may be two completely independent equipments, with all the attendant duplication of apparatus, or the two systems can be integrated (p.a.b.x.).

The logical development of a branch exchange is the one in which the extension is his own operator for the purpose of setting up calls, without reference to the exchange operator. This leaves the switchboard free to deal with incoming calls and situations where operator assistance is required. Small cordless p.a.b.x. installations have been in use for a number of years. However, it is only recently that cordless-switchboard systems having a capacity of more than 100 extension lines have been available. The equipment to be described has been introduced by the G.E.C. to simplify the operator's work and provide a modern operating console.

## Features

**Incoming Calls.** All public exchange calls are routed to the operator for connexion to the required extension. Interswitchboard calls can be routed either to the operator or direct to the extension circuits, as required.

**Outgoing Calls.** All extensions can gain access to public exchange lines by dialling digit '9' but complete or partial barring may be applied to selected extensions if required. Access to interswitchboard lines is gained either via the operator or by dialling the appropriate routing digits.

**Enquiry and Transfer.** Any extension can make an enquiry call to another extension while holding a public exchange or interswitchboard call. Similarly, a call can be transferred from one extension to another. Enquiry and transfer may be repeated as often as required.

**Internal Calls.** Extension-to-extension calls are fully automatic. The enquiry and transfer facility is inoperative on internal calls. To avoid a congestion on equipment due, for example, to a receiver having been incorrectly replaced, first-party release is given.

**Executive Working.** When required, an executive can gain priority operator service on lifting the handset by connecting the extension direct to the console bypassing the selector circuits. He is also able to dial calls himself from the same telephone. When permitted by the Telephone Administration, an executive can introduce an "executive waiting" tone on a busy extension line when he requires urgent connexion to that extension.

**Operator Services.** In addition to answering incoming calls from the public exchange, the operator, when required, sets up outgoing calls particularly from barred and restricted extensions. An indication of "all circuits busy" in any individual route is given by ROUTE BUSY lamps on the console. All calls are set up by means of a 10-digit keysender. A call can be trunk offered to any engaged extension by dialling an additional digit '1'. The operator can be called into a public-exchange or interswitchboard connexion by the extension, and if necessary take over the call. She is able to hold and/or monitor any connexion into which she has been brought.

**Tandem Working.** The equipment can be used as a tandem exchange between interswitchboard lines.

**Night Service.** Full night-service working is provided either by means of a night-attendant's cabinet or by any, or selected, extensions. A call can then be transferred in the normal manner. Outgoing calls are achieved in the normal manner without operator assistance.

## Desk Console

The console-type switchboard is floor mounting and is shown in figure 1. All connexions are established by key operation and keysending. Calling and supervisory lamps are associated with each key. The maximum number of external routes on a standard console is thirty; these are divided between the p.a.b.x., public exchange, and inter-switchboard lines.

The operator answers a call coming into the console by the operation of two keys, a CONNECT circuit key, and either a PABX, public EXCHANGE, INTERSWITCHBOARD or EXECUTIVE route answer key depending on the class of call. A splitting key designated SPEAK PABX/LINE enables the operator to converse with an extension to the exclusion of, but holding, a public exchange line, or vice versa, or to intrude on a conversation (with the key in its central position) when assistance is required. When this intrusion facility is in use, a subdued clicking tone is superimposed to indicate to the conversing parties that the conversation is no longer private. Associated with each CONNECT key are three indicator lamps. The uppermost is arranged to glow when the keysender is pulsing out, while the other two, designated SUPY 1 and SUPY 2, indicate the state of any attempted connexion. Separate ROUTE BUSY lamps are provided for each group of lines, to give an immediate indication of congestion.

A keysender is provided for setting up all calls, whether to extension or public exchange lines. To eliminate any inconvenience in the unlikely event of failure of the keysender, a normal dial is also provided. This is usually out of circuit, and is brought into use by means of a key switch on the console.

For use in s.t.d. areas, timing meters, additional to any fitted in the apparatus room, can be provided to allow the operator to time calls. Up to four of these console-mounted meters, each with its own "in use" indicator lamp, can be provided and are brought into circuit by means of key switches.

Finally, three lamps are fitted to indicate the number of calls, whatever their source, awaiting the operator's attention. The lamps are designated CALLS WAITING, BUSY and CONGESTION. A typical method of operation is for the CALLS WAITING lamp to light for two to six calls waiting, the BUSY lamp for six to twelve calls, and the CONGESTION lamp for twelve or more calls. The number of calls waiting at each stage before its respective lamp will light can be varied to suit individual customer requirements.

The system can be extended easily to incorporate more operators by adding further positions as the overall capacity increases. Because there is no multiple connexion necessary between positions, multi-position consoles do not have to be installed "en suite". The console facia panel is hinged so that it can be easily swung forward to allow access to the wiring at the back of the panel.

Access to the cable terminations is from front or rear so that the consoles may be located against a wall. The desk front allows plenty of space for writing, and compartments are provided for telephone directories and other references.

## Internal Calls

All internal calls are fully automatic. The caller establishes contact with another extension by dialling the appropriate number in the normal manner. If required by a customer, certain selected extensions may be auto-manual, as discussed later under "Executive Working", in this case, the calling extension has access to the operator console via a linefinder and not via the extension group selectors.

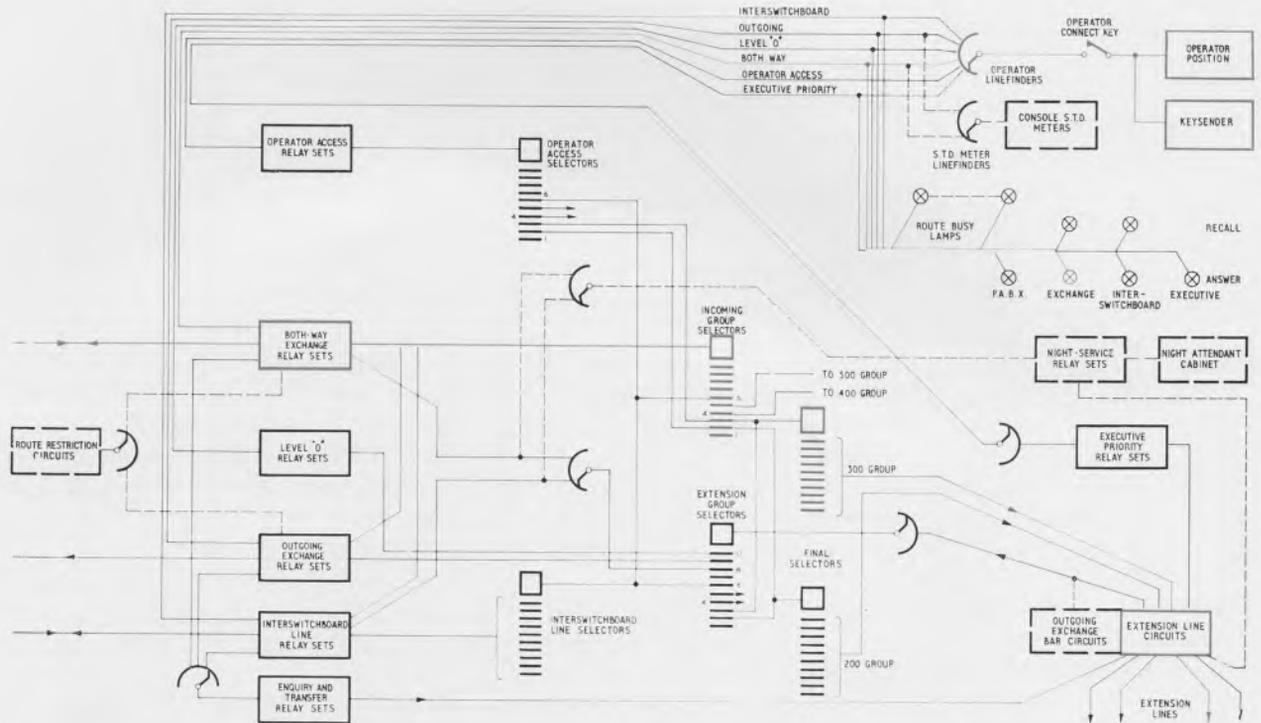


Figure 2. Trunking diagram for incoming calls

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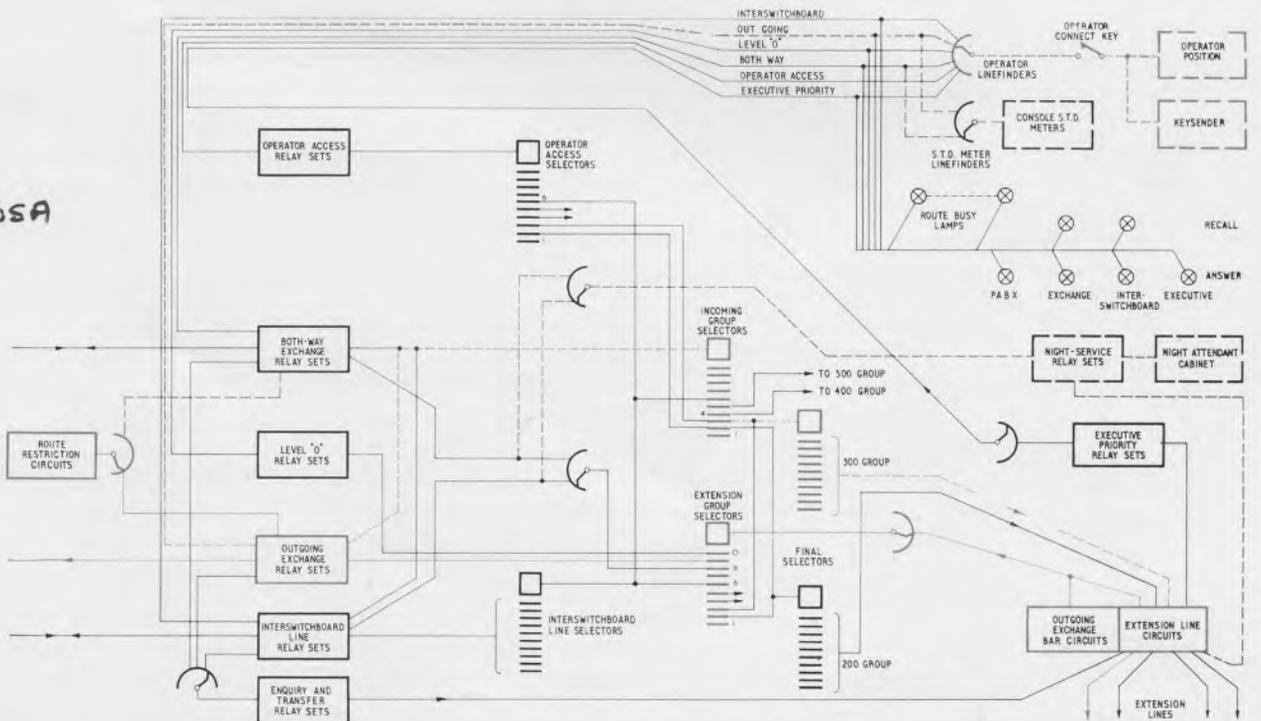


Figure 3. Trunking diagram for outgoing calls

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## Incoming Calls

The routing of an incoming call from the public exchange is shown in figure 2. An incoming call over the public exchange lines is routed first to the p.a.b.x. operator, via the appropriate relay set. The call is indicated at the console by an EXCHANGE ANSWER lamp lighting. When the operator presses one of the CONNECT keys and the EXCHANGE ANSWER key, the operator linefinder hunts until the calling line is seized. The operator is then connected to the caller for conversation. The linefinders used in the G.E.C.4 are of the non-homing type, *i.e.*, they remain in the position set by the previous call handled until required to hunt for a new call, this method reduces contact wear and provides a degree of call queueing.

Having ascertained the required extension, the operator sets the SPEAK PABX/LINE key to SPEAK PABX. This gives the operator access to an incoming first-group selector and applies a "hold" loop to the exchange line. The extension number can then be set up by the operator. After keying the number, the operator returns the SPEAK PABX/LINE key and CONNECT key to their normal positions unless she wishes to introduce the call privately. The operator is still in circuit until the CONNECT key is restored. Ring-when-free is automatically available when connexion to a busy extension is attempted. Alternatively, the operator can trunk offer by keying the additional digit '1'. The operator is then connected to the busy line and the operator-intrusion tone is superimposed, the required extension is rung automatically when the extension receiver is replaced.

At any stage the operator may retire from the circuit by releasing the CONNECT key. Connexions are then released from the console, and controlled by the connected parties. Unanswered calls are automatically held so that the operator can contact the caller. If the operator remains in circuit on an answered call, a subdued intrusion tone is introduced to indicate to the conversing parties that the conversation is not private. Should the operator require to maintain the connexion on the console after the extension has answered, the HOLD key of the connecting circuit is operated. The operator can speak privately on the exchange line by setting the SPEAK PABX/LINE key to SPEAK LINE.

Where several telephones are located in the same room or office, arrangements for hunting over a group of 2-10 consecutive extension numbers can be included to minimise waiting delays when the first number is busy.

## Outgoing Calls

Figure 3 indicates the routing for outgoing calls. All extensions can have access to the public exchange by simply dialling digit '9' after which the extension hears the public exchange dial tone and then proceeds to complete the call by dialling the required number. If required, certain extensions can be barred direct access to the public exchange, either completely or partially.

Complete barring is introduced at the selector level. If a barred extension attempts to gain access to the public exchange by dialling '9', the number-unobtainable tone is returned to the extension. Route restriction is introduced at the exchange relay sets and can be used to allow an extension local calls but prohibit trunk calls, either s.t.d. or via the public exchange operator. When a restricted extension dials '9', the route-restriction linefinder seizes the line. If the extension then continues to dial a barred route, the route-restriction circuit returns the number unobtainable tone to the extension and releases the public exchange equipment. The barring category is determined by straps on the extension line circuit.

Extensions also have access to the public exchange lines via the p.a.b.x. operator. The extension dials '0' and is routed to the operator, via the level '0' relay sets. The

operator ascertains the required number and the number of the calling extension who then clears. The operator sets up the required call over an outgoing line and when the called party answers, calls back the extension via an incoming group selector, as for a normal incoming call. This routing is indicated by the dotted lines on figure 3.

### Interswitchboard Calls

Interswitchboard calls may be established in a similar manner to calls to and from public exchanges. If outgoing auto-access is permitted, an extension seizes the interswitchboard lines by dialling the appropriate routing digit. An incoming call can either be routed to the operator's console, or be given access to an incoming group selector.

Facilities are incorporated whereby the p.a.b.x. can be used as a tandem exchange between interswitchboard lines. This is of considerable importance where there are a number of private exchanges requiring full intercommunication facilities and it is not practicable, technically or economically, to interconnect each exchange directly. The calling extension dials the required code to connect to the central tandem exchange. The equipment can be arranged so that either the p.a.b.x. operator sets up the required call, or the calling extension is given direct access to the incoming first group selectors and dials the appropriate routing digits to give access to the required exchange.

The inclusion of the tandem-working facility could give an incoming public-exchange call access to an interswitchboard line. This is permissible on interswitchboard extension line working but not on a private wire. When private-wire working is used, an exchange call is barred by means of a signal fed from the exchange relay set to the interswitchboard relay set. This does not prohibit an enquiry call, but it does prohibit a transfer of an exchange call to a private wire.

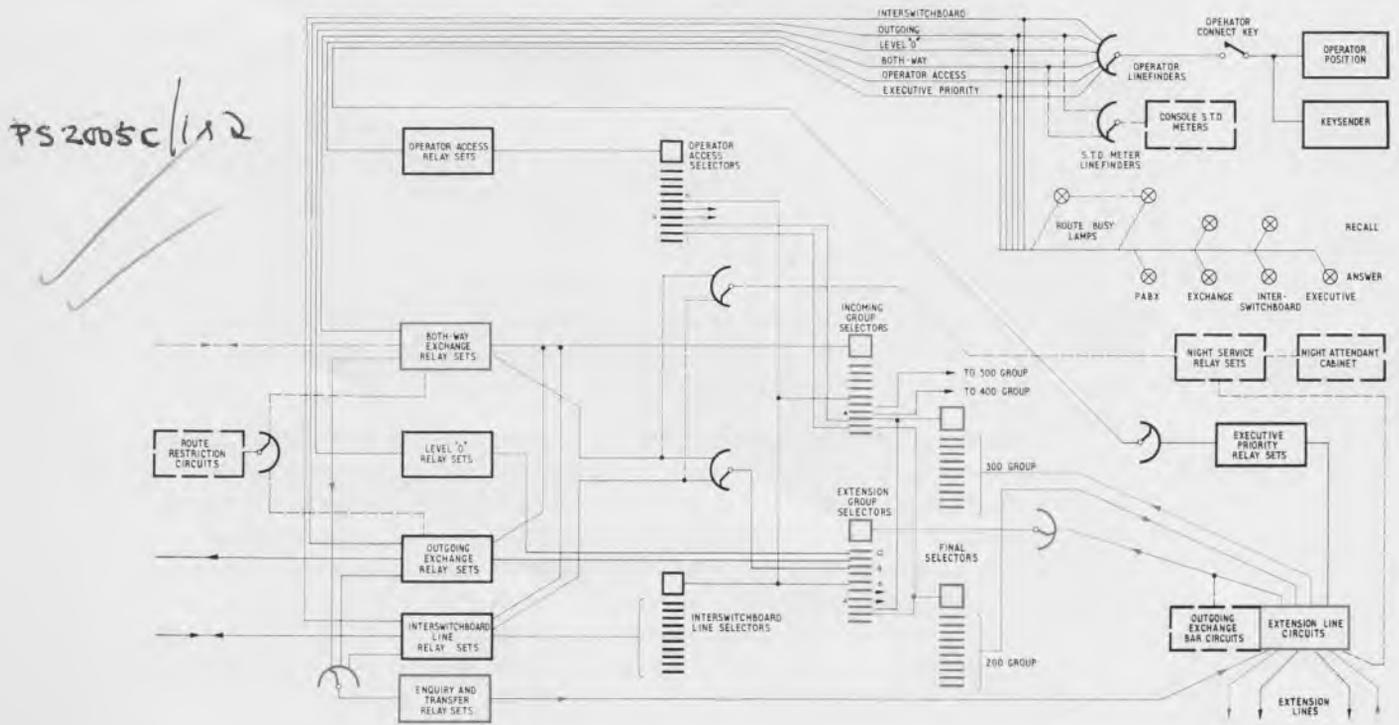


Figure 4. Trunking diagram for enquiry and transfer

## Enquiry and Transfer

The enquiry and transfer facility can only be used when an extension is connected to an external call. To initiate an enquiry call, the extension presses an ENQUIRY button on the instrument to apply a signal to the exchange relay set. Figure 4 shows the condition that exists when it is required to initiate an enquiry call from an incoming public-exchange call. This signal fulfils two functions: first, it seizes a vacant enquiry relay set, and second it enables a hold loop to be applied to the exchange line. When this sequence is complete, the extension has access to an extension group selector. A second extension number can then be dialled while the exchange line is still held at the exchange relay set. If all the enquiry circuits are busy, "operator recall" is automatically given and the operator can be requested to transfer the call if this is required. At the completion of the enquiry, the first extension presses the ENQUIRY button again to release the enquiry call and restore connexion to the exchange line. If the first extension desires to transfer the call to the second extension, all the first extension has to do it replace the handset. The call is then extended to the second extension, via the enquiry circuits, and the incoming selector lines are cleared. If an extension calls another extension for the purpose of transferring an incoming call and receives no reply, or, conversely, the wanted extension is engaged at that time, any attempt made to evade the responsibility of further dealings with the call by replacing the extension instrument handset results in the telephone instrument receiving continuous ringing current. Ringing continues unabated until communication has been re-established with the original calling party. The provision of this safeguard ensures that virtually no calls can be "lost" through negligence or design and that a transfer can be only effected after the desired party has answered his or her telephone.

## Executive Services

When required, executives can be given direct access to the operator immediately on raising the handset. When the handset is lifted, an executive linefinder hunts for the line and passes the signal direct to an EXECUTIVE ANSWER lamp on the console. If the executive does not require operator assistance, normal access is gained to the p.a.b.x. equipment by pressing a button on the instrument.

A further facility that can be incorporated is that of executive right-of-way (E.R.O.W.). This can only be included when permitted by the local Telephone Administration. If an executive dials a busy extension, he can superimpose an "executive waiting" tone on the conversation by dialling the additional digit '1', the executive's speech circuit is unconnected at this stage. As soon as the wanted extension clears, the bell rings and the call can be completed.

## Night Service

To provide maximum telephone facilities out of normal working hours, night-service operation is introduced. It will be appreciated that virtually all outgoing calls can be established in the normal manner by extensions dialling direct, restricted or barred extensions have to make calls via the night-service attendant, where such facility exists. Because the operator's console is unstaffed, a different system for dealing with incoming calls is required.

The simplest method of night service is to have one or more bells situated around the establishment which ring when an incoming call is waiting. Any extension can gain access to the calling line by dialling digit '8' and the circuit is completed via the extension group selectors (and the level '8' linefinders if the number of exchange lines exceeds ten)—figure 5. The call can then be completed to the wanted party by the enquiry and transfer facility. If a second call is waiting while an extension is connected to the first call, the common bells continue to ring. The calling bells are separate from the normal instrument bells.

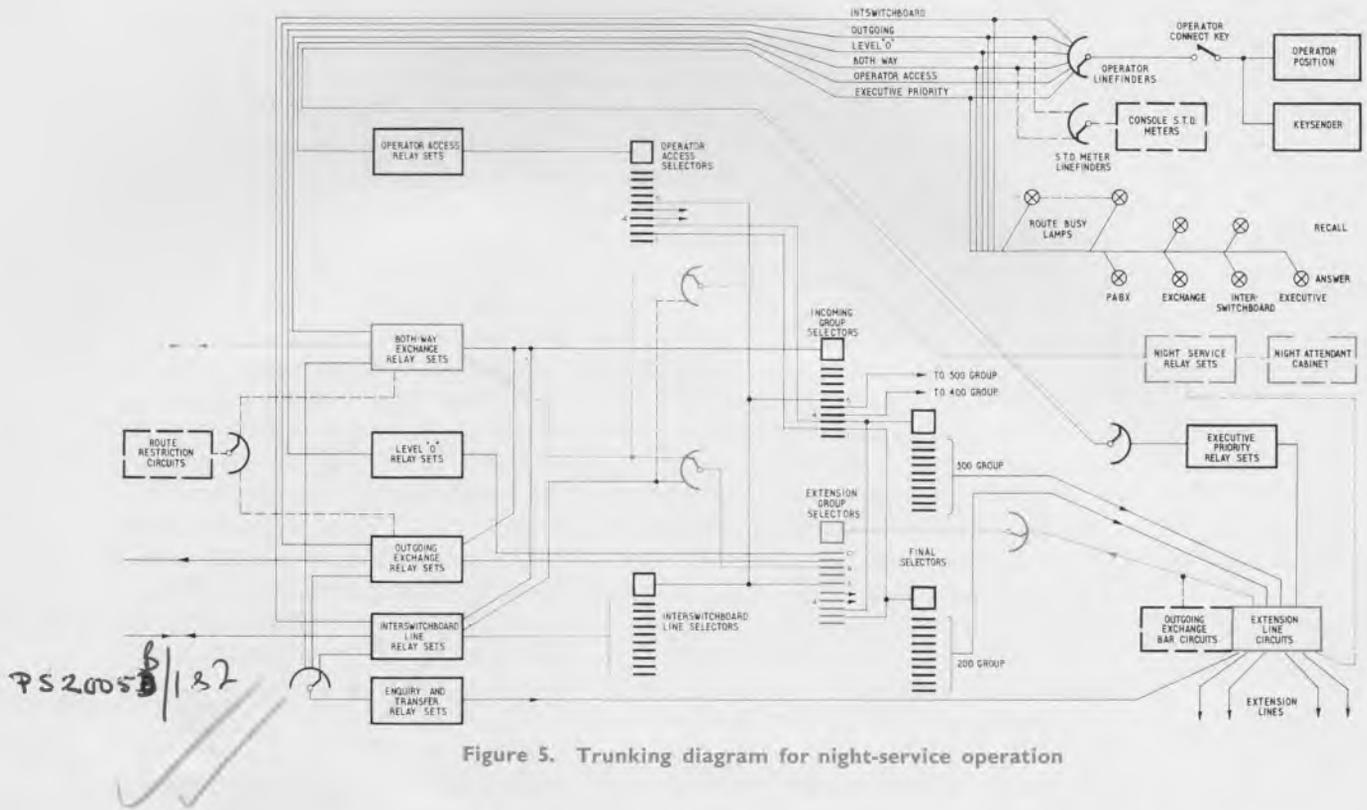


Figure 5. Trunking diagram for night-service operation

A second method is to route each exchange line, or group of exchange lines, to selected extensions. In this case the selected extension has direct access to the incoming line without dialling digit '8', instead of a common bell, the bell of the designated telephone rings. If the extension is using his telephone when an incoming exchange call requires his attention, a "ticker" tone is introduced on the existing conversation to indicate the fact.

When it is required to have the night service under the control of, for example, the night security staff, a night-service attendant's cabinet can be installed, a typical example of which is shown in figure 6. All incoming calls are routed to the cabinet and indicated by lamps. The attendant is able to connect to or hold calls in much the same way as the night service extension. The main difference is that two or more answering circuits are available and trunk offering can be given.

### Conference Lines

These lines enable a conference to take place by telephone while the participants remain at their desks. The connexions can be set up from a single point, for example, from the supervisor's position or from a selected extension. The conference may be entirely between extensions, or may include one public exchange or interswitchboard line. In any event, the number of extensions that may participate will depend on the line-loading conditions as fixed by the local Administration.

### Fault Location Alarms

When an operator, attempting to originate or answer a call, encounters a fault that appears to lie in the relay set on which the particular operator linefinder stands, the faulty set can be identified and busied out by means of a line identification cabinet, (figure 7), usually mounted adjacent to the console. The cabinet contains a series of lamps,

one for each relay set, and associated BUSY keys. The relevant console CONNECT key is left operated while the cabinet LINE key is operated until a LINE lamp glows. This lamp indicates the relay set concerned. To busy out the relay set, the appropriate BUSY key is pressed. Additional lamps are provided to give the operator an indication of any alarm conditions in the automatic equipment. Any faults arising that adversely affect the operation of the exchange give rise to audible and visible alarms on the automatic equipment and/or at the console. An alarm signal is caused by any of the following:

- |                                       |                                      |
|---------------------------------------|--------------------------------------|
| Blown fuse                            | Failure of charging equipment supply |
| Selector failing to restore to normal | Permanent loop on an extension line  |
| Ringing supply failure                | All connect circuits busy            |

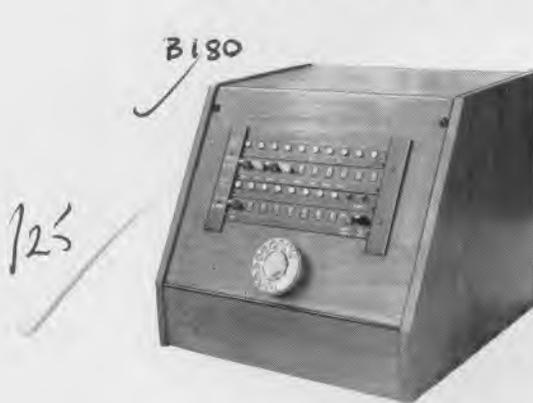


Figure 6. Night attendant's cabinet

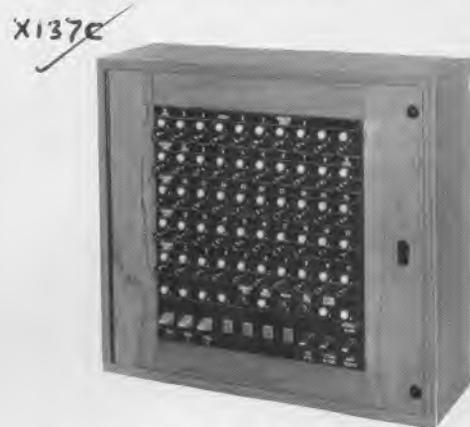


Figure 7. Line identification cabinet

## Exchange Equipment

The automatic switching apparatus is mounted on single-sided open racks providing easy access to the equipment for maintenance (see figure 8). The racks are 7 ft 6 in (225 cm) and 4 ft 6 in (137 cm) wide, except the combined M.A./ringer rack, which is 7 ft 6 in high and 2 ft 9 in (84 cm) wide. A main distribution frame is provided to facilitate connexions between the extensions, exchange lines, interswitchboard lines, and the exchange. The system comprises five different racks.

- |                              |                           |
|------------------------------|---------------------------|
| Line and final selector rack | Operator's connect rack   |
| Group selector rack          | Combined M.A./ringer rack |
| Relay set rack               |                           |

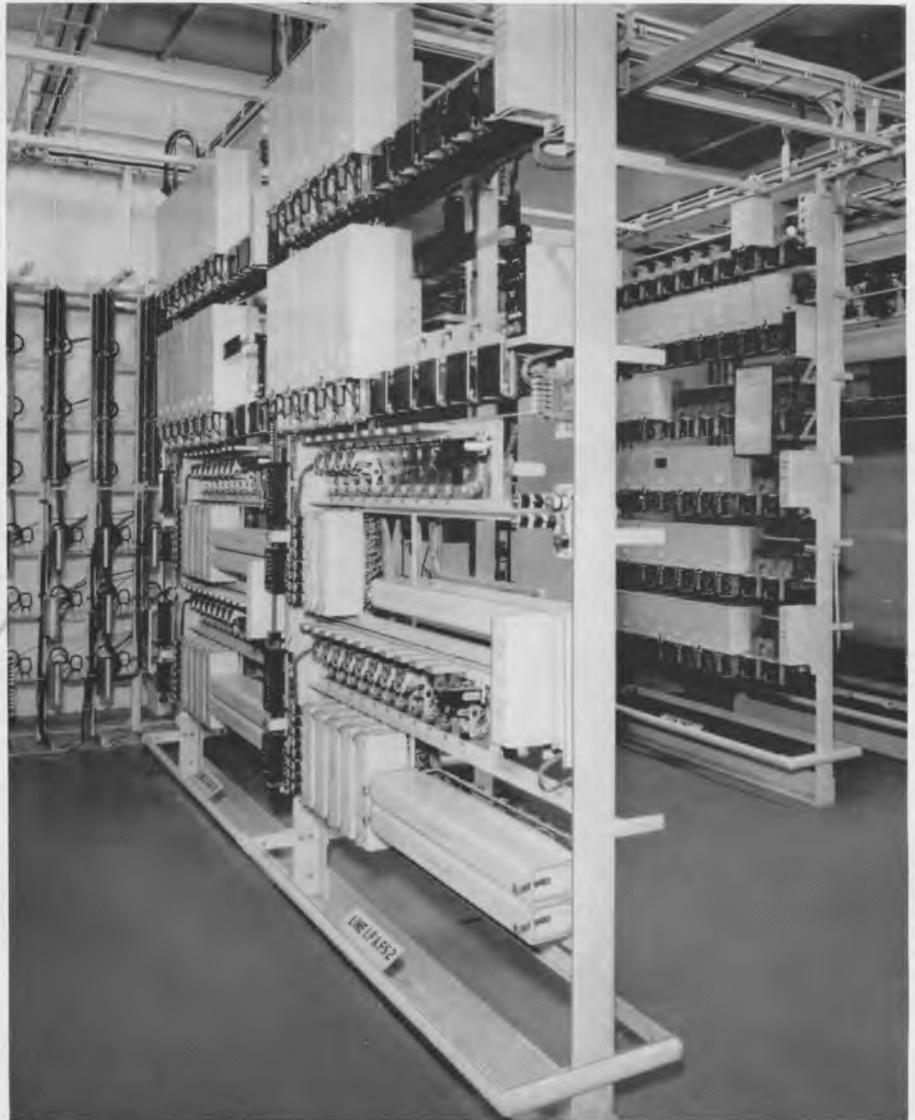
Easily removable metal covers protect the relays against dust and damage. All apparatus is the same as that standardised for large public exchanges in many parts of the world, and includes the G.E.C. SE.50 two-motion selector. Throughout, the exchange and apparatus are designed to give ease of maintenance.

The line and final selector rack accommodates the equipment for one hundred line circuits, linefinders and allotters for these hundred extensions, and twenty final selectors. In addition, any s.t.d. charging meters are fitted to this rack. They can be connected one per public exchange line and also one per extension line, if required. The group selector rack accommodates sixty group selectors and the relay set rack twenty relay sets for exchange or interswitchboard lines together with the relay sets for call-back and automatic transfer service. The operator's connect rack carries the relays and other apparatus associated with the operator's position as well as the keysender equipment. The ringing machines, associated control relay sets, alarms and '0' level relay sets and other miscellaneous apparatus are situated on the combined M.A./ringer rack.

Figure 8. Typical  
apparatus room

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### Power Equipment

The exchange operates on a 50-volt d.c. power supply. This is in the form of a lead-acid battery floating across the terminals of a constant-potential rectifier unit operating from the a.c. mains supply. When the mains supply is d.c., a motor-generator or rotary transformer converts the mains supply to the required voltage. With this arrangement a charge/discharge system is used. This ensures that the battery connected to the mains is isolated from the exchange. Service tones, *i.e.*, dial, ringing, busy, N.U. and warning tones are generated by a battery-driven ring and tone machine. Two machines are provided and in the event of failure of one, a standby is brought into service automatically.

### Line Requirements

Any isolated twin conductor, suitably protected if exposed to risk of damp or mechanical damage, may be used to connect the telephones to the exchange, provided the line loop resistance does not exceed 600 ohms. This can be extended to 1000 ohms by the addition of auxiliary equipment. A third wire is connected from each telephone to a nearby earth (ground) point; if there is no convenient earth, the third wire is run to the exchange. Table 1 gives examples of maximum lengths for various line conductors.

Table 1. Maximum permissible cable lengths

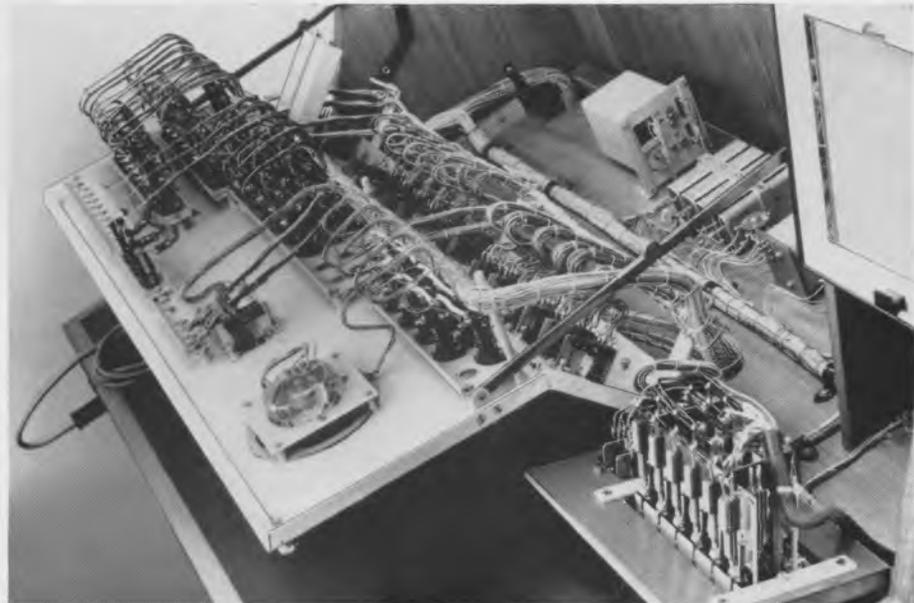
Size of Copper Conductors				Maximum permissible length of cable pair (600-ohm line-loop resistance)	
lb/mile	A.W.G. (B & S)	S.W.G.	mm Diam.	Yards	Metres
4	26	27	0.406	2374	2160
6½	24	25	0.508	3760	3440
10	22	23	0.635	5790	5230

### Distribution and Protection

The simplest method of connecting the extension instruments to the p.a.b.x. is to use separate line wires for each telephone. A saving in line wire and space, with a gain in neatness, may often be achieved by running a multi-core cable from the main distribution frame to a distribution box so situated that only short lengths of wire are required to connect each telephone instrument to the distribution box.

The exchange equipment must be protected against high voltages and heavy currents, which may accidentally be introduced into external lines, for example, due to lightning. All lines to the public exchange and all external interswitchboard lines and external extension lines must be connected to protection apparatus before being connected to the private exchange equipment. The protection equipment is mounted on the main distribution frame. All the exchange lines and external lines terminate on one side of the frame. Cables from the private automatic exchange terminate on the other side. The two sides can be cross-connected as desired by flexible connexions. Changes in the allocation of extension numbers, and line testing facilities, are simplified by the use of a distribution frame.

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Figure 9. The desk console hinges forward to give easy access to all panel wiring