AN OUTLINE OF MANUAL SWITCHING

CONTENTS

Figures 2a, 2b, 4, 6, 7, 11 and 14 are appended to this pamphlet

INTRODUCTION

At a manually operated telephone exchange the subscribers' lines terminate on a switchboard which is equipped so that one line can be cross-connected to another by an operator at the verbal request of the calling subscriber. Each exchange has lines, termed junctions, outgoing to and incoming from at least one other exchange, usually more than one, and the junction network between exchanges is such that any subscriber can be connected to any other subscriber on the telephone system.

During the early years of the public telephone system two distinct types of switchboard, one known as the 'plug and cord' and the other as the 'crossbar' were developed. On the original type of crossbar switchboard each line terminates on a vertical metal bar and the cross connecting circuits consist of horizontal metal bars. A connexion between two subscribers is established by connecting the appropriate vertical bars to the same horizontal bar.

The basic trunking arrangement of a manual crossbar system which provides for two simultaneous connexions is shown in Fig. 1. Each line terminates on a calling indicator and the lever springs of a 3-position key, the make springs of which are connected to two connecting circuits, labelled A and B in Fig. 1. The operator's telephone is connected to a 3-position key as shown. Connexion between a line and the operator's telephone or between two lines is effected by operating the appropriate two keys to, say, position A. Another connexion can then be made by operating the keys of the two parties concerned to position B.

Issue 2.2, 2/62
(6/67)

Operating and mechanical complexities occur when the arrangement is extended to deal with a large number of lines and connecting circuits. The crossbar system has therefore, not been adopted as standard for public exchanges but is in general use for small switchboards employed at subscriber' installations.

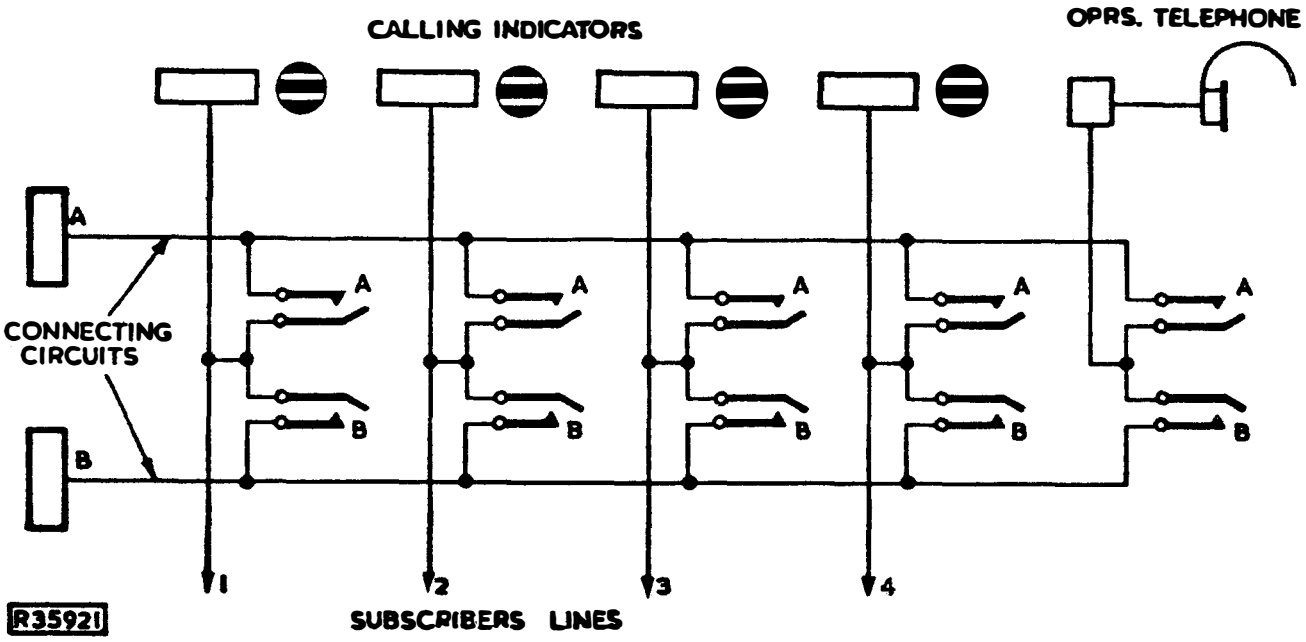

Fig. 1

On the plug and cord type switchboard each subscriber's line terminates on a jack, and plug-ended flexible conductors, termed cords are used to connect together the appropriate jacks when establishing a connexion between two subscribers. Each junction terminates at the outgoing end on a jack but at the incoming end may terminate on either a jack or single plug-ended cord. The plug and cord switchboard has proved suitable to accommodate a very large number of lines and to handle high rates of calling, consequently it is the standard type of manual switchboard used by the B.P.O. in public telephone exchanges. A diagram of an elementary plug, and cord connexion between two subscribers on a switchboard having the same general shape as those used by the B.P.O. is shown in Fig. 2a (appended). A key type switch is included in each connecting cord, or cord circuit, to allow the operator's telephone to be connected to the circuit as and when desired. A trunking diagram of the arrangement is shown in Fig. 2b (appended).

LOCAL LINE SIGNALLING SYSTEMS

General

Equipment to receive or send a number of standardized signals between the subscriber and the operator must be associated with the plug and jack arrangement shown in Fig.2a to provide an efficient service. The basic signals necessary are,

(a) to the operator

(i) a 'calling signal' indicating that a subscriber wishes to make a call,

(ii) a 'clearing signal' indicating that a subscriber has completed a call,

(iii) a 'supervisory signal' indicating that a called subscriber has answered.

(b) to the subscriber,

(i) a 'ringing signal' indicating that the exchange is calling.

For ease of operating it is desirable that the calling and clearing signals cause a positive indication, i.e. the appearance of a lamp glow or operation of an indicator, at the switchboard, and that the supervisory signal causes a negative indication. The precise nature and arrangement on the switchboard of the equipment provided to meet the signalling requirements is largely dependent on the system of local line signalling employed. In all the local line signalling systems, however, alternating current is used for the ringing signal. The 'ringing current' is applied to only one wire and the terminal of the generator remote from the line is earthed. Earth or earthed battery potential is applied to the other wire of the line during the application of the ringing signal.

There are two basic systems of line signalling, magneto and central battery.

The Magneto System

The magneto system employs low frequency alternating current signals between subscriber and operator and vice versa; the signals operate electromagnetic indicators at the exchange and magneto bells at the subscribers' telephones. Hand operated generators are provided at subscribers' premises and at the switchboard to produce the signalling currents; at large switchboards, however, it is more convenient to have a motor driven generator and switching arrangements for applying the currents to the lines. Facilities are not provided for a supervisory signal, and the clearing signal to the operator is dependent on the subscriber operating the hand-generator at the conclusion of the call, this action is known as 'ringing off'.

An element diagram of a connexion between two subscribers is shown in Fig. 3.

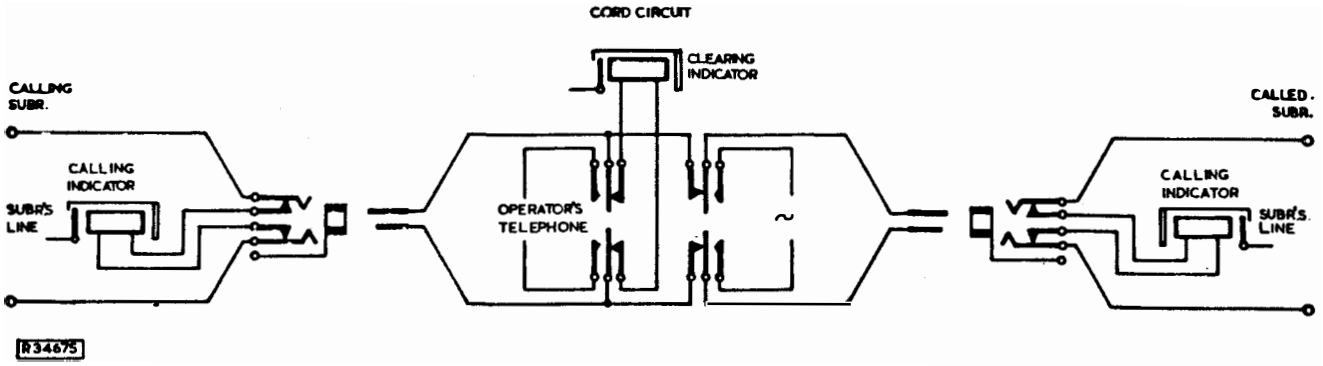

Fig. 3

The Central Battery System

The magneto system has been superseded by the central battery system which employs direct current signals between the subscriber and the operator. The current conditions appropriate to the calling, clearing and supervisory signals are established when the subscribers remove and replace their telephone handsets, therefore the signalling may be considered as automatic. The battery supplying the signalling currents is situated at the exchange.

There are two main types of telephone exchange, the Central Battery (C.B.) and Central Battery Signalling (C.B.S.) which employ the central battery system.

Central battery system

In the C.B. system the power for both the signalling and the transmission of speech is provided by a battery situated at the exchange. The calling and supervisory signal conditions are established by a d.c. connexion, termed a loop, between the line wires at the subscriber's telephone. The clearing signal is a disconnexion, consequently a capacitor is connected in series with the telephone bell to prevent the bell circuit from providing a permanent d.c. loop on the line. Lamp type indicators are fitted on the switchboard and they are controlled by contacts of relays which in turn are controlled by the calling, supervisory and clearing signals.

The C.B. system has the great advantage over Magneto that neither local batteries or hand generators are required at the subscribers' premises. However, the high currents necessary to energize the telephone transmitters, on short lines they may be of the order of 80 mA, necessitate the use of a battery of large capacity accumulators at the exchange. At the time of its introduction into the U.K. in the 1890's the need for battery charging equipment confined the use of the C.B. system to the towns which had a public electricity supply.

There are two main types of C.B. public exchange, the C.B. No. 1 having a capacity of up to 10,000 subscribers lines, and the C.B. No. 10 having a normal maximum capacity of 2800 subscribers lines. The exchanges work on a 22 volt or 40 volt battery.

An element diagram of the connexion between two subscribers on a C.B. 40 volt switchboard is shown in Fig. 4 (appended).

The cord circuit provides a path for the speech currents but for d.c. signalling purposes it is divided by the 'transmission bridge' into an 'answering side' and 'calling side'. The division allows the use of separate indicators to provide the clearing and supervisory signals to the operator. The 3-position lever type key allows the operator's telephone or the ringing signal to be connected to the circuit. A theoretical treatment of the transmission bridge is beyond the scope of this pamphlet.

The effect of the d.c. signals is as follows:-

When the calling subscriber removes the telephone handset the resultant calling signal completes an operate circuit for the line, or L relay in the line circuit. Contact L1 completes a circuit for the calling lamp associated with the calling subscriber's jack. The operator answers the calling signal by inserting the answering cord plug into the calling subscriber's jack. The battery condition on the 'sleeve' wire of the cord circuit completes an operate path for the 'cut-off', or CO relay which operates and disconnects relay L from the line.

The calling signal is extended by the plug and cord to operate relay LA in the cord circuit. The contact of relay LA disconnects the circuit for the clearing lamp. When the calling cord plug is inserted into the 'called' subscriber's jack, relay CO in that line circuit operates to the battery condition on the sleeve wire of the calling cord and disconnects relay L from the line. At this point in the completion of the connexion the called subscriber's telephone is normal, consequently there is no direct current path to cause the operation of relay LC in the cord circuit. There is, therefore, a circuit for the supervisory lamp via contact LC to the earth condition on the sleeve of the jack.

The ringing signal is applied to the called line by means of the cord circuit key. When the called subscriber answers, the resultant loop between the line wires causes relay LC in the cord circuit to operate. The supervisory lamp is extinguished by contact LC, so giving the operator a negative indication on 'called subscriber answer'. Thus during conversation the clearing and supervisory lamps do not glow, should either subscriber wish to attract the attention of the operator, however, replacing and removing the handset will cause the appropriate cord circuit relay to release and operate successively so causing the associated lamp to 'flash'.

When the subscribers replace their handsets relays LA and LC release and contacts LA and LC complete the circuit for the clearing and supervisory lamps respectively. The operator, therefore, receives a positive clearing signal from both subscribers at the termination of the call, the calling cord supervisory lamp acting also as a called subscriber clearing lamp.

It is usual to call both the clearing and supervisory lamps 'supervisory lamps'; the lamps associated with the answering and calling cords are termed the 'answering supervisory' and 'calling supervisory'. The elements of the cord circuit used at a 22 volt C.B. exchange are shown in Fig. 5, the subscriber's line circuit is similar to that shown in Fig. 4. The supervisory lamp conditions produced by the relays LA and LC are the same as those produced by the corresponding relays in the 40 volt cord circuit.

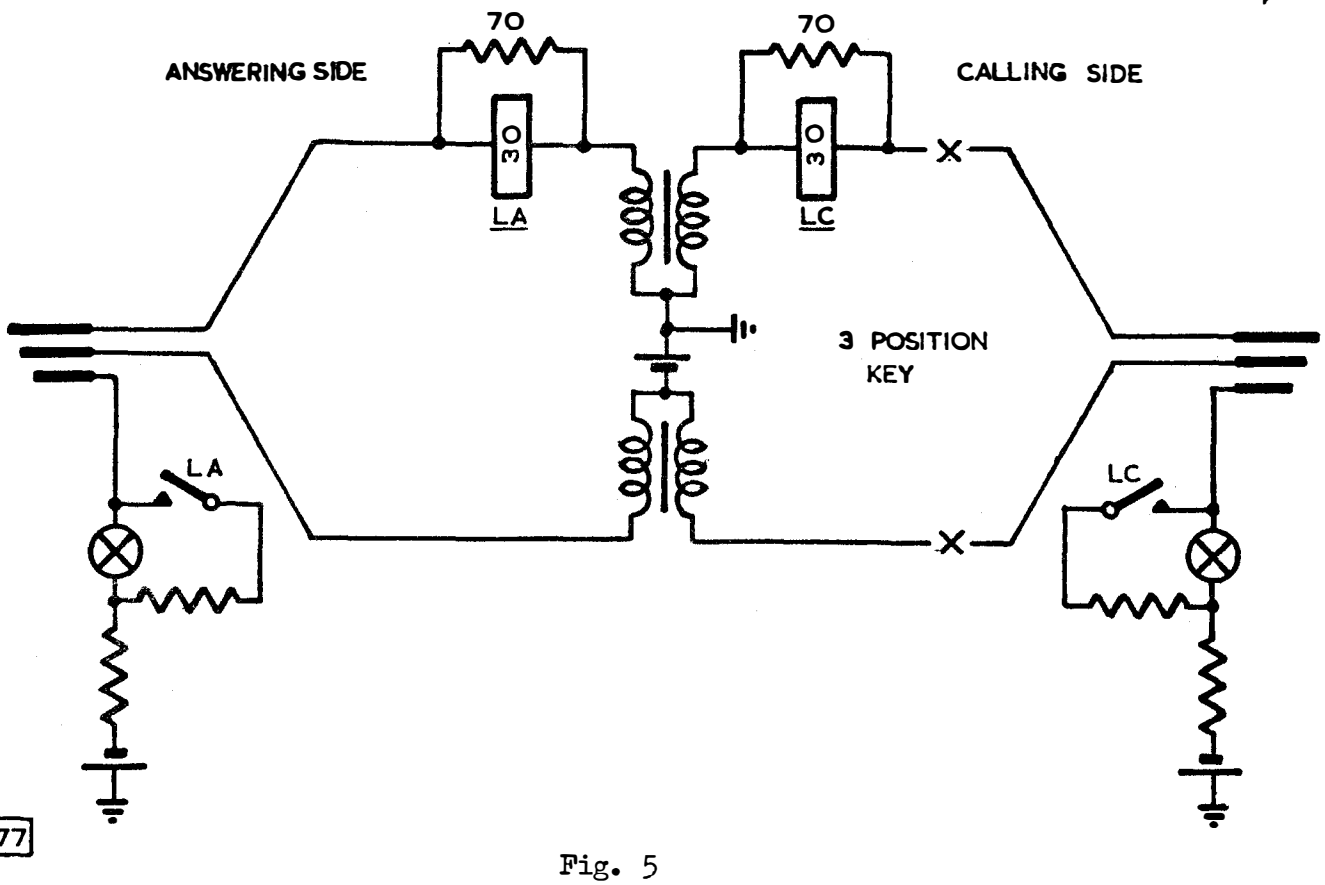

Fig. 5

Central battery signalling system

The C.B.S. system was designed by the B.P.O. to provide the automatic signalling and supervisory conditions given by the C.B. system but using only a battery of primary cells at the exchange, thus dispensing with the need for battery charging equipment. The use of primary batteries is made possible by using high resistance signalling equipment at the exchange and local batteries for energizing the telephone transmitters. There are three types of C.B.S. system; namely C.B.S.1, C.B.S.2 and the C.B.S.3. The C.B.S. No. 3 is similar to C.B.S.2 but is used only for very small exchanges.

The C.B.S.1 system employs lamp type indicators at the exchange but requires an earth connexion at the subscriber's telephone to effect the clearing signal. The use of 'earth clearing' results in a saving of exchange equipment but increases the maintenance problems.

The C.B.S.2 system is the only C.B.S. system still in general use and it employs electromagnetic indicators at the exchange, and signalling conditions similar to those described for the C.B. system. An element diagram of the connexion between two subscribers on a C.B.S.2 switchboard is shown in Fig. 6 (appended).

The calling signal completes an operate circuit for the indicator associated with the calling subscriber's line jack. The insertion of the answering plug into the jack disconnects the indicator from across the line and extends the calling signal to operate relay LA in the cord circuit. The contact of relay LA disconnects the operate circuit of the clearing indicator, i.e. the answering supervisory. When the calling plug is inserted into the required subscriber's jack the calling indicator is disconnected, leaving the line clear for the ringing signal which is applied by means of the cord circuit key. At this stage the 'calling supervisory' indicator

is operated by the earth on the bush of the jack, and gives a positive signal to the operator. When the called subscriber answers, the resultant signal operates relay LC, and contact LC1 disconnects the supervisory indicator; thus a negative signal is given when the called subscriber answers. At the end of the call both subscribers replace their handsets and consequently the loops from the lines. Relays LA and LC release and complete circuits for both the calling and answering supervisory indicators, thus giving positive clearing signals to the operator.

The C.B.S.2 system was used for exchanges estimated to have an ultimate capacity of up to 800 subscribers, but has now been superseded by the C.B. and automatic systems.

SWITCHBOARDS

The line drawings of switchboards shown in this pamphlet are intended only to convey the principles of the equipment layout and are not necessarily drawings of particular types of switchboard. Nearly all the public manual exchanges in the U.K. are of the C.B.S.2 and C.B. type, consequently only these types of switchboard will be considered.

The Non-Multiple Switchboard

The arrangement of the equipment on a C.B.S.2 switchboard which provides facilities for one operator, a maximum of 180 subscribers' line terminations, and 60 terminations for junctions to and from other exchange, is shown in Fig. 7 (appended). For clarity the equipment associated with 6 cord circuits only is shown, in practice the switchboard can be equipped with up to 16 cord circuits. The number of circuits provided is largely governed by the number and the average duration of the calls likely to occur during the busiest hour of the day.

The vertical face of the switchboard is divided into two 'panels' which contain the subscribers' line terminations arranged in strips of 10. Each termination consists of a number label, jack and electromagnetic indicator arranged one above the other as shown in Fig. 7. The plug-ended cords, supervisory indicators and the 3-position lever type key associated with each cord circuit are arranged on the 'keyshelf', the remaining equipment associated with the cord circuits is contained within the switchboard. The cords are held in tension by a sliding weight arrangement, the principle of which is shown in Fig. 7. The operator's telephone instrument is plug-ended and is connected to the cord circuit keys via the jack mounted on the vertical face of the keyshelf. The operator can connect the telephone to any cord circuit by moving the appropriate key to the forward position. The backward position of the key, which is non-locking, connects the calling side of the cord circuit to the supply of ringing current. When the size of the switchboard does not warrant the provision of a motor driven generator a hand driven one is provided as shown.

The junction circuits to and from other exchanges which are provided on the switchboard are considered later in this pamphlet.

Switchboard capacity

The maximum number of subscribers' terminations which can be accommodated on the single operator type switchboard shown in Fig. 7 is governed by the two main considerations

(a) The limit of the operator's reach or the maximum permissible length of the connecting cords, and

(b) the ability of one operator to handle efficiently the calls that originate during the busiest period of the day.

The ultimate capacity of the exchange can be increased by placing two switchboards side by side. Each subscriber's line will terminate at only one jack, and each operator will normally deal only with calls originated by subscribers terminated at her position. The width of the switchboards is such, however, that either operator can complete calls to subscribers terminated in any of the four panels, thus one operator only is needed to deal with a call between any two subscribers on the exchange.

The introduction of the second position also improves operating efficiency; when one operator is overloaded with calls the other operator can assist by answering calls originating on any panel, it being unlikely that both operators will be overloaded at the same time. Also at certain times of the day or night only one operator will be needed to handle the calls originated at both positions.

When the number of subscribers is such that a third switchboard is required, only the operator at the middle switchboard has all the subscribers within her reach. The problem of completing a connexion between two subscribers terminating at opposite ends of the switchboard can be resolved by providing 'transfer circuits' between operating positions 1 and 3. A transfer circuit terminates on a jack at the outgoing end and on a jack having an associated calling indicator at the incoming end. The routing arrangements of a call from a subscriber terminating on position 1 to a subscriber on position 3 is shown in Fig. 8. A major disadvantage of the system is that two operators and two cord circuits are used on each call using the transfer circuit; it is therefore used only for subscriber to subscriber connexions when there is no reasonable or economical alternative.

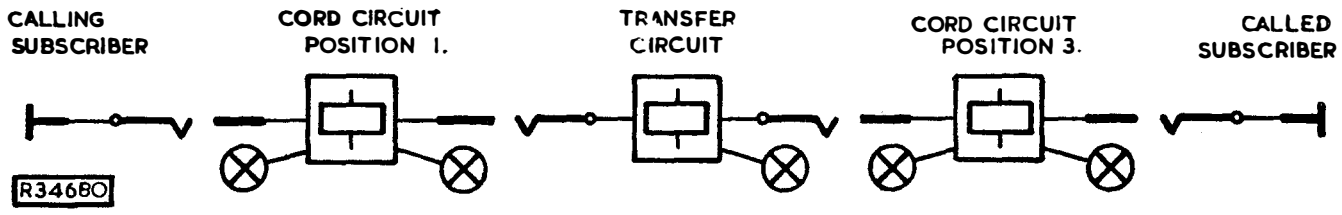

Fig. 8

The Multiple Type Switchboard

The use of transfer circuits on multi-position switchboards can be obviated by providing access to every subscribers' line by means of jacks positioned at regular intervals along the face of the switchboard. The intervals are such that every operator has, within reach, access to every subscribers line connected to the exchange. The multiple type switchboard is used at all C.B. type public exchanges and at the majority of the remaining C.B.S.2 exchanges.

The arrangement of the subscribers terminating equipment is similar to that shown in Fig. 7 but is confined to the lower portion of the panels. The other jacks, termed multiple jacks, associated with the subscriber's terminations are arranged in numerical order and positioned in the upper portions of the panels.

The calls originated by subscribers are normally answered at the jacks in lower portions of the panel and the connexions to the called subscribers are made via the multiple jacks. When the switchboard is not fully staffed, however, calls originating at unstaffed positions are answered at the multiple jacks, the use of such a procedure increases the operating efficiency of the switchboard.

The arrangement of the jack field on a section of the face of a typical C.B. multiple type switchboard is shown in Fig. 9; the same general arrangement is also used on the C.B.S.2 type switchboard.

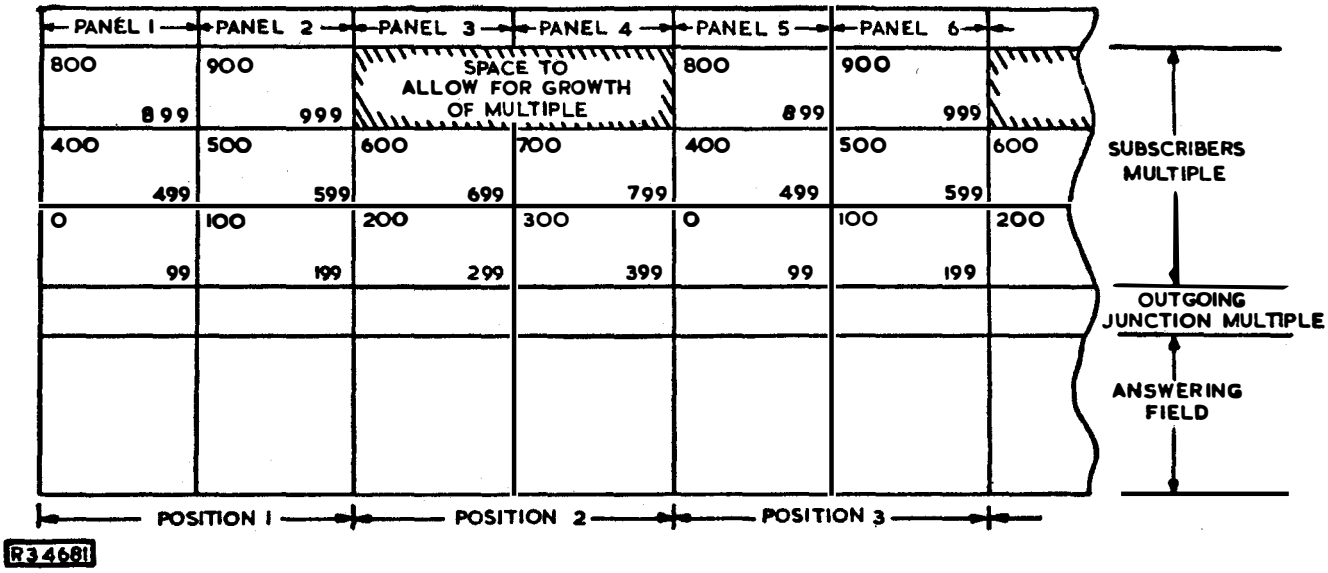

Fig. 9

The answering field. The lower portions of the panels accommodate the strips of jacks, calling lamps and number labels which make up the answering field. As the jacks are not normally used for the connexion of calls to subscribers they need not necessarily be arranged in subscribers number order. In practice, the subscribers are distributed over the answering field so that over a given period of time each operator does the same amount of work. The number of subscribers proper to one operator's position depends on the calling rate of the particular subscribers; the number will be low in business areas and high in residential areas, but usually comes within the limits 60 and 120. The answering jacks, calling lamps and labels can be provided in rows of 10 or 20; the arrangement for rows of 10 is shown in Fig. 10(a) and that for rows of 20 in Fig. 10 (b).

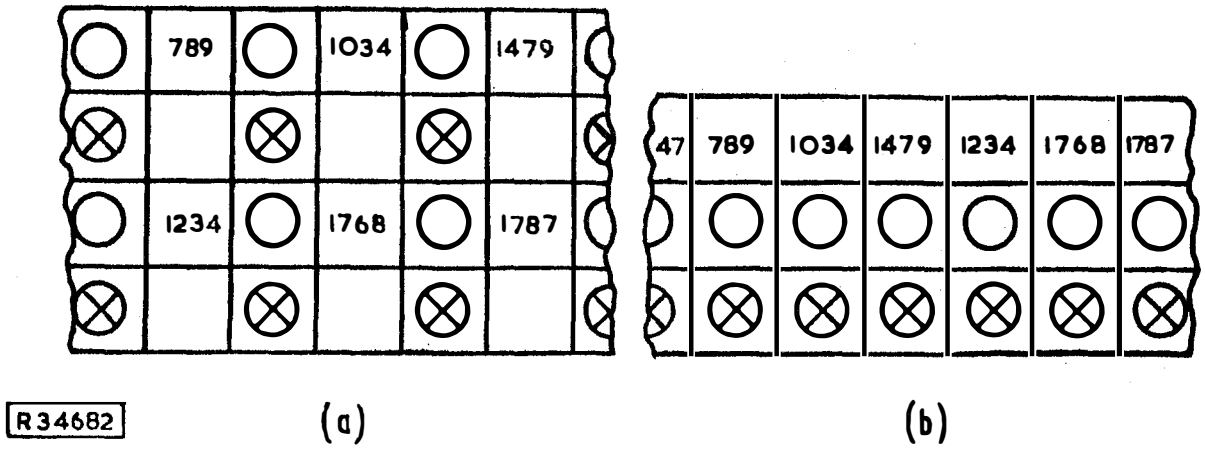

Fig. 10

The subscribers' multiple. The multiple jacks are arranged in groups of 100 in the upper portion of each panel; Fig. 9 shows a typical arrangement for an exchange having an ultimate capacity for 1200 subscribers. The numbering is always started from the bottom to facilitate extensions to the multiple when necessary during the growth of the exchange. In the example shown, each subscriber's jack is repeated every fourth panel, that is the multiple has a four panel repetition. In the larger exchanges the multiple jacks have a 6, 8 or 9 panel repetition, the number of panels depending on the ultimate capacity of the exchange. When the multiple repetition is greater than 4 panels it is extended beyond the working positions to facilitate operating at the end positions.

Fig. 11 (appended) illustrates a section of the multiple jacks at a large manual exchange, it should be noted that within each block of 100 jacks the numbering is arranged from top to bottom.

The provision of a complete multiple to solve the operating problem on a 3 position switchboard would be wasteful of equipment. The problem can be efficiently resolved by the provision of a 'partial multiple' arranged as shown in Fig. 12. The principle of partial multiple can be extended to 4 and 5 position exchanges.

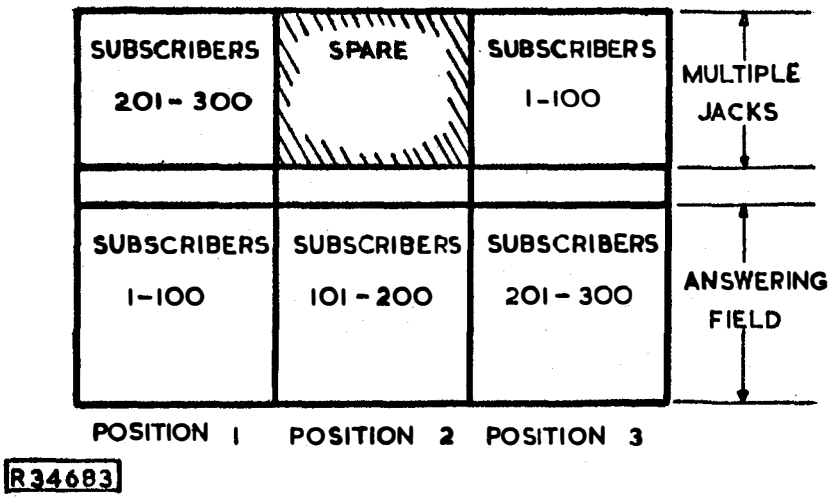

Fig. 12

The C.B.S. exchanges have a 'series' or 'break jack' type multiple arranged as shown in Fig. 13a in order that the calling indicator is disconnected from the line when a plug is inserted into any jack. In a C.B. exchange the multiple jacks are connected in parallel with the answering jacks, Fig. 13b and are not of the break type because the line relay is disconnected by contacts of the cut-off relay.

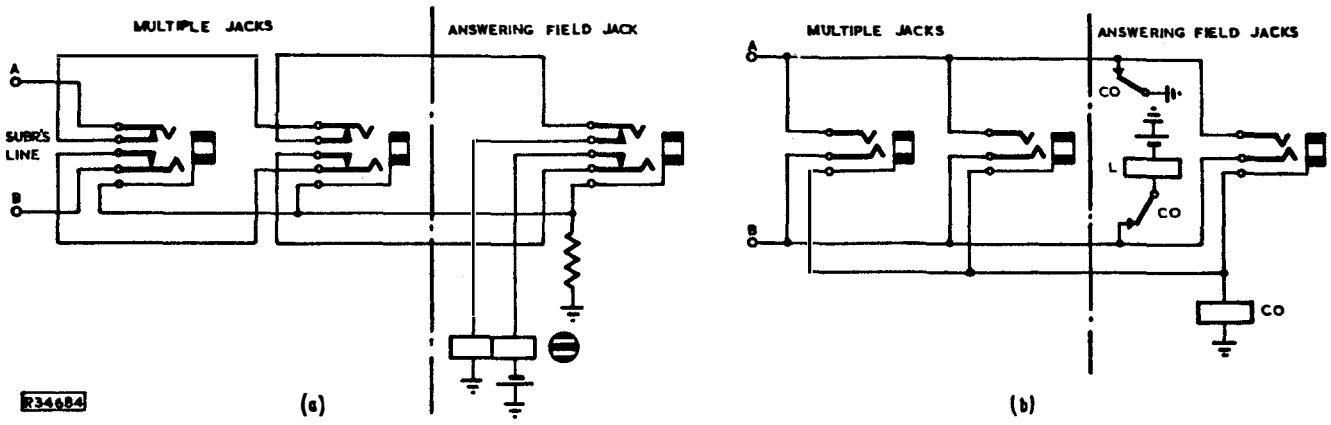

Fig. 13

The outgoing junction multiple. The outgoing junctions are accommodated on strips of 10 or 20 jacks positioned between the subscribers' multiple and the answering field. A suitably inscribed designation strip is inserted between each row of jacks when the jacks are in strips of 20. The junctions are repeated usually every 4 or 6 panels depending on conditions at the particular exchange.

In Fig. 9 one operator's position is shown to cover 2 panels of face equipment; in the larger manual exchanges, however, a small gauge plug and jack is used and enables each position to cover nearly three panels. The larger switchboards are made up in 'sections', each section having 3 operating positions and 8 panels of face equipment. The switchboard sections on which the subscribers' calling equipments are terminated are known as 'A' position sections. The face equipment of an 'A' position section at a C.B. No. 1 exchange is shown in Fig. 14 (appended).

The keyshelf. The layout of the cord circuit equipment on the keyshelf of a multiple type switchboard is similar to that shown in Fig. 7. On a C.B. switchboard keyshelf, Fig. 15, items associated with the timing and metering of calls are included in the cord circuits. The timing of calls will not be dealt with in this pamphlet but the other items are considered in the appropriate sections.

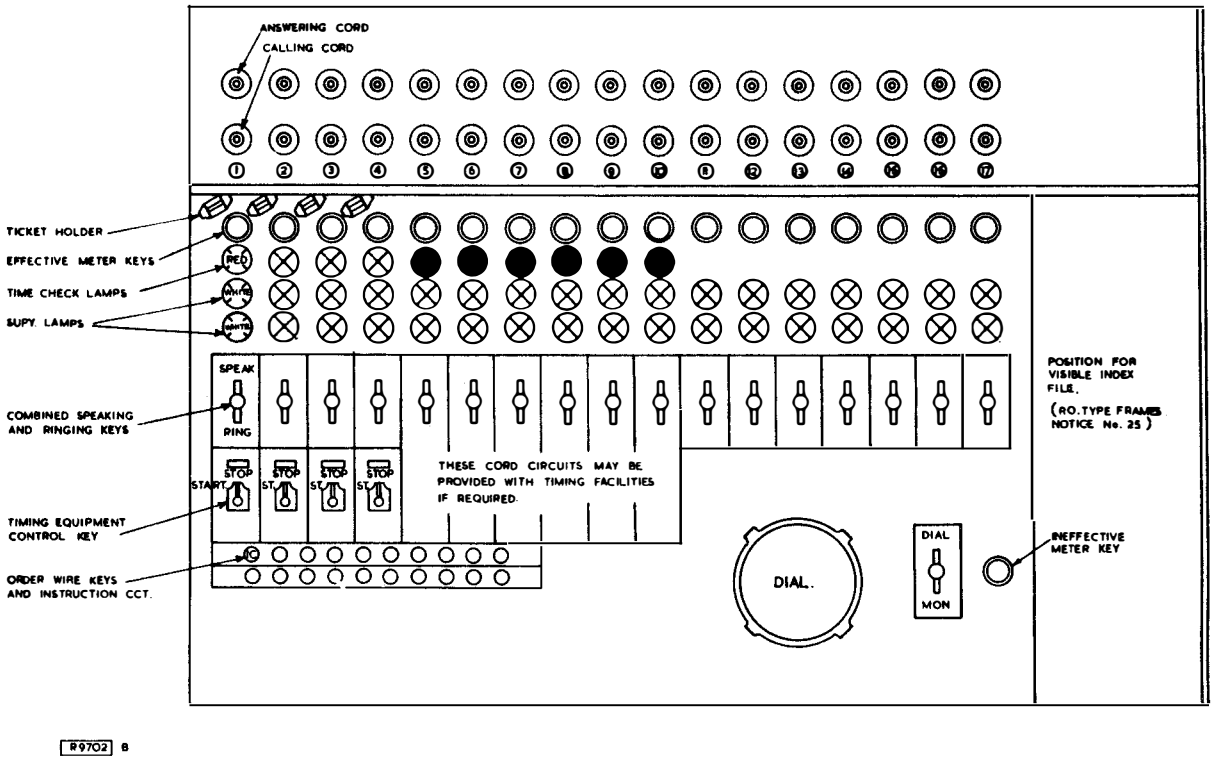

Fig. 15

Engaged test. In a multiple type exchange a subscriber's circuit can be engaged in the answering field or multiple remote from an operator wishing to complete a connexion to that particular circuit. In such circumstances an operator cannot discern if the circuit is free by scrutinizing the surrounding jack field. It is, therefore, arranged that the insertion of a plug into a subscriber's jack causes an 'engaged condition' to be applied to the bush of all the jacks associated with that particular subscriber. The operator tests the required line by tapping the tip of the calling plug on the bush of the subscriber's jack; if the subscriber is engaged, the engaged condition on the bush causes a distinct click to be produced in the operator's telephone, absence of a click indicates the circuit is free.

Metering. The method used to record a call against the calling subscriber's account is either manual or mechanical. In the manual method the operator prepares a docket for every call, consequently, on busy switchboards, this method tends to cause congestion. The mechanical method which is in general use in all the larger manual exchanges requires the operator only to depress a plunger type key immediately prior to clearing down an effective connexion. The operation of the key causes the operation of a call register meter associated with the calling subscriber's line termination and also the operation of a 'total calls' meter associated with the position. Each cord circuit has a meter key positioned between the calling plug and the answering supervisory.

As the operation of the subscriber's meter provides a figure on which his account will be prepared it is important that the operator receives some indication that mechanical metering has been effective. A visual signal is, therefore, provided on the switchboard by a 'meter pilot' lamp which is arranged to glow only when a subscriber's meter has operated.

Ineffective calls are not registered against a subscriber's account but they are registered against the position on which they originate. A suitable key and meter are provided for the purpose of registering ineffective calls.

JUNCTION WORKING

General

Calls originated by subscribers on one exchange to subscribers on other exchanges are routed over junctions which link the telephone exchanges in the U.K. Because it is uneconomical to directly connect one exchange with every other, certain suitably positioned exchanges act as junction lending, or junction switching centres. A manually operated junction lending centre is usually part of a normal telephone exchange switchboard, but in some of the larger cities a separate switchboard is needed to handle the 'through junction' traffic. It should be appreciated that modern junction switching centres are equipped with automatic switching equipment, thus dispensing with the need for a switchboard.

Each exchange has junctions to and from a centre, and junctions radiate from the centre to other centres as shown in the explanatory diagram, Fig. 16. Direct junctions are provided between individual exchanges when justified by the traffic. In general junctions which exceed 15 miles are known as 'trunk lines'

Small lightly loaded groups of junctions are often arranged for 'both-way' working, i.e. capable of passing originating traffic in either direction, an explanatory diagram of the arrangement is shown in Fig. 17. The associated CO relay is operated when the circuit is seized, and the subsequent operation of the distant calling equipment also extends the engaged condition to the outgoing jacks at that end.

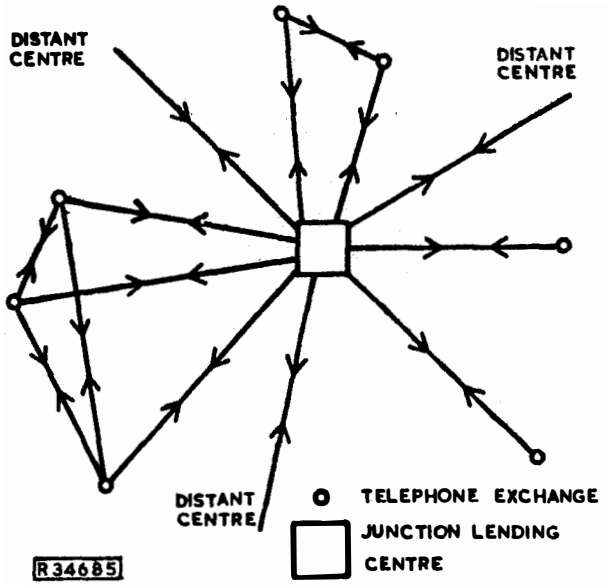

Fig. 16

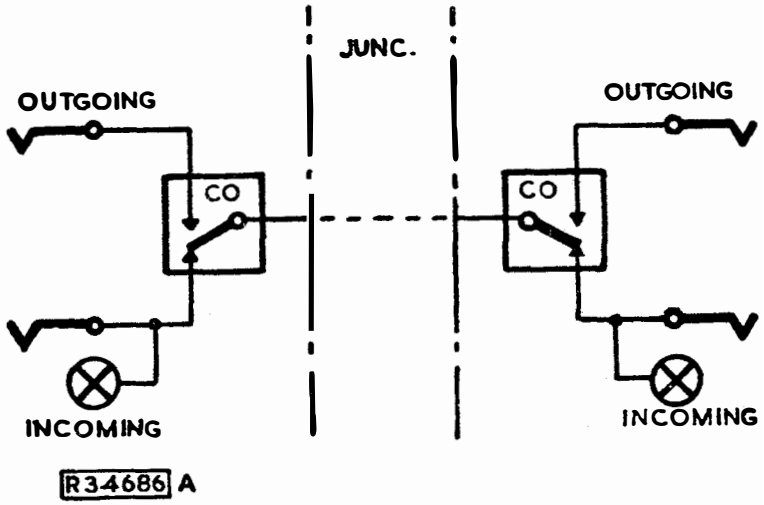

Fig. 17

The heavily loaded and larger groups of junctions are arranged for one way working only. An exchange will thus have groups of 'outgoing' junctions and groups of 'incoming' junctions. It is not unusual, however, for a very small exchange to have direct junctions to only one other exchange.

Junction circuits are of two distinct types, 'jack-ended' and 'plug-ended', the type referring to the method used to terminate the junction at the incoming end. At the outgoing end access to both types of junction is made via jacks.

The signalling over the majority of manual junctions is automatic and is known as C.B. signalling because it employs the conditions extended by the C.B. A-position cord circuit, i.e. earth on the A-wire and battery potential on the B wire. The calling signal is a battery potential extended on the B-wire, and the answering signal a battery potential returned on the A-wire. The A wire of the junction is terminated on the ring of the incoming jack to allow the answering signal to be returned from a cord circuit which extends C.B. conditions. Fig. 18 shows the elementary principles of C.B. signalling over a simple jack-ended junction arrangement.

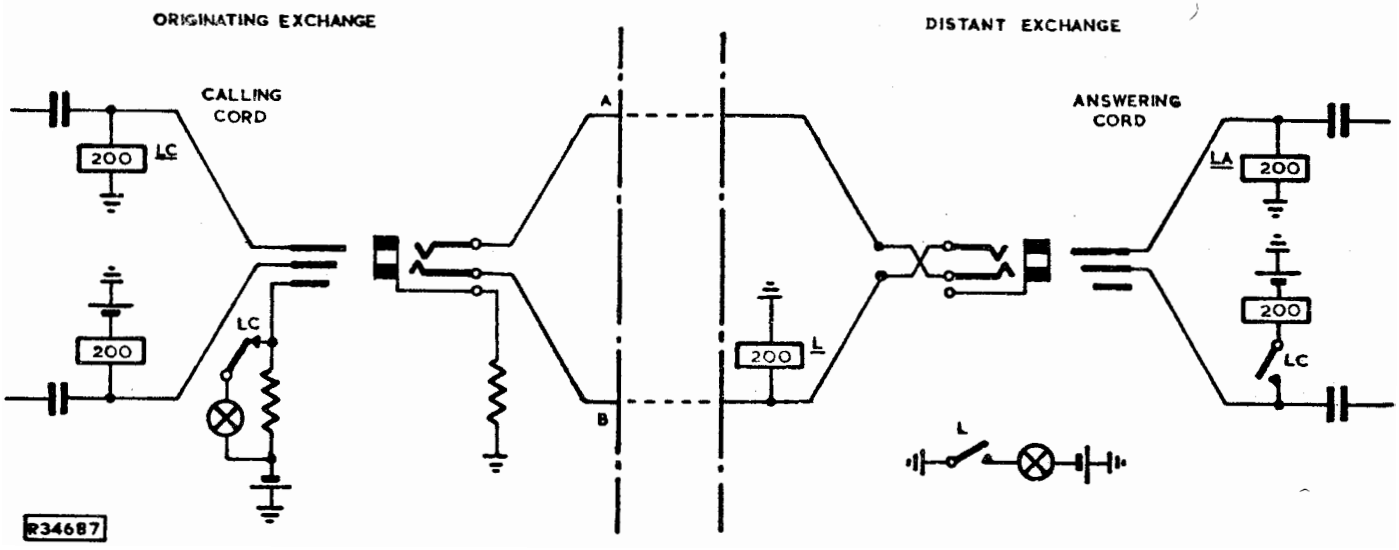

Fig. 18

The cord circuits used to answer calls incoming from junctions are arranged to give 'through signalling' conditions and thereby place the clearing signal under the control of the operator at the originating exchange. When a call is extended over a junction it is standard practice for the originating operator to have complete control of the connexion. When the called subscriber replaces the telephone handset at the end of a call the calling cord supervisories glow at the distant and originating exchanges. The answering cord supervisory at the originating exchange glows when the calling subscriber clears, but the answering cord supervisories at the intermediate and distant exchanges glow only when the originating operator clears down the connexion.

Outgoing Junctions

The position and arrangement of the outgoing junction circuits on non-multiple and multiple type switchboards are shown in Figs. 7 and 9 respectively. The

designation strips associated with the junction jacks indicate the name of the distant exchange and, for ease of operating, whether the junctions terminate on a manual board or automatic equipment. When any group of junctions terminate at the distant end on automatic equipment each operator's position is equipped with a telephone dial. The dial can be associated with the calling cord of any cord circuit by the operation of a 'dial key' and the appropriate cord circuit key to the 'ring' position, Fig. 15.

The normal 'click' engaged test is provided on the junction jacks, but as the junctions are often in large groups operating time is saved on the larger switchboards by employing either the 'group engaged test' or the 'free line signal' (F.L.S.) systems.

The group engaged test. The junctions on a particular route are divided into groups of five circuits, and when all the junctions in a group are engaged the operator receives a distinctive tone when she taps the bush of the first jack in the group. The operator need, therefore, only test each fifth jack, these are distinctively marked, and then each jack within the first group not marked with the tone.

Free line signal (F.L.S.) A glowing signal, restricted in size and brightness to avoid confusion with a calling signal, is provided over the first free junction; for ease of operating, however, the junctions are divided into groups of ten circuits. When a circuit is taken into use the free line signal is automatically transferred to the next free circuit; should a circuit earlier in the group become free the signal automatically drops back to that circuit.

Incoming Junctions

The incoming junctions at an exchange terminate either on jacks or single plug-ended cords. The plug-ended type of termination is used only where the traffic is heavy and the number of junctions is sufficient to load at least one operator.

When the number of junctions incoming to an exchange is sufficient to provide a full load for one or more operators they are segregated on 'B' positions. The 'B' positions are situated at the non-growing end of the switchboard and in the larger exchanges usually form a line remote from the subscribers' switchboard. Greater space is allowed for the subscribers' multiple in order to keep it within a 6 panel repetition, and the junction multiple is provided only when the exchange is used as a junction lending centre.

When there are insufficient junctions to provide a full load for one operator, jack-ended terminations are always used and are distributed over the switchboard panels. At C.B. type exchanges however, the terminations are usually confined to one position because special cord circuits are required to provide the through clearing conditions, Fig. 18. An operating position dealing with both incoming junction and subscriber traffic is termed a 'mixed 'A' and 'B' position'.

Jack-ended junctions

On the face of the switchboard the jack-ended junction terminations consist of a jack, calling lamp or indicator and a designation label. The position and arrangement of the terminations on a C.B.S. 2 switchboard are shown in Fig. 7. On a C.B. switchboard the answering jacks, lamps and labels are fitted in strips of 10, but for ease and speed of operating each strip accommodates five working circuits only, arranged one to every other jack. The terminations, usually about 30 to

a position, are placed low in the panels to allow for the 6 panel subscriber's multiple, and on mixed A and B positions they are placed below the subscribers' answering field. The arrangement of the cord circuit equipment on the keyshelf of a J.E.J. 'B' position is similar to that on an 'A' position, consequently the position can be readily converted to an 'A' position or vice-versa to suit the needs of the exchange.

An explanatory diagram of a connexion over a jack-ended junction is shown in Fig. 19. Because the operating procedure adopted on a J.E.J. 'B' position is similar to that employed on an 'A' position, the total time required to set up a call over such a junction is of the order of twice that of a local call. Jack-ended junctions are, therefore, suitable only for lightly loaded groups of junctions.

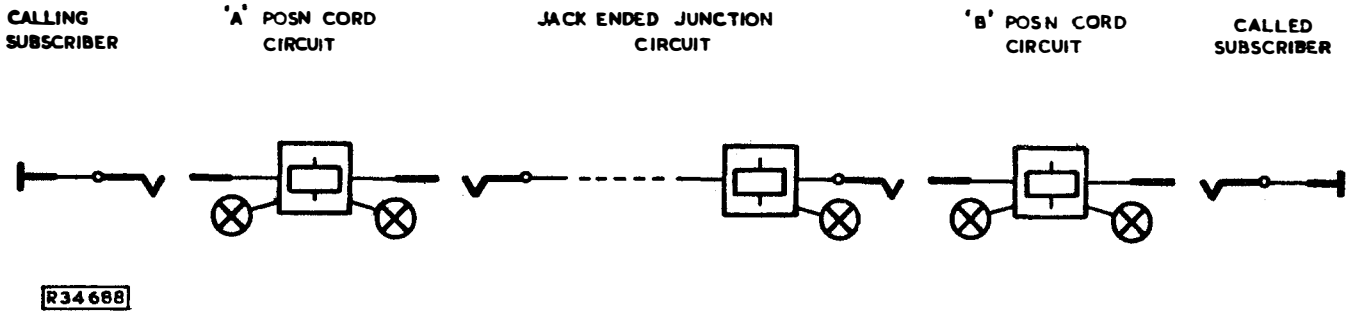

Fig. 19

Plug-ended junctions (P.E.J.)

The P.E.J. method of junction working is more efficient than the J.E.J. method and is usually used when the number of heavily loaded junction groups provide a full load for at least one operator. From time to time changes have been made to the original method of P.E.J. working, and this pamphlet will consider the three main methods,

(i) original (ii) keyless-ringing order-wire, and (iii) straightforward. A description of keyless-ringing order-wire working is given, but this method has been superseded by the straightforward method and is now obsolete.

On all types of P.E.J. positions the equipment on the switchboard directly associated with the junctions is mounted on the keyshelf. In the original method of working, each position had accommodation for 33 sets of junction equipment, each one consisting of a single plug-ended cord, a combined calling and supervisory lamp and a combined speak and ring key arranged one behind the other. An outline of the operating procedure is as follows:-

The originating A-operator selects a free junction and the B-position operator answers the resultant signal by operating the key associated with the junction termination to the speak position. At the A-operator's request the junction plug is inserted into the wanted subscriber's multiple jack and the key moved to the 'ring' position. Only a momentary operation of the key is necessary because the circuit is arranged to continue ringing the subscriber's bell after the key is restored to normal. Ringing current is automatically cut-off and the supervisory lamp is darkened when the called subscriber answers. The plug is removed from the jack when the supervisory lamp glows at the termination of the call. When the

required subscriber's circuit tests engaged, the B-operator inserts the plug into a jack to which the busy tone is permanently connected, so giving the engaged signal back to the A-operator.

The first major change to the system of working reduced the operating time by dispensing with the combined speak and ring key in the junction termination, and the need for an A-operator to search for a free junction. Junctions working to the modified system were known as 'keyless ringing order-wire circuits'.

Order-wire junctions

The order-wire system allowed the A-and B- position operators to set up the connexion simultaneously. The instructions between the A-and B- operators were passed over a separate circuit, the 'order wire', associated with the group of junctions. The order wire was permanently connected to the B-operator's telephone and the A-operator's telephone was connected to it, when necessary, by means of a suitably labelled key on the keyshelf, Fig. 15.

In practice it was often economical to work junction groups containing as few as 4 circuits on the order-wire system, consequently in certain cases several order-wires were terminated on the same B-position. It was not usual, however, to connect more than 4 order-wires to one B-position; such an arrangement was known as split order-wire working. The speed of working was improved on large junction groups by dividing them into smaller groups, each one having a separate order-wire, and terminating on different B-positions.

The arrangement of the order-wire between the A-positions at, say, West exchange and the B-position at South exchange is shown in Fig. 20. The principle of working was as follows:-

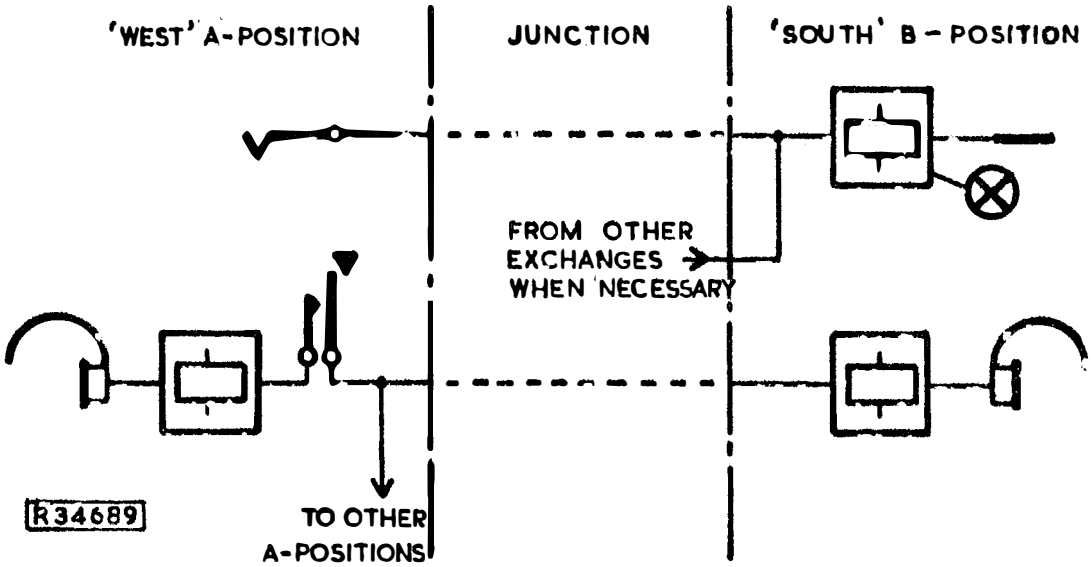

Fig. 20

Consider a call between a subscriber on West exchange and a subscriber on South exchange.

(a) The A-operator at West answered the calling subscriber and received a request for say, "South 1234".

(b) The A-operator depressed the "South" order-wire key so connecting her telephone direct to the B-operator's telephone at South, and said "West 1234". The word "West" was necessary in order that the B-operator should know the originating exchange and thus be able to allot a junction in the correct group.

(c) The South B-operator picked up the plug of a free junction from the West exchange and gave the number of this junction to the West A-operator. Thus if junction 4 was free, the B-operator said "on 4".

(d) The West operator then released the order-wire key and inserted the calling plug of her cord circuit into the outgoing multiple jack of junction 4, thereby causing the clearing lamp of West No. 4 junction to glow at South exchange. This indicated to the South operator that the assigned junction had been picked up and she then inserted the plug into the multiple jack of subscriber 1234 having first tested to see if the circuit was free. The ringing current was applied to the called line automatically when the plug was inserted into the multiple jack and disconnected when the subscriber answered. If the required number was engaged, the 'B' operator inserted the plug into a 'Busy tone' jack as previously described.

At the termination of the call, both subscribers replaced their receivers, and both supervisory lamps in the cord circuit at West glowed. The junction clearing lamp at South remained dark, however. The A-operator at West withdrew both her plugs, after metering the call, causing the junction clearing lamp at South to glow. This constituted a clearing signal to the B operator who withdrew the junction plug from the called subscriber's jack, so restoring normal conditions.

The order-wire system, although saving in operating time had certain disadvantages, three of which were

(a) The use of the separate circuit for instruction purposes made the system uneconomic when applied to small lightly loaded groups.

(b) The possibility of wrong numbers because of phonetic errors due to the simultaneous passing of requests.

(c) The difficulties encountered in efficiently staffing the B-positions during slack periods.

Straightforward junction (S.F.J.) working

The S.F.J. method of working retains many of the advantages of order-wire working but dispenses with the separate order-wire and the possibility of two operators simultaneously passing instructions to the same B-operator. Because a separate order-wire is not required small groups of junctions can be economically worked by the straightforward method, consequently the bulk of the incoming traffic can be handled on plug-ended B-positions.

There are two schemes of S.F.J. working, Non-distribution and Distribution. The B-positions for both schemes are fitted with 36 junction terminations, each consisting of a single-plug ended cord and a combined calling and supervisory lamp, the operator's telephone circuit and a 'busy' key. The switchboard multiple arrangements are similar to those already described for plug-ended B-positions.

When there is more than one B-position 'position coupling' facilities are provided to improve operating efficiency during slack periods of the day. The removal of the operator's telephone plug from the jack causes the terminations to be associated, i.e. coupled, with the operator's telephone on a staffed position. For example if position B of a 6 position suite is unstaffed the first 18 cords

on the position are associated with position A and the second 18 cords with position C. A description of the complete pattern of coupling between S.F.J. positions is beyond the scope of this pamphlet.

Non-distribution. The outgoing and terminating arrangements for the junctions are shown in Fig. 21. Two 25 point uniselectors are used to associate the operator's headset with the junctions; uniselector X selects the junctions connected to plugs 1 to 18 and uniselector Y those connected to plugs 19 to 36. A change-over arrangement associates the B-operator's telephone with the uniselector which has picked up the calling junction. If the telephone is connected to a junction via, say, uniselector X and a call originates on a junction connected to Y, uniselector Y steps to the calling circuit in readiness to extend the circuit to the operator's telephone as soon as the operator has dealt with the call in hand.

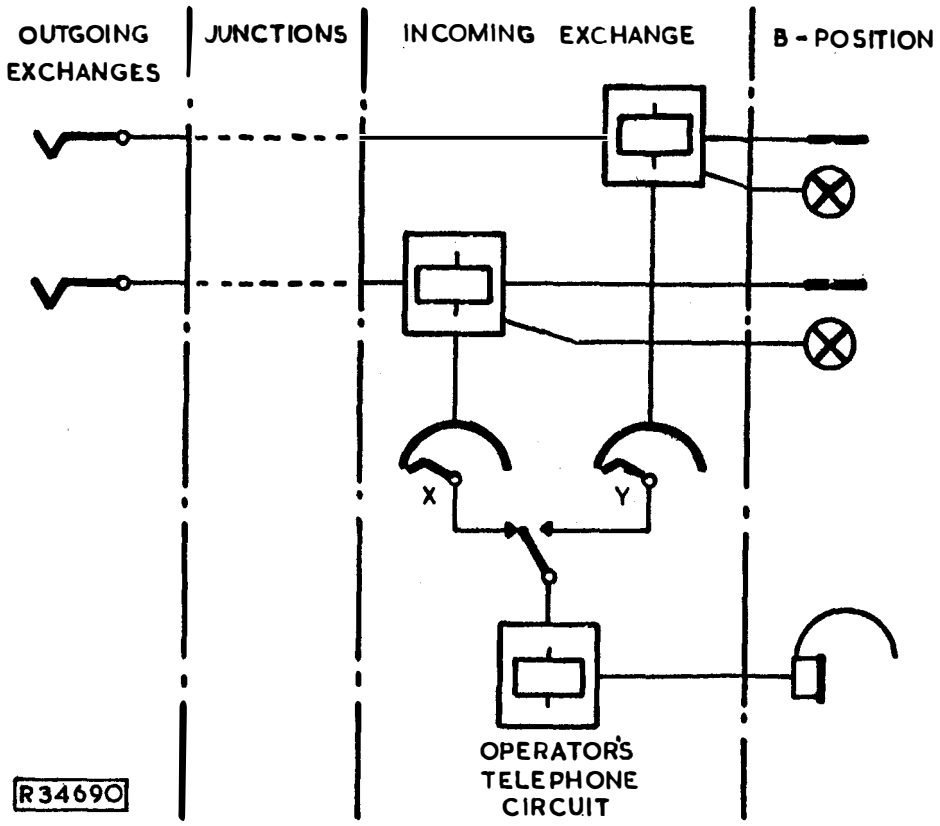

Fig. 21

When an A-operator inserts a calling plug in an outgoing junction jack, the lamp associated with the corresponding plug and cord on the B-position glows steadily until the B-operator's telephone is connected to the junction. When this occurs the lamp commences to flicker, 0.2 sec. off and 0.2 sec. on, denoting to the operator the junction to which she is connected and on which the connexion is desired. Simultaneously with the connexion of the operator's telephone to the junction, two pips of 900 cps tone are transmitted to the A-operator to advise her that the B-operator is listening. The A-operator then passes the required number over the junction and the B-operator completes the connexion by inserting the plug into the appropriate multiple jack, her telephone then being immediately disconnected from the junction and the lamp goes out. Ringing current is applied to the called subscriber's line and ring tone transmitted to the calling subscriber when the plug is inserted into the jack. When the called subscriber

answers, the lamp associated with the plug is extinguished and a called subscriber answer signal passed back over the junction to extinguish the A-position calling cord supervisory lamp.

In the event of the called subscriber's line testing engaged the B-operator depresses the position busy key, thereby transmitting busy tone to the A-operator. Upon the release of the busy key, the B-operator's telephone is disconnected from the junction and she is free to deal with subsequent calls, the busy tone, however, is transmitted until the A-operator clears down the connexion.

At the cessation of the call the action of the called subscriber replacing the telephone handset causes the A-position calling cord supervisory to glow. When the A-operator clears down the connexion, a steady signal is given on the lamp at the B-position, the junction is disconnected from the called subscriber's line, and the engaged test condition removed from the bush of the jack, thus leaving the line free for subsequent calls. There is a possibility of an A-position operator picking up a junction in the period between the A-operator removing the calling plug from the junction jack and the B-operator removing the junction plug from the called subscriber's multiple jack. Should such a 'follow on' call originate the junction will, in its turn, be connected to the B-operator's telephone and the lamp commence to flicker. The B-operator sets up the new connexion by withdrawing the plug from the multiple jack and inserting it in the jack of the required subscriber.

Distribution. The distribution system of S.F.J. working provides a uniform distribution of the incoming traffic over the B-positions. The distribution arrangements are shown in schematic form in Fig. 22.

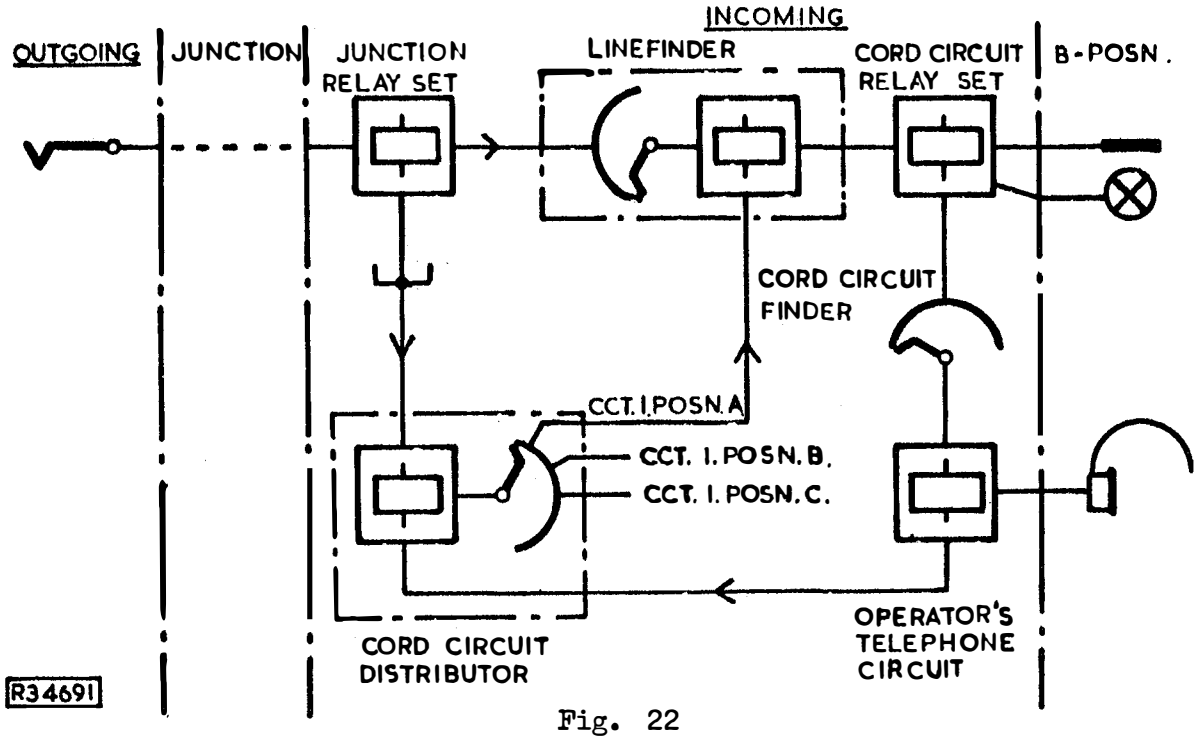

Fig. 22

The junctions incoming to the exchange are arranged in groups, each group containing up to 49 junctions which, in general, come from more than one exchange. The junctions in each group are wired to the banks of a number of uniselector type linefinders, each of which is connected via a relay set to a single plug ended cord and combined calling and supervisory lamp. The number of cords, and consequently linefinders, allocated to each group of junctions is dependent on the amount of traffic which the group is estimated to carry. The incoming traffic of each group is distributed over the 'B' positions by,

(a) providing each position with a number of cords associated with each junction group, and

(b) allocating the incoming calls on each group to the positions in turn by means of a cord circuit distributor associated with each group.

Consider a group of 49 junctions allocated 36 cord circuits. The junctions are connected to the bank contact multiple of the 36 linefinders and the cords are evenly distributed over 6 B-positions. Suppose the cord circuit distributor to be standing on a free cord, assume it to be cord No. 1 on position A.

When an A-operator plugs into a junction which is within the particular group we are considering, the cord circuit distributor circuit causes the linefinder connected to cord No. 1 on position A to step until it finds the calling junction. When the linefinder has connected the cord to the junction, the cord circuit finder on position A steps to the particular cord and connects it to the B-operator's telephone. The position is now closed to further calls until the operator has either inserted the appropriate plug, No. 1 in the example, into the called subscriber's jack or depressed the position busy key.

When the calling junction is connected to the B-operator's telephone, the cord circuit distributor steps to the next free cord, in the example this will be cord No. 1 on position B unless that position is already engaged in setting up a call originated in another group. If position B is engaged the distributor is stepped to cord No. 1 on position C, thus the incoming calls are evenly distributed over the positions.

The cords on an unstaffed position are coupled automatically to adjacent staffed positions, but are marked busy on the cord circuit distributors. When a call originates in a group which has all outlets staffed positions engaged, facilities are provided to unbusy and route the call to one of the coupled cords.

Discrimination. When a group of straightforward working junctions is used both as

(a) a direct route to another exchange, and

(b) a link in the route to an additional exchange or exchanges, a development of the S.F.J. system, termed discrimination, is employed.

At the outgoing end each junction is equipped with two sets of jacks, and at the incoming end a discriminating relay set and two terminations arranged as shown in Fig. 23. Direct traffic is routed via the 'direct' jack and S.F.J. equipment in the normal way, but a call extended via the 'through' jack is routed by the discriminating relay-set to the jack-ended termination situated on a special B-position. The call is extended over the appropriate junction by a double ended cord circuit which is specially arranged to provide the necessary through signalling arrangements

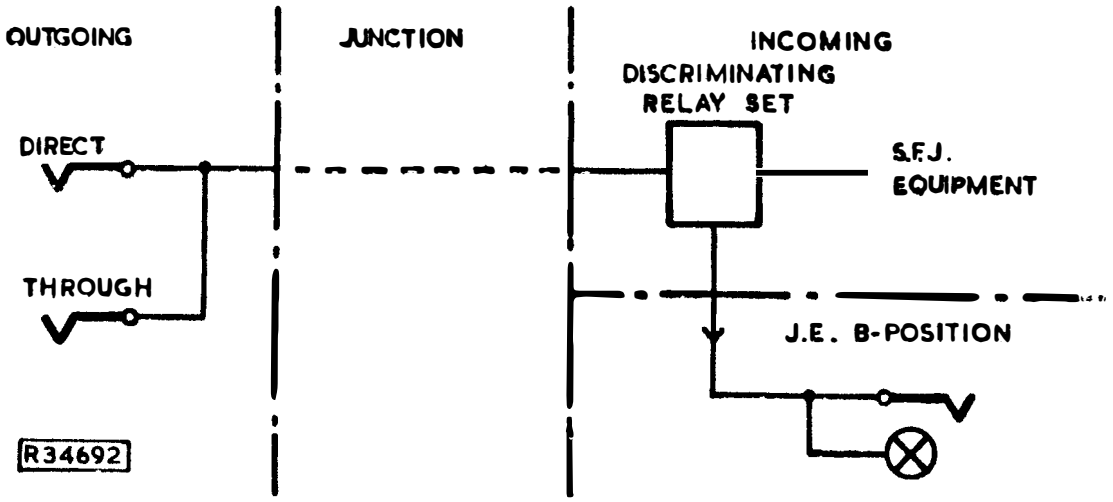

Fig. 23

SHARED SERVICE

General

In the shared service method of working, two subscribers share a pair of wires to the exchange and one set of calling equipment, but have separate telephone numbers. An explanatory diagram of the arrangement is shown in Fig. 24. On outgoing calls the operator requests the calling subscriber's number and records the call on a docket. The ringing signal normal to the particular exchange is used to call the X subscriber and a reversed ringing signal, i.e. the ringing current is applied to the other wire of the pair, to call the Y subscriber. The reversal of the ringing signal is effected by an additional key on the switchboard or a line reversal between the Y subscriber's multiple jacks and the junction with the X subscriber's circuit as shown in Fig. 24.

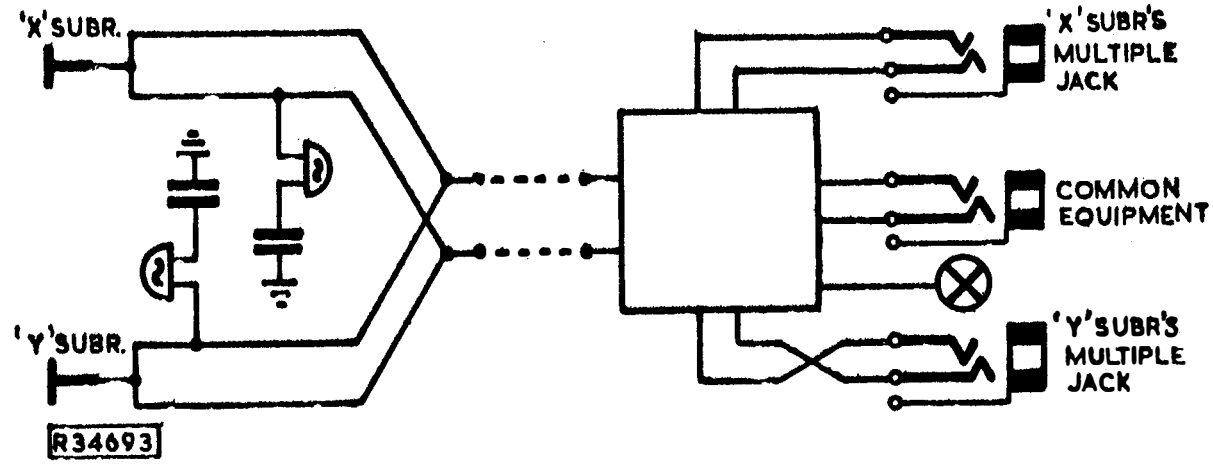

Fig. 24

C.B.S. Exchanges

At C.B.S. non-multiple type exchanges the Y subscriber is allocated the X subscriber's number prefixed with a digit which puts the resultant number outside the exchange numbering range, e.g. 56 and 356 on a 1-200 numbering range. The same jack is used for both subscribers, and a 'ringing reversing' key is fitted in the ringing current supply lead to effect X and Y ringing signals. Arrangements similar to this are provided for shared service working on magneto switchboards.

The multiple jacks of sharing subscribers on a C.B.S. multiple switchboard are so wired together that the common calling indicator is disconnected from the line when a plug is inserted into an X or Y subscriber's multiple jack. The number label associated with the calling indicator shows both the X and Y subscribers' numbers.

C.B. Exchanges

The Y subscriber ringing signal is effected by reversing the line wires to the Y subscriber's multiple jack, consequently an additional key in the ringing circuit is not required. Both the X and Y subscribers' numbers are indicated on the calling equipment, the arrangements at C.B.1 and C.B. 10 exchanges are shown in Figs. 25a and 25b respectively. At a C.B.1 exchange only the 2nd, 4th, 6th, 8th and 10th jack in the strip are used. The arrangement used at the C.B.10 exchange allows all the jacks,

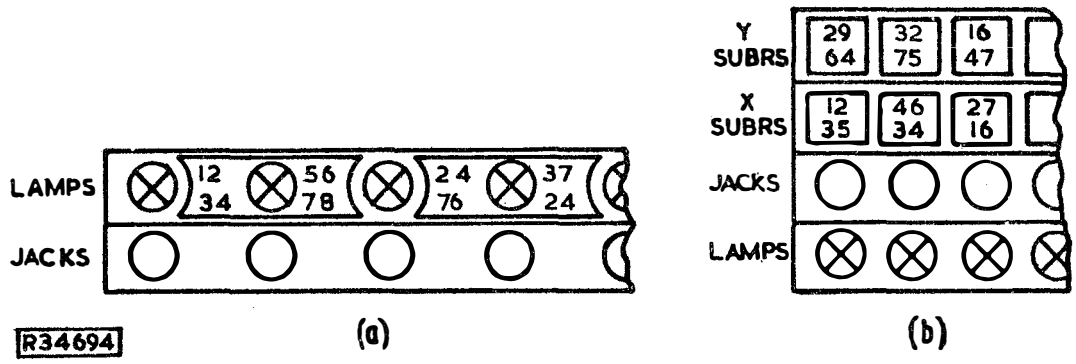

Fig. 25

20, in the strip to be used but necessitates an additional strip of labels. Whenever possible the shared service terminations are positioned at the top of the answering field.

END

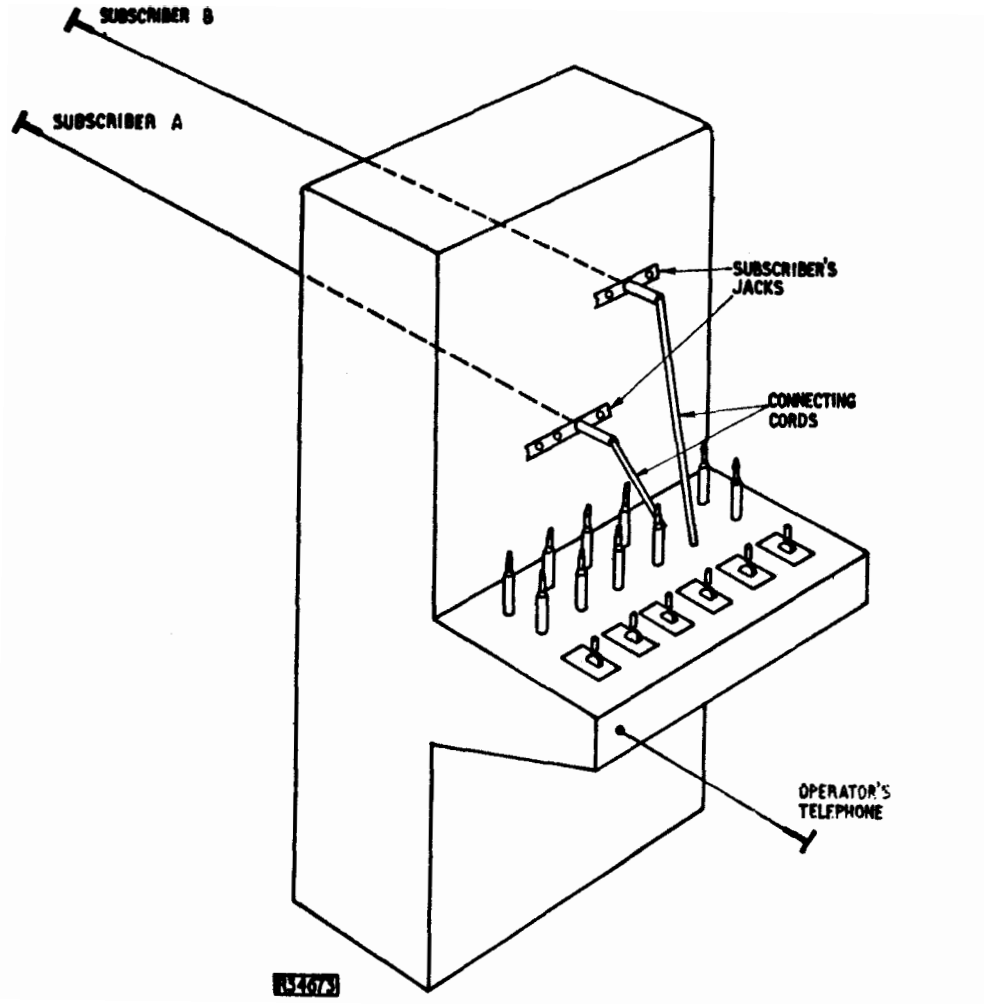
SUBSCRIBER B
SUBSCRIBER A
SUBSCRIBER'S JACKS
CONNECTING CORDS
OPERATOR'S TELEPHONE
R34673

Fig. 2a

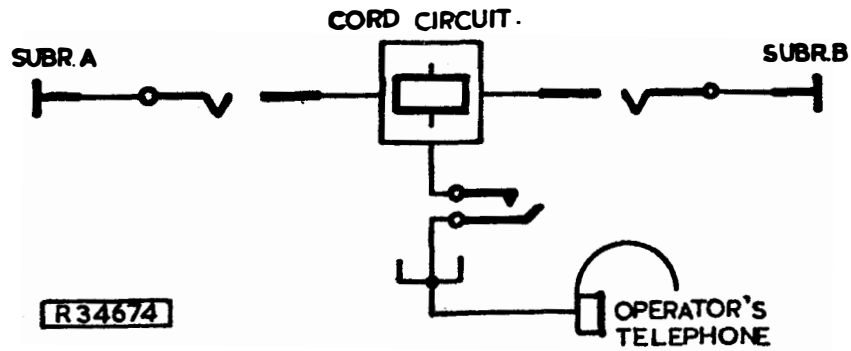
CORD CIRCUIT.
SUBR.A
SUBR.B
R34674
OPERATOR'S TELEPHONE

Fig. 2b

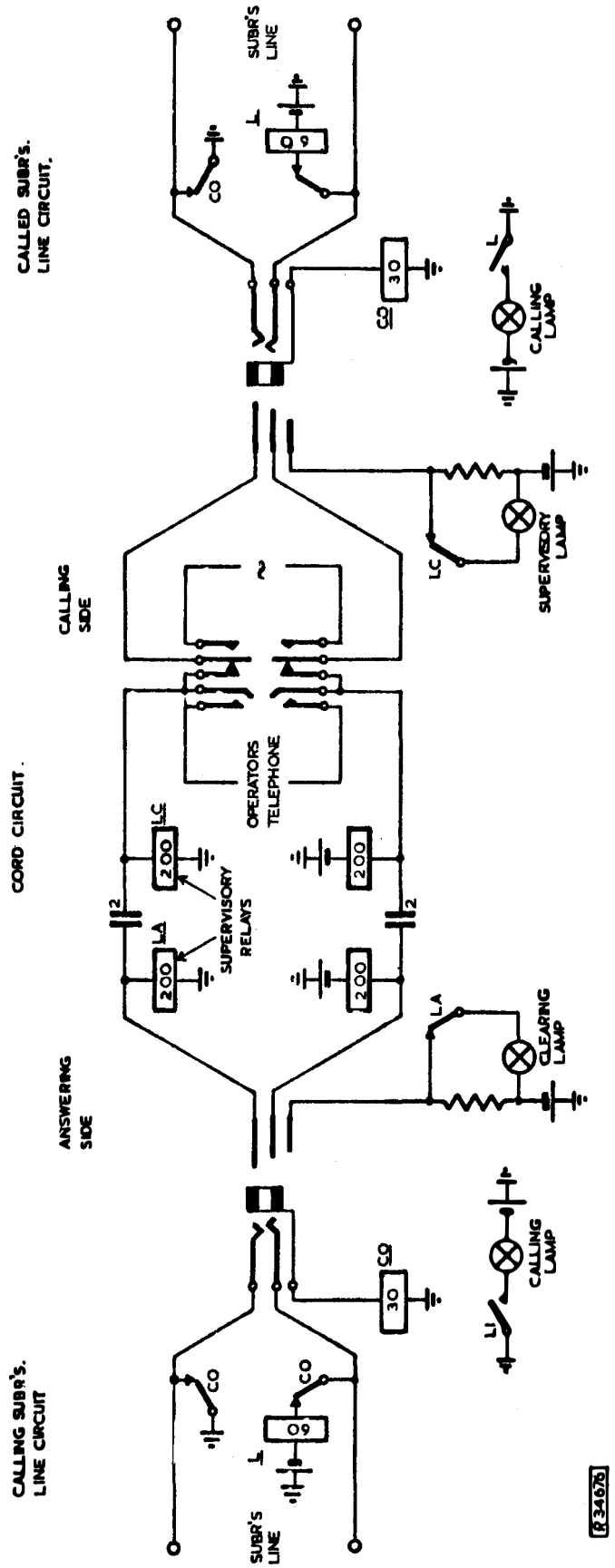
CALLED SUBR'S. LINE CIRCUIT.
SUBR'S LINE
CALLING LAMP
SUPERVISORY LAMP
CALLING SIDE
CORD CIRCUIT.
OPERATORS TELEPHONE
SUPERVISORY RELAYS
CLEARING LAMP
ANSWERING SIDE
CALLING SUBR'S. LINE CIRCUIT
SUBR'S LINE
CALLING LAMP
R34676

Fig. 4.

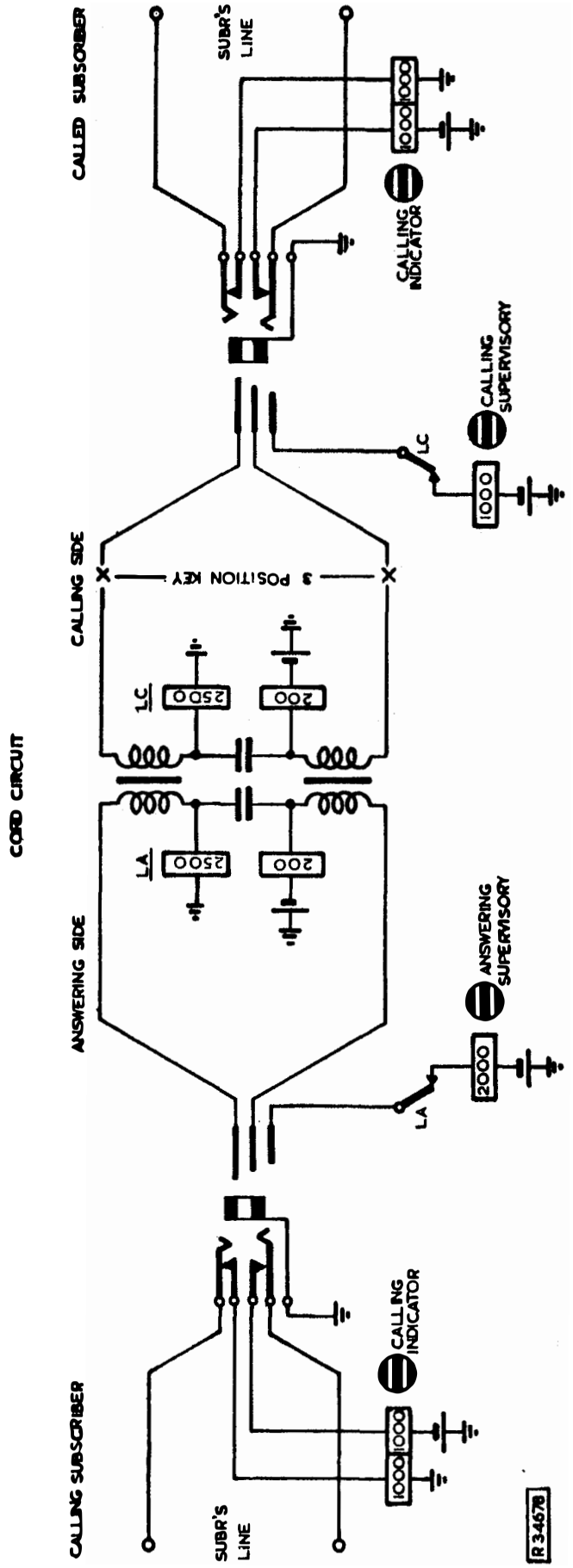
CALLED SUBSCRIBER
SUBR'S LINE
1000
1000
CALLING INDICATOR
CALLING SUPERVISORY
LC
1000
CALLING SIDE
3 POSITION KEY
LC
2500
200
CORD CIRCUIT
LA
2500
200
ANSWERING SIDE
ANSWERING SUPERVISORY
2000
LA
CALLING SUBSCRIBER
CALLING INDICATOR
1000
1000
SUBR'S LINE
R34678

Fig. 6

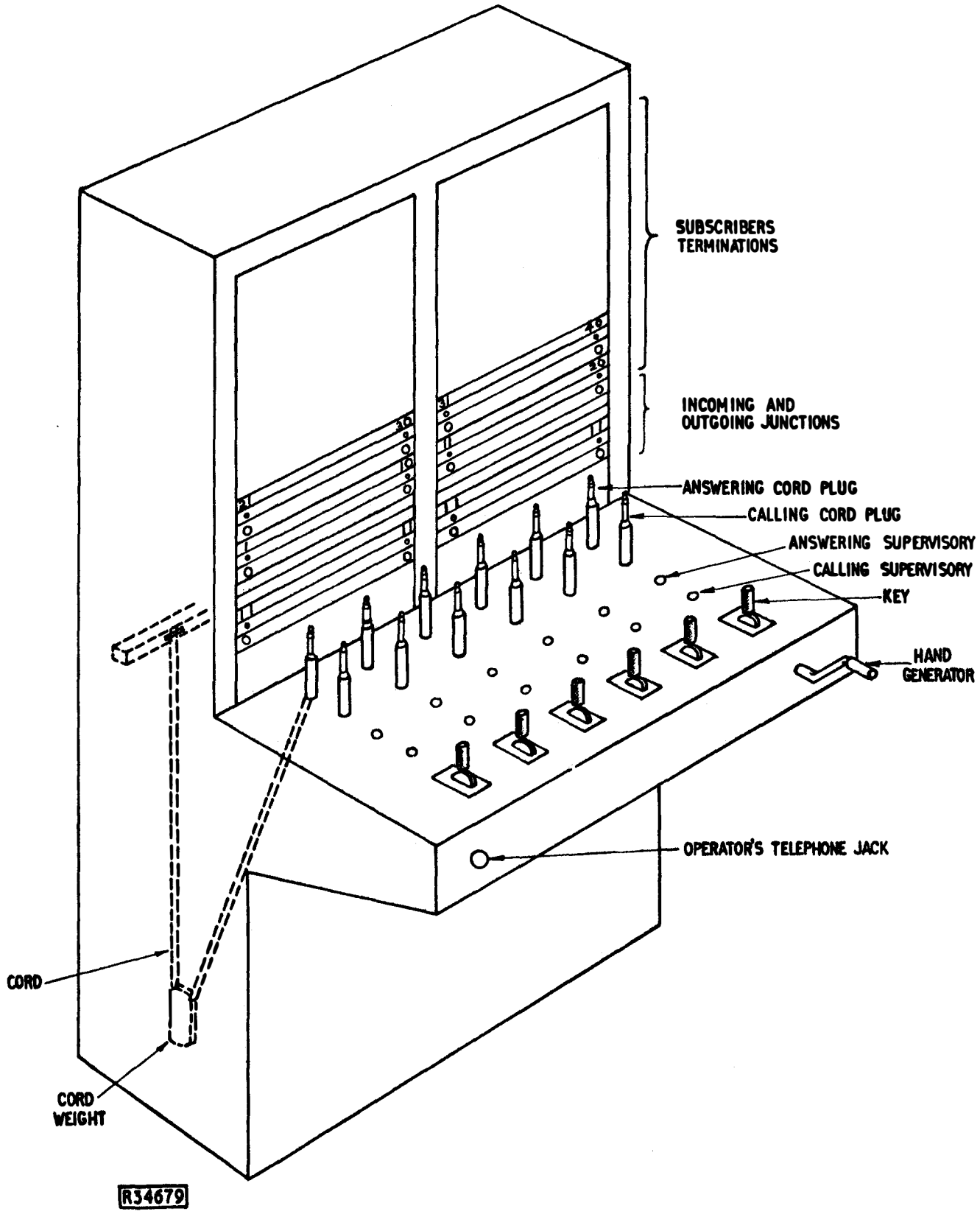
SUBSCRIBERS TERMINATIONS
INCOMING AND OUTGOING JUNCTIONS
ANSWERING CORD PLUG
CALLING CORD PLUG
ANSWERING SUPERVISORY
CALLING SUPERVISORY
KEY
HAND GENERATOR
OPERATOR'S TELEPHONE JACK
CORD
CORD WEIGHT
R34679

Fig. 7

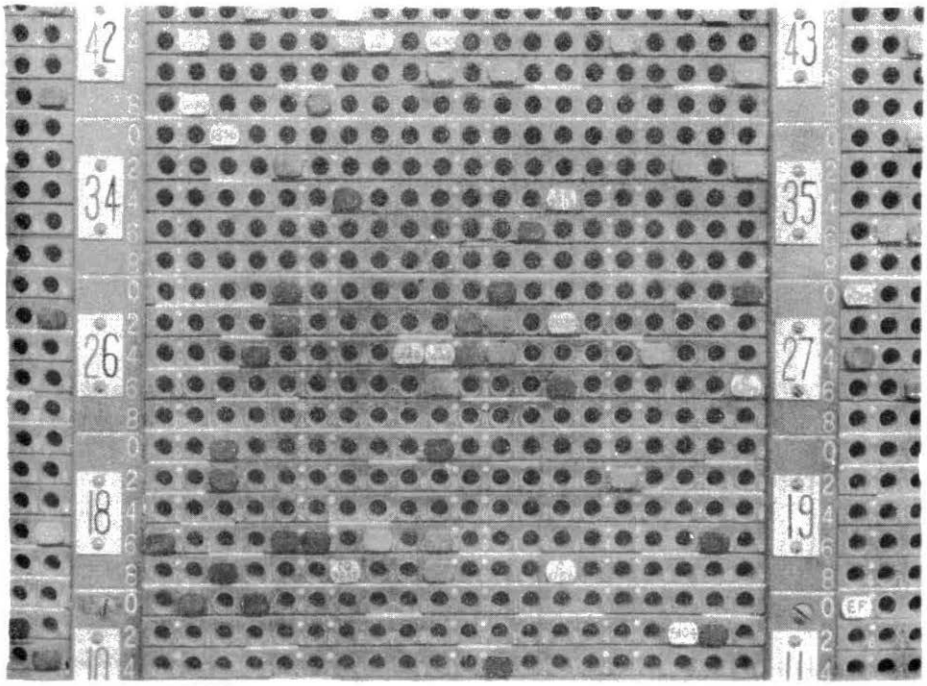
42
43
34
35
26
27
18
19
10
11
R34583

Fig. 11

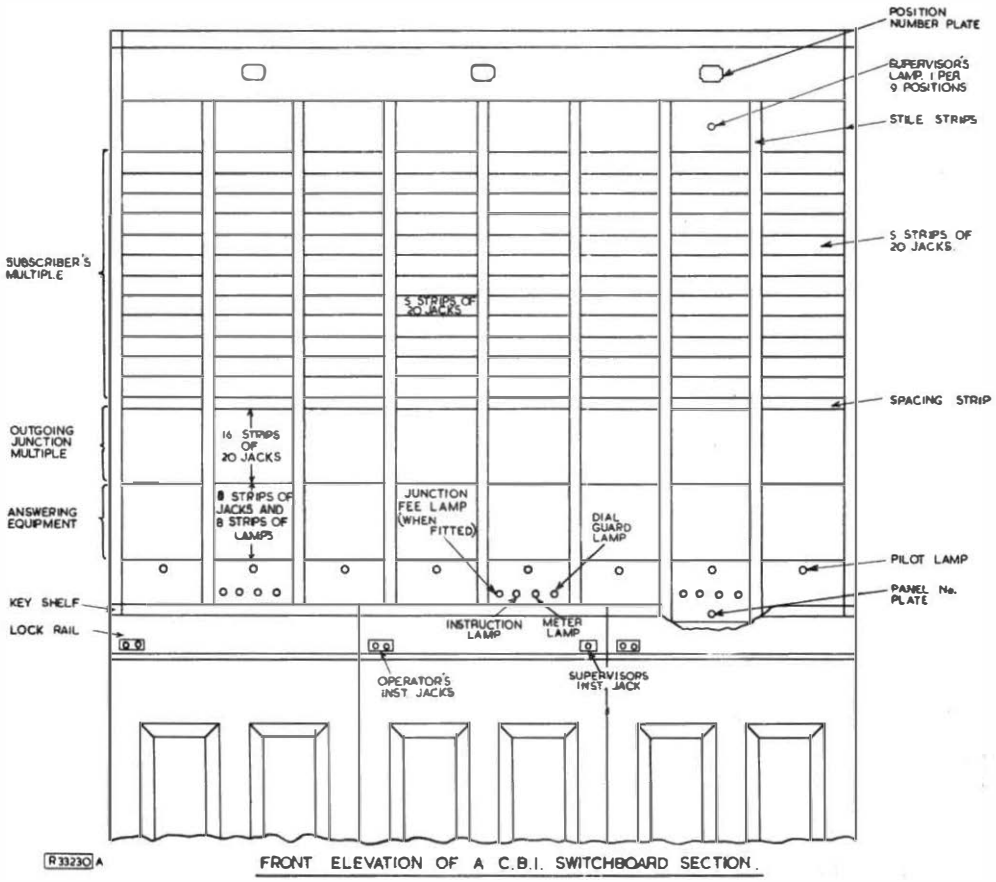
POSITION NUMBER PLATE
SUPERVISOR'S LAMP, 1 PER 9 POSITIONS
STILE STRIPS
5 STRIPS OF 20 JACKS
SPACING STRIP
PILOT LAMP
PANEL No. PLATE
SUBSCRIBER'S MULTIPLE
OUTGOING JUNCTION MULTIPLE
ANSWERING EQUIPMENT
KEY SHELF
LOCK RAIL
16 STRIPS OF 20 JACKS
8 STRIPS OF JACKS AND 8 STRIPS OF LAMPS
5 STRIPS OF 20 JACKS
JUNCTION FEE LAMP (WHEN FITTED)
DIAL GUARD LAMP
INSTRUCTION LAMP
METER LAMP
OPERATOR'S INST. JACKS
SUPERVISORS INST. JACK
R33230 A
FRONT ELEVATION OF A C.B.I. SWITCHBOARD SECTION.

Fig. 14