WS No. 19 Mark III

D.7.

P.W.D.7

Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject

C.B.S. EXCHANGES

Multiple Type

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1919

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Technical Pamphlets for Workmen

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CORRECTION SLIP TABLE.

The month and year of issue is printed at the end of each amendment in the Correction Slips, and the number of the slip in which any particular amendment is issued can, therefore, be traced from the date. In the case of short corrections made in manuscript, the date of issue of the slip should be noted against the correction.

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CORRECTION SLIP TABLE (contd.)

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C.B.S. EXCHANGES

MULTIPLE TYPE

(D.7.)

The following pamphlets in this series are of kindred interest:

D. 1. Elementary principles of Telephony.

D. 6. C.B.S. Exchanges—Non-Multiple type.

C.B.S. EXCHANGES—MULTIPLE TYPE

(D.7.)

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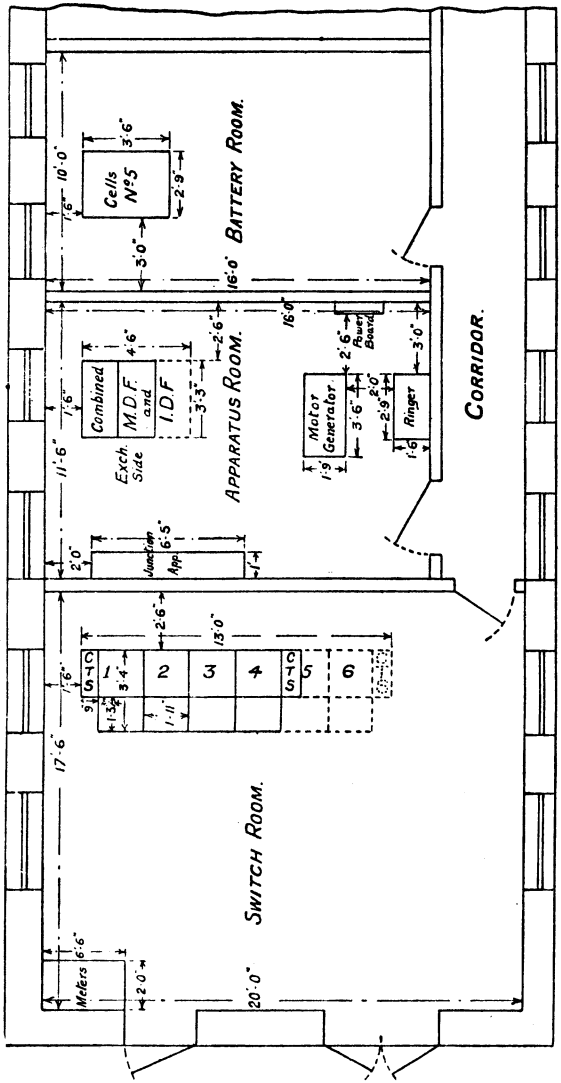


FIG. 1.—TYPICAL EXCHANGE LAYOUT.

C.B.S. MULTIPLE EXCHANGE.

GENERAL DESCRIPTION.

The C.B.S. No. 1 Multiple Switchboard was designed to meet the requirements of exchanges intermediate between exchanges served by non-multiple switchboards and exchanges where the prospective telephonic development renders a C.B. type of switchboard necessary. A C.B.S. No. 1 Multiple Switchboard was therefore usually installed at exchanges of 200 to 800 subscribers' circuits. The C.B.S. No. 1 Multiple Switchboard is, however, obsolescent, and its place is now taken by an installation of the minor C.B. No. 10 type.

The C.B.S. No. 1 multiple exchange was intended originally to work from primary cells, but it is frequently more economical to utilize secondary cells if suitable arrangements can be made for charging them. The conditions as they exist at up-to-date exchanges will be dealt with in this pamphlet.

Three separate rooms, *viz.*, Battery Room, Apparatus Room, and Switch Room are required for the accommodation of the exchange plant, the principal items of which comprise :—

(1) At exchanges having a common battery consisting of either primary or secondary cells—

Batteries. Combined Main and Intermediate Distribution Frame (the two portions of which will be referred to hereafter as M.D.F. and I.D.F.), M.D.F. Testing Set. Junction Apparatus Rack. Engaged Test Buzzer. Howler. Test Case. Switchboard. Cable Turning sections.

(2) At exchanges equipped with secondary cells—

Power Ringer (Ringing Vibrator or Ringing Machine), Fuse Panels. Charing Machine (Motor Generator or equivalent). Meter Rack.

(3) At exchange equipped with primary cells—

Power Ringer (Ringing Vibrator). Battery Distribution and Test Case.

A Test Case is not always required.

The Switch Room contains only the Switchboard, Cable Turning Sections, Test Case (of provided) and, at secondary cell exchanges, the Meter Rack.

The **layout** of the complete equipment at a typical exchange is shown in Fig. 1.

If **secondary cells** are provided, two sets of 11 cells (only one set of which is used at a time), each having an ampère-hour capacity suited to the exchange requirements, are installed as a common signalling battery from which current is also taken for the operators' speaking sets.

A **Power Switchboard** fitted with charge and discharge switches, ammeter, voltmeter and other testing and protective apparatus, and a Main Distribution Fuse Panel (both of which are usually located in the Apparatus Room) are associated

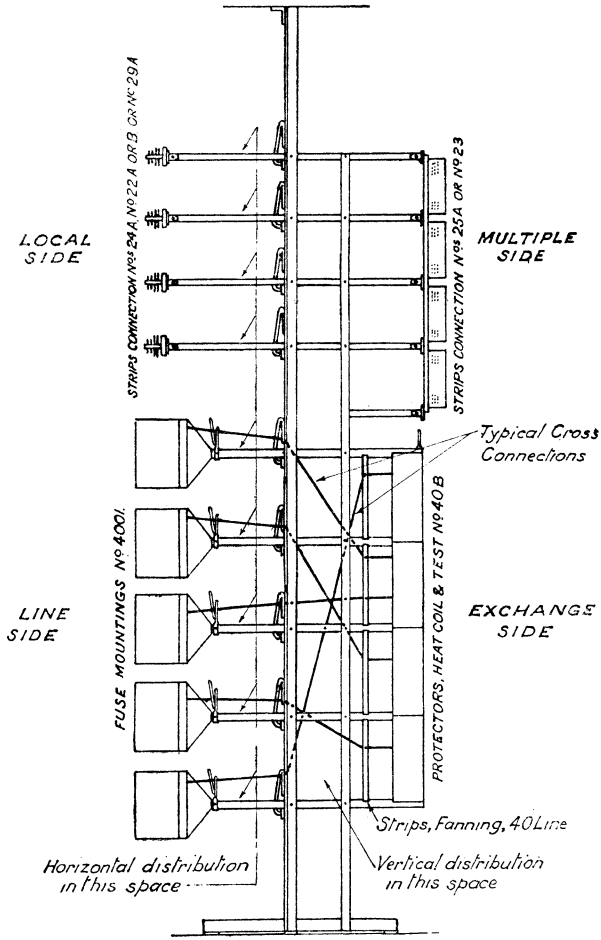


FIG. 2 (PART).—COMBINED M.D. AND I.D.F.

with the battery and battery charging plant and there are also subsidiary distribution fuse panels as follows :—

One in the Apparatus Room serving junction circuits.

One per switchboard position fitted at the rear of each switch section.

If **primary cells** are provided, two main signalling batteries are installed. One consists of a number of sets of Cells, Leclanché, No. 0, connected in parallel, and the other of 20 Dry Cells of the Z type. The former is used as a " Working " and the latter as a " Reserve " battery. The number of sets of Leclanché No. 0 cells employed depends on the traffic to be provided for. Separate operators' speaking batteries,

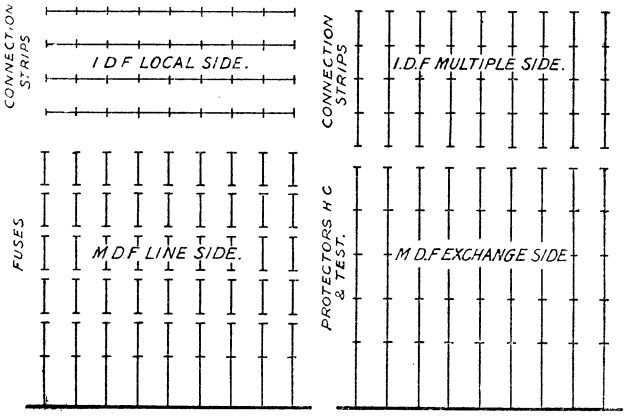


FIG. 2 (PART).

consisting of Cells, Leclanché, No. 1, are provided and other small batteries are used for various " Service " circuit and testing purposes.

At primary battery exchanges the main signalling batteries are connected to a Battery Distribution and Test Case to facilitate battery testing and to afford a ready means of bringing the " Reserve " battery into use in cases of emergency

Fig. 2 illustrates the **Combined M.D.F. and I.D.F.** Its functions are explained in Pamphlet P.W.—D.18.

The combined M.D.F. and I.D.F. is a two-sided iron framework divided into a lower and an upper portion. The lower portion comprises the M.D.F. and the upper portion the I.D.F. The space between the two sides of the frame serves as a field for cross-connections.

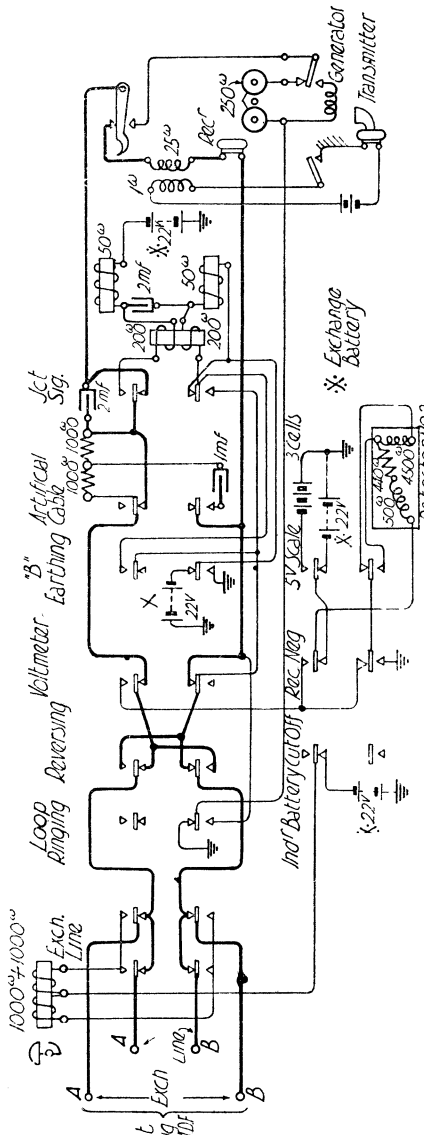


FIG 3A.—M.D.F. TESTING SET.

The "Line" side of the M.D.F. is fitted with fuse mountings and fuses, and the "Exchange" side is equipped with "Protectors, Heat Coil and Test."

On both sides of the M.D.F. the protective devices are mounted in 20 circuit units, which are fitted in vertical rows. On the "Line" side each "vertical" accommodates 100 circuits (200 wires), but on the "Exchange" side each "vertical" takes only 80 circuits (160 wires). The reason for this difference is that the "Line" side has to provide for a proportion of spare wires over and above the capacity required on the switchboard.

Both sides of the I.D.F. are fitted with "Strips, Connection" (blocks of wiring tags). On the "Multiple" side four connection strips are fitted vertically in each row. On the "Local" side the strips are mounted horizontally, but are grouped and numbered in vertical rows for wiring purposes.

The return cables from the subscribers' multiple and the cables from the exchange side of the junction apparatus

terminate on the "Multiple" side of the I.D.F. Each connection strip to which the former are connected accommodates the wiring for 20 circuits, but in the case of the latter the number of circuits accommodated is 5, 6, 10 or 20 according to the type of junction.

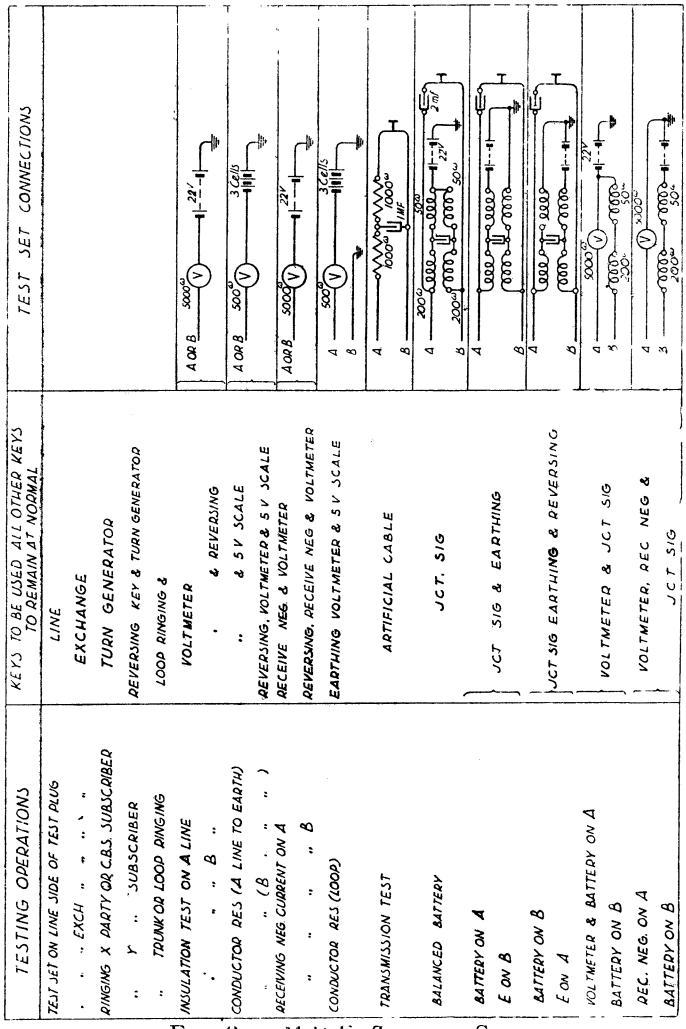


FIG. 3B.—M.D.F. TESTING SET.

The cables from the subscribers' answering jacks, incoming junction jacks and outgoing junction multiple jacks terminate on the " Local " side of the I.D.F. The strips proper to subscribers' circuits accommodate 20 circuits each, and those associated with junction circuits, both incoming and outgoing, 10 circuits each.

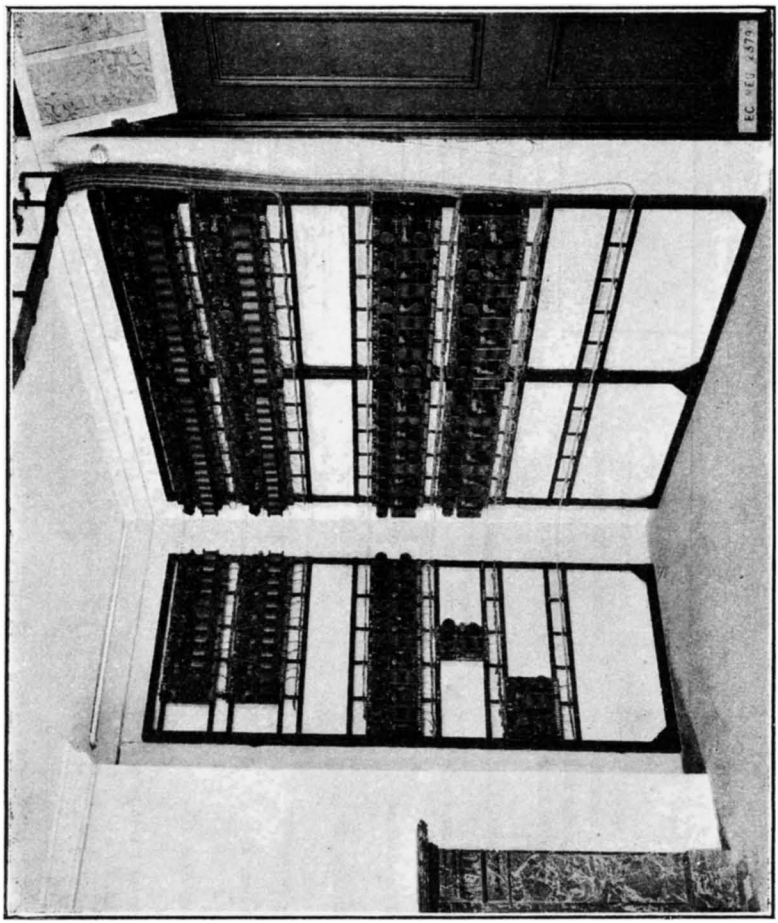


FIG. 4.—JUNCTION APPARATUS RACK.

The **M.D.F. Testing Set,** which is a small wall or table fitting equipped with a number of keys, a voltmeter and ringing and speaking apparatus, is used for the testing of circuits from the M.D.F. The test set is provided with a test plug and cord and the insertion of the plug into the test springs of a Protector, H.C. and Test, extends the circuit to the test set. Fig. 3a shows the arrangement of the test set and Fig. 3b the various tests which can be carried out.

Fig. 4 shows a **Junction Apparatus Rack.** The apparatus required for each type of junction circuit is mounted on a small wallboard and is issued as a complete unit. These units are screwed to an iron framework fixed to a wall as illustrated.

The line side tags of the unit are wired to the exchange side of the M.D.F. and the exchange side tags to the multiple side of the I.D.F. An appropriate unit is connected to a junction circuit by cross-connections (jumpers) on the M.D.F. and I.D.F. There is no cross-connecting field on the junction apparatus rack. All the cross-connecting required for junction circuits is carried out on the M.D.F. and I.D.F.

The Switchboard at C.B.S. exchanges consists of sections of the two-panel type, each of which constitutes an operator's position.

The *sections* are so designed that they can be fitted together in one suite starting from the right or left, as may be most convenient for the growth of the switchboard.

The positions on which subscribers' lines terminate are known as " A " positions.

Sections which are fitted only with calling and answering equipments for junctions or trunks are known as " B " positions and Trunk positions respectively. In certain circumstances, however, a position may carry all classes of circuits. It is then styled a " Mixed B " position. The Subscribers' and Outgoing Junction multiples are continued over " B " and Trunk positions.

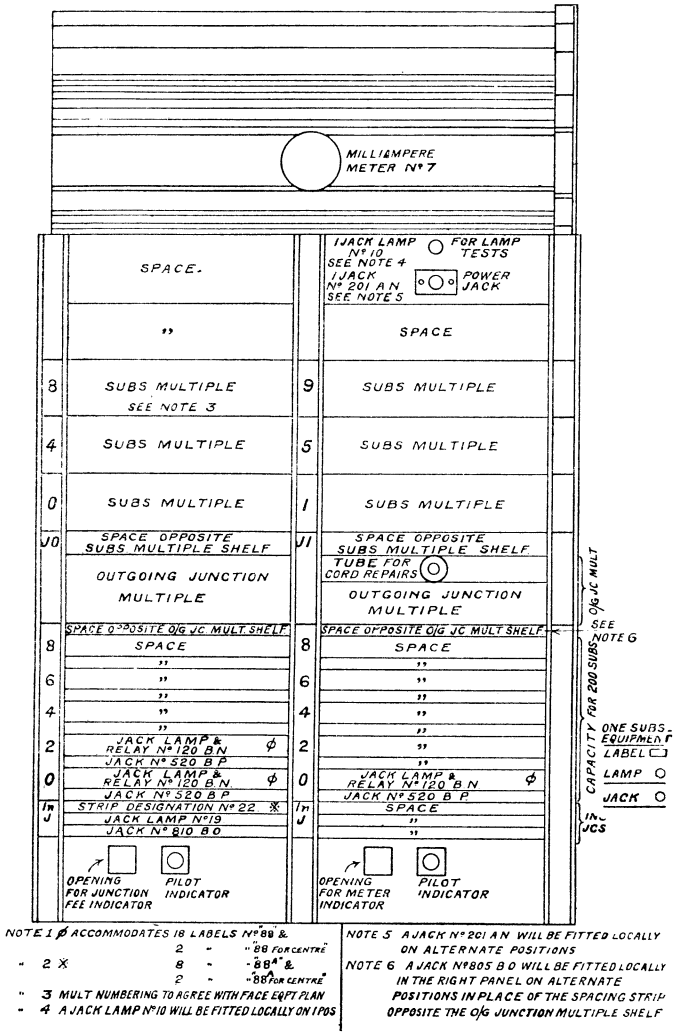
Fig. 5 illustrates the *face equipment* of an " A " operator's position.

The lower part of the jack field in each panel is reserved for the answering and calling equipments, the Incoming Junction equipments being placed below the Subscribers' equipments.

The *Incoming Junction equipments* consist of strips of 10 jacks, 10 lamps and a designation strip for 10 labels placed one above the other in the order named.

The *Subscribers' equipments* consist of strips of 20 jacks and 20 combined line lamps and relays. The combined lamps and relays are placed above the jacks and a designation strip for 20 labels is provided on the front of the mounting plate

(see the marginal sketch in Fig. 5). The opal caps of the line lamps are engraved and coloured in accordance with the Official Code to denote the service allowed to each subscriber.



NOTE 1 Ø ACCOMMODATES 18 LABELS Nº 88 &
2 - "88 FOR CENTRE"
" 2 ✕ 8 - "88A" &
2 - "88B FOR CENTRE"
" 3 MULT NUMBERING TO AGREE WITH FACE EQPT PLAN
" 4 A JACK LAMP Nº 10 WILL BE FITTED LOCALLY ON 1 POS

NOTE 5 A JACK Nº 201 A.N. WILL BE FITTED LOCALLY ON ALTERNATE POSITIONS
NOTE 6 A JACK Nº 805 B O WILL BE FITTED LOCALLY IN THE RIGHT PANEL ON ALTERNATE POSITIONS IN PLACE OF THE SPACING STRIP OPPOSITE THE O/G JUNCTION MULTIPLE SHELF

FIG. 5.—"A" POSITION—FACE EQUIPMENT.

Above the answering equipments are the *Outgoing Junction Multiple Jacks* in rows of 10 and designation strips. The outoing junction multiple is repeated in every four panels of the switchboard.

Above the Outgoing Junction multiple jacks are the *Subscribers' multiple jacks*. These are in strips of 20, arranged and numbered in groups of 100 jacks. The method of numbering is illustrated in Fig. 6. The Subscribers' multiple, like the Outgoing Junction multiple, is repeated in every four

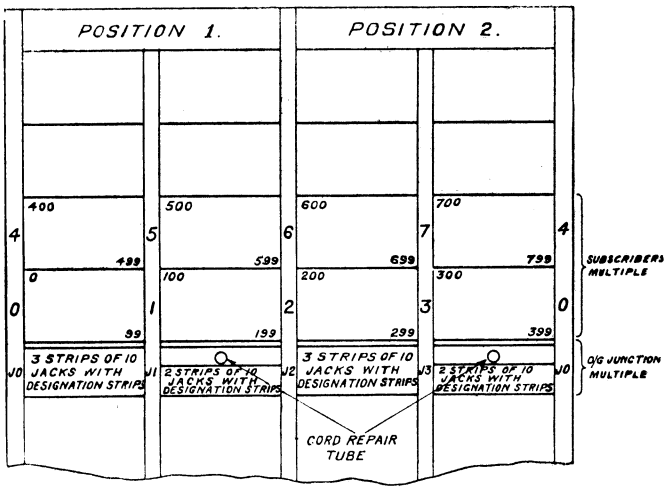


FIG. 6.—SUBSCRIBERS' AND OUTGOING JUNCTION MULTIPLE.

panels of the switchboard. The figure shows the face equipment (multiples only) of two sections fitted with a Subscribers' multiple for 800 and an Outgoing Junction multiple for 50 lines.

Each panel is also fitted below the jack field with a Line Pilot Indicator and provision is made for a junction fee Pilot Indicator in the left panel and a meter Pilot Indicator in the right panel.

The *Line Pilot Indicator* is operated whenever a call is made on any line terminating in the panel above the indicator, and the arrangements provide for an audible alarm if constant attention is not given at the switchboard.

The *Junction Fee Pilot Indicator*, if fitted, is associated with the order wire keys on order wires to other exchanges and is

operated whenever one of those keys is depressed, acting as a reminder to the operator that a special junction fee is chargeable to the subscriber whose call is being handled.

The *Meter Pilot Indicator*, if fitted, is associated with the meter keys and is operated whenever one of those keys is depressed.

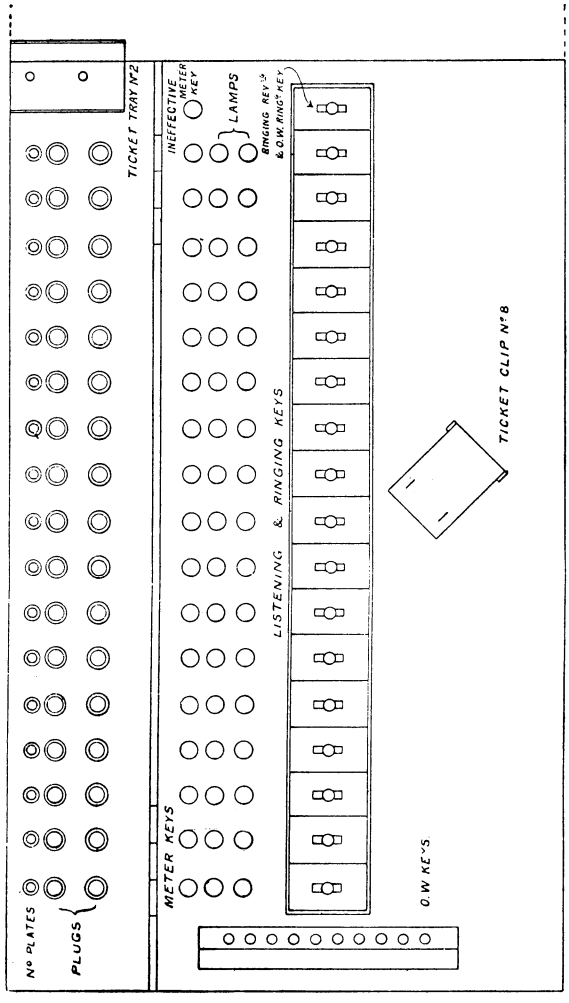


FIG. 7.—"A" SECTION KEYBOARD.

A *milliampèremeter* is fixed on each " A " section to indicate the total leakage current on the group of subscribers' lines connected to the section.

A *cord repair tube* is provided in the right panel of each section.

Fig. 7 is a view looking down on the *keyboard.* It will be seen from this figure that each position is equipped with 17 cord circuits in connection with which are fitted as shown 17 pairs of plugs, 17 pairs of lamps, 17 combined listening and ringing keys and 1 combined ringing reversing and order wire ringing key. Provision is also made for fitting 17 effective meter keys, 1 ineffective meter key and two strips of 10 order wire keys which are shown but which are not supplied with the section. The plugs, lamps and key in line with one another from back to front of the keyboard are associated with one cord circuit. The rear lamp of a pair is associated with the back or answering plug and the front lamp with the calling plug. When a plug is inserted into a subscriber's jack the corresponding lamp glows whilst the subscriber's receiver remains on its rest and darkens when the receiver is removed.

The ringing reversing action of the combined ringing reversing and order wire ringing key is required at some exchanges in order to provide for ringing party line subscribers with bells connected to the *B* lines of the circuits. This method, however, is obsolescent as party lines are now connected to two jacks per multiple, the connections of which are so arranged that subscribers with bells connected either to the *A* or *B* line of the circuit can be rung in the normal manner without recourse to the use of a ringing reversing key. The order wire ringing portion of the combined ringing reversing and order wire ringing key is used to gain the attention of the wanted exchange operator when continuous attention is not given at the incoming end of order wires.

An *effective* meter key, when fitted, is used to register a call on a subscriber's meter for accounting purposes and, at the same time, record an effective call on the operator's position meter. The depression of the ineffective meter key has no effect on a subscriber's meter, but it records an ineffective call on the operator's *ineffective* position meter. The records obtained from the effective and ineffective position meters are used for traffic purposes.

Fig. 8 is a sectional view of the section. The equipment at the rear of the section includes the relays, condensers, resistances, etc., associated with the cord circuits, a fuse panel and connection strips on which the wiring to subscribers' and

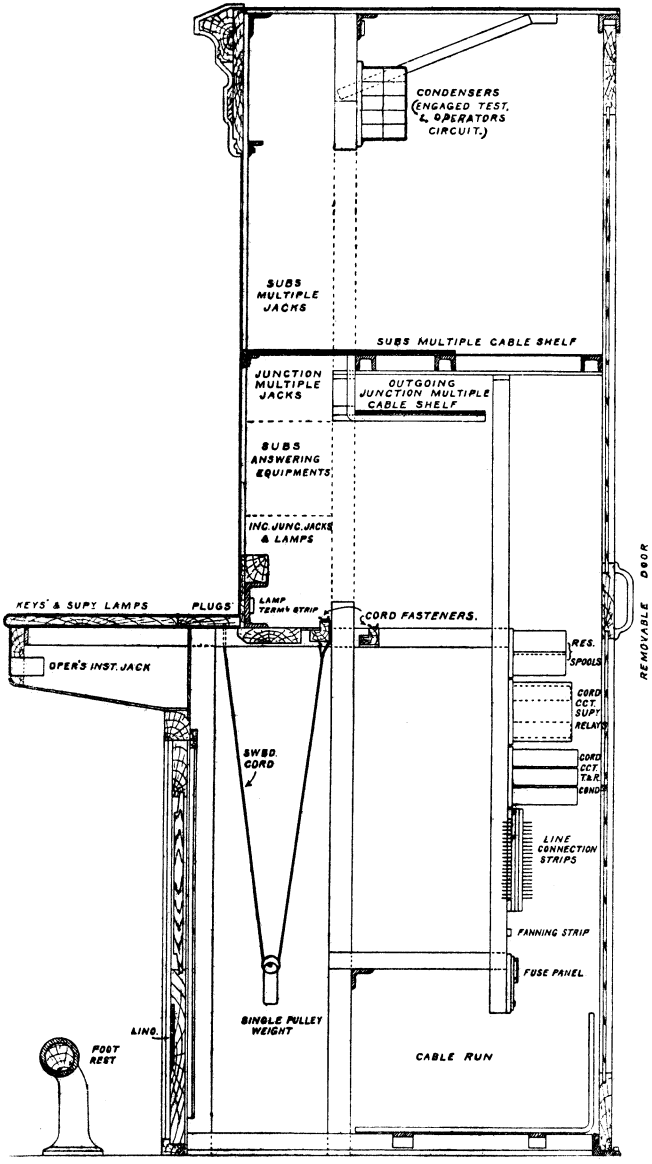


FIG. 8.—C.B.S. MULTIPLE SWITCHBOARD—"A" SECTION.

incoming junction equipments and to order wire keys is terminated. The provision made for the accommodation of cables in the switchboard is apparent.

The **Meter Rack** has a unit capacity for 400 meters, and the subscribers' meters and the operators' position meters (Effective and Ineffective) are placed upon it.

A **Test Case** for junction and trunk lines is placed in the switchroom at exchanges where the services of an engineering officer are not continuously available, and the co-operation of the Traffic Staff in line testing and fault localisation is required.

The **switchboard cables** from the combined M.D.F. and I.D.F. to the switchboard and meter rack, are carried on a cable rack or racks built up of suitable iron work or of wall and ceiling brackets.

Cable Turning sections, which give the switchboard a finished appearance, cover up the cables as they leave the cable racks to enter the switchboard at the first section, or as they pass from the upper to the lower portion of the switchboard at the last section.

Fig. 9 is a general plan of the **exchange cabling scheme** and indicates the size of cable usually used between the various parts of the exchange equipment.

The **subscribers' line circuits** are carried in groups of 20 from the combined M.D.F. and I.D.F. to the switchboard. Cables, switchboard, 42-wire/9¼, oval, are used between the protector strips on the exchange side of the M.D.F. and the switchboard where the pairs of wires are connected direct to the " line in " springs of individual jacks on the subscribers' multiple on the first or second sections according to the hundreds group in which the subscriber's number is included. The cables used for the connections between each set of multiple jacks, and between the " line out " springs of the multiple jacks at the end of the multiple and the connection strips on the " Multiple " side of the I.D.F., are 63-wire/9¼, oval, switchboard cables. As a general rule, " slack " is provided on the 63-wire cables returning from the switchboard to the I.D.F. in order to provide for an extension of the switchboard, thus avoiding the necessity, which would otherwise arise, of cutting the cables when additional sections are to be installed. The slack is stored in the cable turning section and in the lower portion of the last section. Cables, switchboard, 63-wire/9¼, oval, are used also for the connections between the connection strips on the " Local " side of the I.D.F. and the connection strips to which the subscribers' calling and answering equipments are connected at the rear

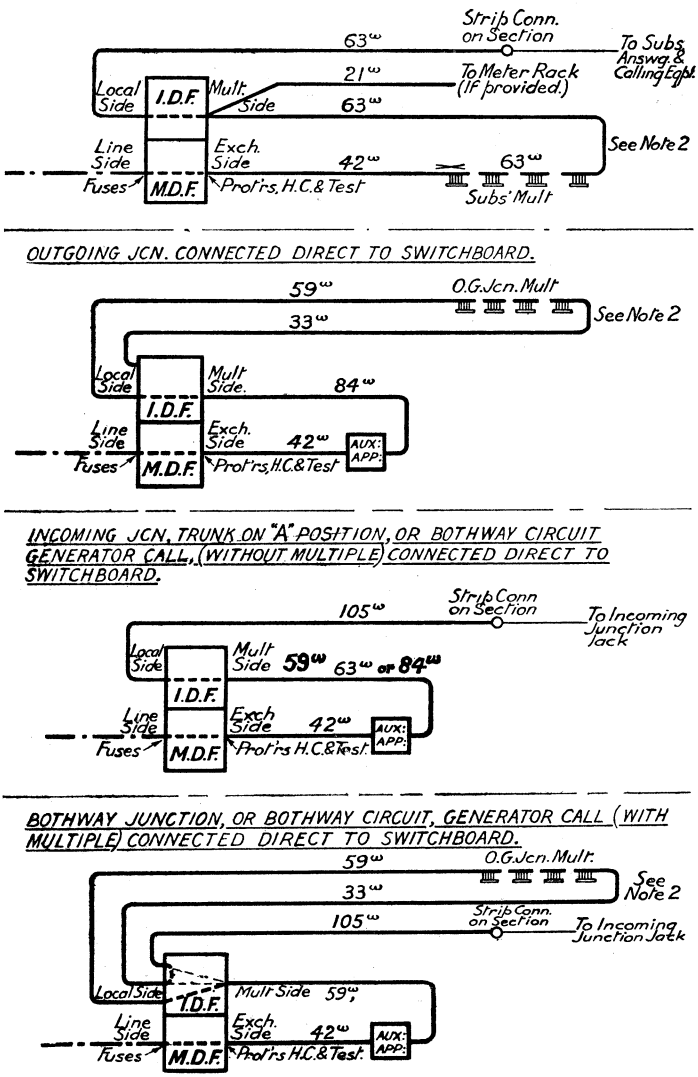
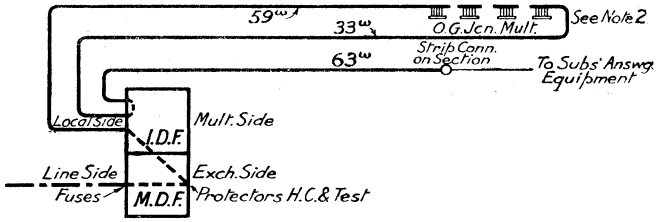
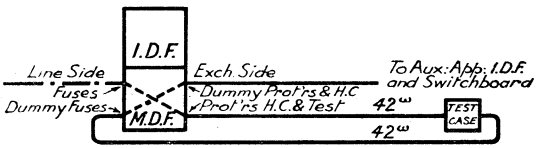


FIG. 9 (PART).—GENERAL WIRING SCHEME.

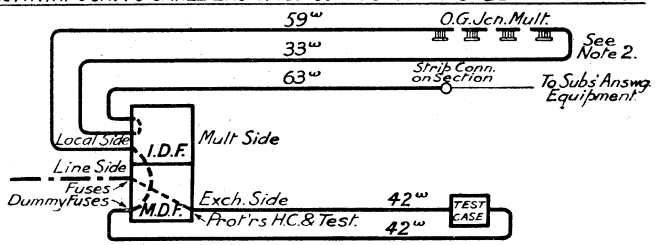
BOTHWAY JCN. TO SMALL EXCHANGE CONNECTED DIRECT TO SWBD.



OUTGOING, INCOMING OR BOTHWAY JCN, TRUNK ON "A" POSITION, OR BOTHWAY CIRCUIT, (GENERATOR CALL) CONNECTED TO SWITCHBOARD VIA TEST CASE.



BOTHWAY JCN. TO SMALL EXCHANGE CONNECTED TO SWBD. VIA TEST CASE.



Exchange Leading-in Cable
Switchboard Cable
Switchboard Wiring
Main. Signalling } Cross Connections

Note 1. The M.D.F and I.D.F are combined in one frame.
Note 2. Slack will generally be provided on the cables between the I.D.F. and the end of the Multiples, as installed initially, to allow of the extension of the Switchboard to the ultimate

FIG. 9 (PART).

of the sections. Bearing in mind that the circuits are dealt with in groups of 20, it will be recognised that there are two spare wires available in each 42-wire cable for use in case of faults and three spare wires in each 63-wire cable. Two wires per circuit are used in the 42-wire cables and three per circuit in the 63-wire cables, the third wire per circuit in the latter cables being required in connection with the registering of subscribers' calls and the provision of an indication to operators when a subscriber's line is engaged.

If **meters** are installed they are connected to the Multiple side of the I.D.F. by means of Cable, switchboard, 21-wire/9¼, round, each cable serving a set of 20 meters. 42-wire/9¼, oval, switchboard cables are used between the protector strips on the " Exchange " side of the M.D.F. and the line side of the junction auxiliary apparatus. Switchboard cables are also used between the exchange side of the junction auxiliary apparatus and the multiple side of the I.D.F., but the sizes vary from 33-wire to 105-wire. All are 9¼, oval, except the 105-wire, which is 9¼, round.

The **Outgoing Junction Multiple** was originally of the branching type, but the break jack type of multiple has now been adopted as standard. The " line in " springs of the jacks on each of the first strips in the multiple are connected to the connection strips on the " Local " side of the I.D.F. by means of cable, switchboard, 59-wire/9¼, oval, and the same class of cable is used for the connections between the strips of jacks in the multiple. The " line out " springs of the jacks on each of the last strips on the multiple are connected by 33-wire switchboard cables, 9¼, oval, to tags on the same connection strips on the " Local " side of the I.D.F. as the 59-wire cables are wired to. As in the case of the 63-wire cables associated with the subscribers' multiple " slack " is provided on the 33-wire cables.

Cables, switchboard, 105-wire/9¼, round, are used between the connection strips on which the Incoming Junction cabling and answering equipments are terminated at the rear of the sections, and the connection strips on the " Local " side of the I.D.F.

The outgoing, incoming and bothway junction lines entering the exchange are cross-connected on the M.D.F. to the line side of appropriate sets of junction auxiliary apparatus, and the exchange side of the sets are cross-connected on the I.D.F. to the outgoing junction multiple, the incoming junction jacks, or to both as may be required by the character of the circuit.

OPERATING.

Local Calls.—The subscriber calls the exchange by removing his receiver from its rest. The call is indicated at the exchange by the glowing of a line lamp.

Using one of the rear or answering plugs, the operator plugs into the answering jack associated with the line lamp which is automatically darkened, presses back the appropriate listening key and ascertains the requirements.

The operator next tests to ascertain whether the required number is engaged. This she does by touching the bush of the wanted subscriber's multiple jack with the tip of the front or calling plug. If the line is engaged, the operator hears a " click " in her receiver and advises the calling subscriber accordingly. If the line is free she thrusts the plug into the jack, thus setting up the required connection. The ringing key is next drawn forward intermittently. Where machine ringing is in operation the ringing current passes out to the subscriber's line ; in other cases, the hand generator must be operated simultaneously with the manipulation of the key. There is no need for the operator to remain in circuit to supervise the call as, on the key being restored to its normal position, the front lamp will glow until the called subscriber answers.

On the completion of the call, the replacement of the subscribers' receivers, on their respective rests causes both the cord circuit lamps to glow. After depressing the meter key (where installed) the operator takes down the connection.

Junction Calls.—Should the calling subscriber require a number connected to another exchange, the connection will be made over a Junction Circuit.

Junctions between two exchanges are of two types known as " Order Wire " junctions and " Ringing " junctions.

Order wire junctions are operated in one direction only. At the outgoing end they terminate on jacks in the outgoing junction multiple, and at the incoming end on a plug and cord associated with signalling apparatus and apparatus for ringing subscribers. At the outgoing end each order wire is connected to a series of order wire keys (one on each operator's position) by means of which the operators' speaking sets can be connected to the order wire line. At the incoming end the order wires terminating on one position are connected to the operator's speaking set.

Information regarding the provision of order wire junctions is given in Pamphlet P.W.—D.11.

A *Ringing Junction* equipped for operation in one direction only is connected at the outgoing end to jacks in the outgoing

junction multiple, and at the incoming end it is terminated on a jack, or plug and cord, associated with calling apparatus. At C.B.S. exchanges an incoming ringing junction is always jack-ended.

If traffic considerations do not warrant one-way working, a ringing junction is equipped with apparatus to provide both the incoming and outgoing facilities at each end.

If a subscriber at a C.B.S. exchange requires a subscriber at another exchange reached by ringing junctions, the " A " operator, after testing for and finding a disengaged junction " plugs-in " and calls the distant exchange. The calling is effected automatically on the insertion of the plug, and the front lamp on the cord circuit at the originating exchange glows until the called exchange answers. At the distant exchange the " B " operator, having obtained particulars of the call, makes the connection to the required number and rings the wanted subscriber. The front lamp of the cord circuit used by the " A " operator glows again until the called subscriber answers.

If the wanted subscriber is on an exchange reached by order wire junctions, the " A " operator depresses an order wire key bearing the code of the exchange required and passes the details of the call to the " B " operator who allots a disengaged junction. The " A " operator finds this junction in the outgoing junction multiple and connects to it, whilst the " B " operator tests the wanted subscriber's line and, if found to be disengaged, connects it to the junction.

If the wanted subscriber's line is engaged, the " A " operator is informed orally in the case of Ringing Junctions and, in the case of order wire junctions, by a flashing signal on the front lamp of her cord circuit and a " tone " on the line, produced by the " B " operator connecting the junction to a " busy back " jack.

If the connection to the wanted subscriber is duly made, the front lamp on the cord circuit used by the " A " operator glows until the wanted subscriber answers.

The replacement of the subscribers' receivers operates the " A " cord circuit lamps as in a direct connection, and the " B " operator receives the clearing signal on the withdrawal of the " A " cord circuit plug from the outgoing junction jack. It will be noted that the taking down of the connections at the two exchanges follows the receipt of glows on *both* lamps of the " A " operator's cord circuit.

In the case of incoming jack-ended ringing junctions the " B " operator also receives the called subscriber's clearing signal.

The foregoing complete supervisory facilities are afforded only when calls pass between the C.B.S. exchange and an automatic signalling exchange or a Magneto exchange with a condenser in the cord circuit and in the bell circuit at the

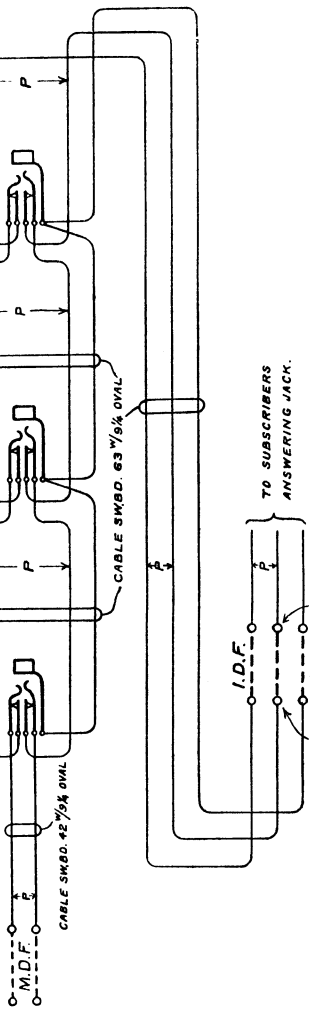


FIG. 11.—SUBSCRIBERS' MULTIPLE.

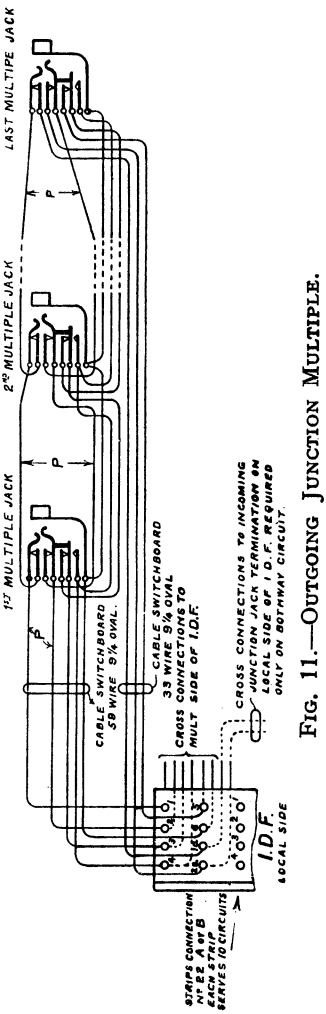


FIG. 11.—OUTGOING JUNCTION MULTIPLE.

subscribers' stations. In the case of a call from the C.B.S. exchange to a Magneto exchange without a condenser in the cord circuit and at subscribers' stations, the front lamp is not controlled by the Magneto exchange subscriber's switchhook, and does not glow after a plug has been inserted in the junction jack by the " B " operator in answer to a call. The " A " operator, therefore, depends solely on the calling subscriber's clear to indicate the termination of a call.

If a call is received from another exchange for a subscriber on the C.B.S. exchange, the required connection is made in the same manner as a call from one local subscriber to another. When the call is terminated and the called subscriber " clears," the C.B.S. operator receives a clearing signal on the *front* supervisory lamp, but waits for the *rear* lamp to glow, as a clearing signal from the originating exchange end of the junction circuit, before taking down the connection.

SUBSCRIBERS' AND OUTGOING JUNCTION MULTIPLES.

As already explained, one end of the Subscribers' multiple terminates on the exchange side of the M.D.F. and the other on the multiple side of the I.D.F. In the case of the outgoing Junction multiple, both ends terminate on the Local side of the I.D.F.

The multiples are illustrated in Figs. 10 and 11, respectively.

In the figures which follow only one multiple jack is shown, but it must be understood that in reality the multiples consist of a series of jacks connected as shown in Figs. 10 and 11.

FUNDAMENTAL CIRCUITS.

C.B.S. working depends fundamentally on the provision (1) at a central point (the exchange) of a common battery which supplies current required for signalling purposes on all lines and (2) of local batteries at all stations for speaking purposes.

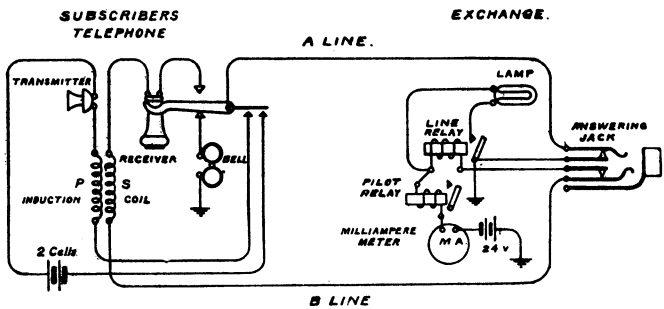


FIG. 12.—SUBSCRIBER'S EXCHANGE LINE.

The normal calling and clearing signals are made automatically.

Fig. 12 is a simplified diagram of a subscriber's disengaged exchange line, showing the arrangements provided for signalling a call to the exchange. The 22-volt battery is common to

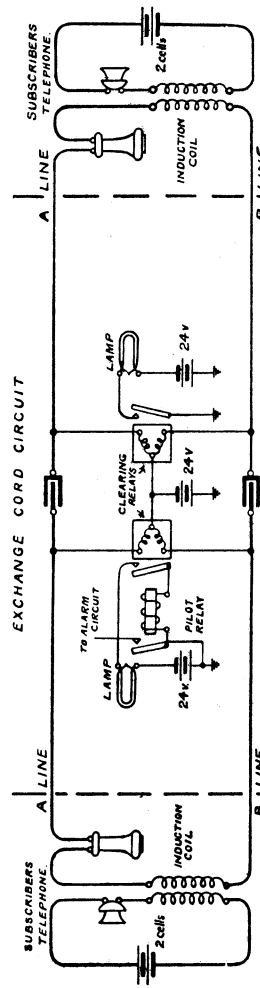


FIG. 13.—SPEAKING CIRCUIT BETWEEN TWO LOCAL SUBSCRIBERS.

all the lines terminating at the exchange, the milliampère meter is common to all the subscribers' lines connected to one section, and the pilot relay, the function of which will be referred to later (see Figs. 16 and 17), is common to all the calling equipments in one panel of a section.

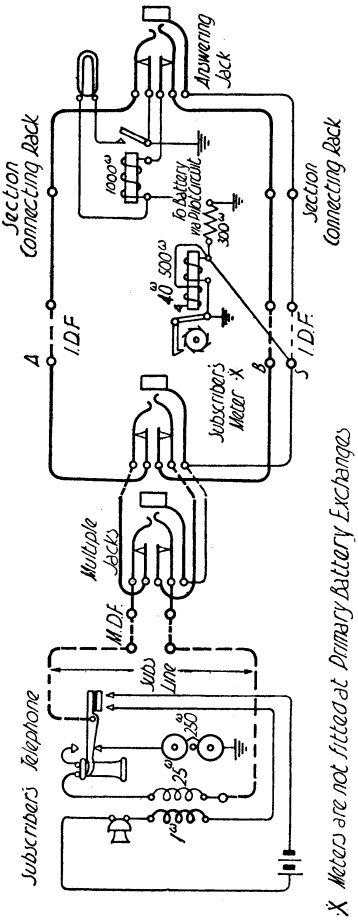


FIG. 14.—SUBSCRIBER'S CIRCUIT.

When the subscriber lifts his receiver to make a call, a circuit is completed from the exchange common battery, the positive of which is earthed, *via* the line relay, *B* line

springs and contact of the answering jacks, *B* line, induction coil secondary, receiver, switch arm and contact, *A* line, *A* line springs and contact of answering jack to earth. The operation of the line relay follows, closing the circuit of the calling lamp. When the operator inserts a plug in the answering jack the contact between the springs of the jack ceases and the circuit through the line relay is broken. The armature of the relay falls back, cutting off the current supply of the lamp, which therefore ceases to glow.

The subscriber's attention is gained by ringing the magneto bell connected to the *A* line when the receiver is on the rest. The bell is rung by current from an earthed generator applied at the exchange to the *A* line.

The removal of the subscriber's receiver disconnects the bell and joins up the line and local transmitter circuits in readiness for talking.

Fig. 13 illustrates the speaking circuit between two local subscribers, *via* the exchange cord circuit. Only such details are shown as are essential for speech and clearing signals at the close of a conversation.

The cord circuit relays are differentially wound and the common battery is connected to the centre points as shown. During conversation, the *A* and *B* lines are looped through the receiver and secondary winding of the induction coil at each subscriber's station and no current passes through the relay coils. Immediately the subscribers replace their receivers on their respective rests, the *B* lines are disconnected and the *A* lines are connected to the call bells and earth, as shown in Fig. 12. Current then flows from the common battery to the *A* lines, *via* the *A* winding of the cord circuit relays, causing them to operate and completing the circuits of the cord circuit lamps, with light up and indicate that the connection may be severed. The relays act independently of one another, but the operator should not take down the connection until the " double " clearing signal is received.

STANDARD CIRCUITS.

Fig. 14 illustrates completely the subscriber's line circuit and includes the multiple jacks and meter omitted from Fig. 12.

The multiple jacks are of the break-jack pattern. They are placed in series with the answering jack, and the insertion of a plug in the multiple jack has the effect of intercepting the lines at that point and disconnecting them from the jack beyond in the direction of the " home " position. A means of apprising operators that the line is engaged is provided on

the bushes of all the jacks, including that of the answering jack. The manner in which this engaged signal is given will be dealt with later.

Cord Circuit.—Fig. 15 is typical of the cord circuits used at C.B.S. Multiple Exchanges for either local or junction working. Each cord circuit consists of a pair of 3-way plugs attached

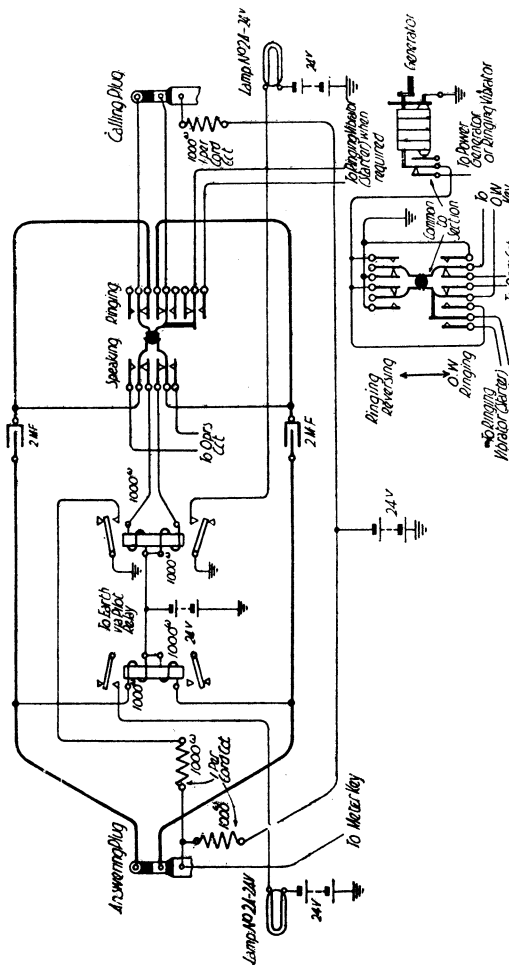


FIG. 15.—CORD AND RINGING CIRCUITS.

to three conductor cords with which are associated the apparatus shown in the figure. Each cord circuit has its own special listening and ringing key, relays, lamps, condensers and 1,000Ω resistances. The other items shewn in the figure are common either to all the cord circuits in one position or to all the cords in the exchange. The common battery is connected to the relays and lamps, but separate batteries are shewn in order to simplify the diagram.

The conductors connecting the Tips and Rings of the plugs are each intercepted by 2 μf. condensers in order that the signalling on one side of the cord circuits may be independent of that on the other.

The combined Listening and Ringing key on the calling plug side of the condensers enables the operator to connect her instrument to the cord circuit, or to connect the ringing circuit to the calling plug, as required. Incidentally, it will be observed that, when the latter operation is performed, the calling plug is dissociated from the rest of the cord circuit. The 1,000Ω + 1,000Ω relays, both of which have double armatures and are wound differentially, are provided for supervisory signal purposes and the centre point of each is connected to the common battery, the positive pole of which is earthed.

On the answering side, the relay is permanently connected to the tip and ring conductors and only one armature is used. The armatures of all the answering side relays on one position are connected to earth *viâ* a common pilot relay, the function of which will be explained later. The inner contact of each relay is connected to a supervisory lamp and thence to the main battery and earth. The actuation of the relay armature closes the lamp circuit and the lamp lights.

On the calling side, the relay is connected *viâ* the listening key to the tip and ring conductors. Both the armatures are connected to earth. On one side the inner contact is connected to a supervisory lamp and thence to battery and earth, and on the other side to an individual 1,000Ω resistance and thence to the sleeve of the answering plug. The operation of the relay causes one of the armatures to close the lamp circuit, and the other to close a circuit which provides for a supervisory signal at a distant exchange when the cord circuit is used to complete a call over a junction circuit.

Three connections are taken from the sleeve of each answering plug, one to the 1,000Ω resistance already referred to in the preceding paragraph, one to a 1,000Ω resistance associated with the engaged test circuit and one to the cord circuit effective meter key. The purpose of the last two connections will be dealt with under Engaged Test and Meter Circuit.

The sleeves of all the calling plugs are connected to an individual 1,000Ω resistance, which is also associated with the engaged test circuit to be referred to later.

Fig. 16 illustrates the milliampèremeter, pilot and alarm circuit. Each section is equipped with a milliampèremeter,

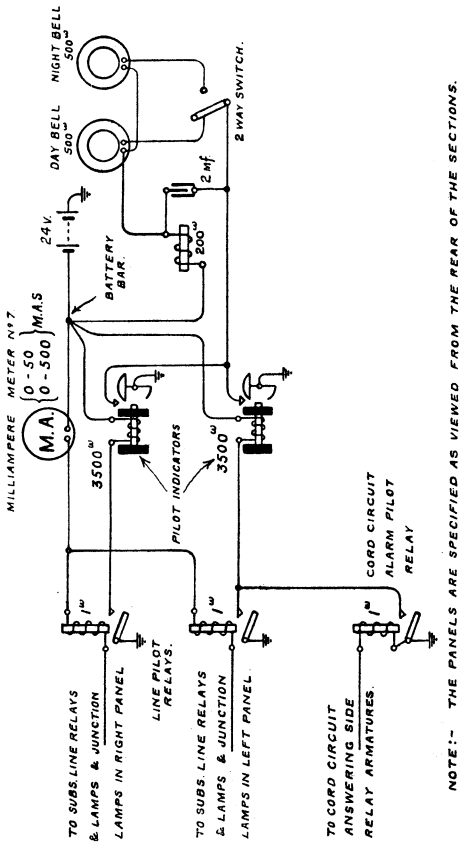


FIG. 16.—MILLIAMPÈREMETER, PILOT AND ALARM CIRCUIT.

three pilot relays and two pilot indicators. The milliampèremeter is associated with the subscribers' lines and indicates the amount of leakage through the insulation resistance of the lines. When the switch section is idle, a deflection in excess

of a calculated standard, which is proportional to the open wire mileage of the *B* lines of the subscribers' circuits, shows the existence of a fault.

Two of the pilot relays are associated with the subscribers' line relays and lamps and incoming junction calling lamps, one being allocated to each panel of a section, and the third pilot relay is placed in the circuit of the cord circuit supervisory lamps on the answering plug side.

A Pilot Indicator is fitted at the bottom of each panel as shown in Fig. 5. Each pilot indicator is associated with the pilot relay proper to the panel in which the former appears, and the one in the right panel is also associated with the cord circuit pilot relay.

A day bell and a night bell, common to the exchange and controlled by a switch, are connected in parallel to the contacts of the pilot indicators on all sections.

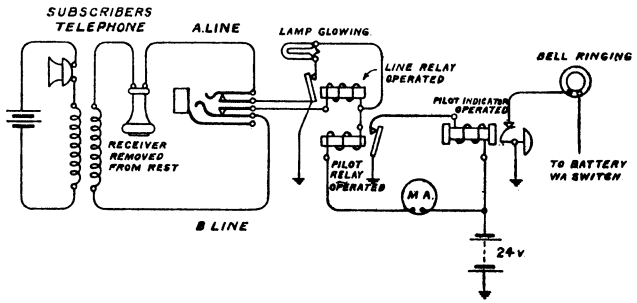


FIG. 17.—SUBSCRIBER CALLING.

It is the function of the pilot circuit to provide a general visual signal and, when required, an audible alarm signal whenever a call is received or whenever a clearing signal appears on the answering side of a cord circuit.

Figs. 17 and 18 respectively illustrate the operation of the pilot circuit when a subscriber calls the exchange and clears on the close of a conversation.

At Secondary Cell exchanges the main battery is used to supply current to the operators' circuits. In Fig. 19 certain portions of a cord circuit are illustrated in order to show the connections of an operator's instrument. At the points marked X, the section wiring actually terminates on a 4-way instrument jack. The operator's headgear receiver and breastplate transmitter are connected to a 4-way cord and plug and are joined up by inserting the plug in the jack.

The 165Ω retardation coil suitably reduces the current through the transmitter and its impedance prevents high frequency currents from traversing the battery circuit. The condenser completes a local circuit, *i.e.*, transmitter, primary

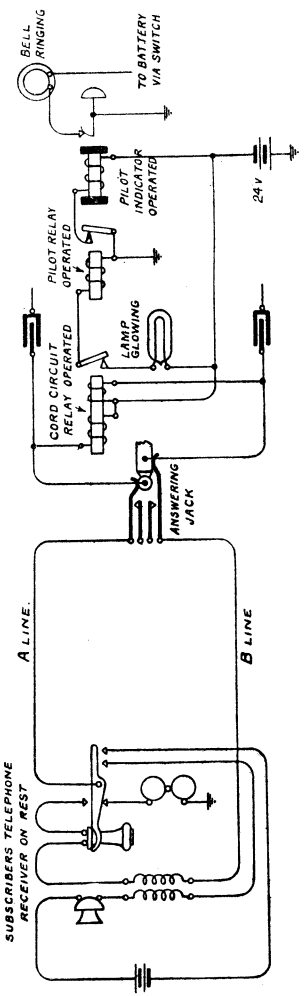


FIG. 18.—SUBSCRIBER CLEARING ON ANSWERING SIDE OF CORD CIRCUIT.

windings and condenser, and the combination of the condenser and retardation coil gives in some measure the effect of a separate battery for each operator's circuit.

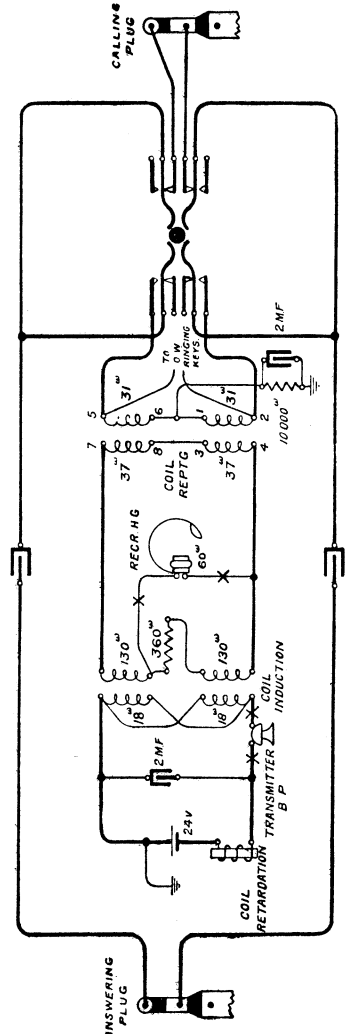


FIG. 19.—OPERATOR'S CIRCUIT—SECONDARY CELL WORKING

The induction coil has two primary windings, each of 18Ω resistance, joined up in parallel and two inductive secondary windings of 130Ω resistance separated by a non-inductive winding of 360Ω connected in series. The receiver is joined across the 360Ω and one of the 130Ω windings. The object is the elimination of " side tone." " Side Tone " is the reproduction of the operator's own voice in her receiver.

The provision of an engaged test necessitates the introduction of a repeating coil in the operator's secondary circuit. The repeating coil has two primary windings of 37Ω each and two secondary windings of 31Ω each. The two primary and the two secondary windings are joined up in series and the centre point of the secondary windings is connected to a 2 μf. condensers hunted by a non-inductive resistance of 10,000Ω.

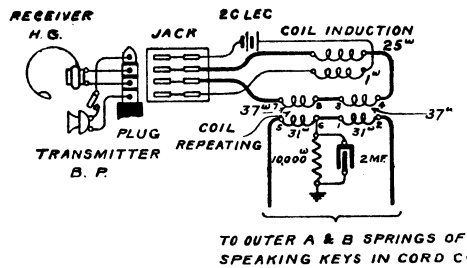


FIG. 20.—OPERATOR'S CIRCUIT—PRIMARY BATTERY WORKING.

At Primary Battery exchanges current is supplied to each operator's primary circuit from independent 2-cell Leclanché batteries. Fig. 20 illustrates the primary battery exchange operator's circuit.

When, in any circuit, there is more than one point on the switchboard where another circuit can be connected to it, some signal must be provided whereby an operator may ascertain whether the circuit is already engaged. In the case of the C.B.S. Multiple exchange, the signal is a " click " that is heard in the operator's receiver when she " tests " to see if a line is engaged.

The **Engaged Test Circuit** is illustrated in Fig. 21 which shows a portion of a cord circuit connecting two lines, and of another being used to test for a disengaged line. The exchange battery is connected to the bushes of the jacks on the engaged line *viâ* 1,000Ω resistances and the sleeves of the plug.

The jacks are thus maintained at a negative potential. Consequently, when an operator, having thrown a listening key touches the bush of an engaged circuit jack with the tip of the plug connected to the key, thus providing a path from the bush of the jack to earth, *viâ* one portion of the secondary winding of the repeating coil and the shunted condenser in her telephone circuit, the condenser receives a charge and a click is heard by the operator in the receiver, caused by the momentary current acting inductively on the primary winding of the repeating coil. The intensity of the click will be less at secondary cell exchanges where subscribers' meters are installed than at primary battery exchanges where they are not. The absence of a click indicates a disengaged circuit.

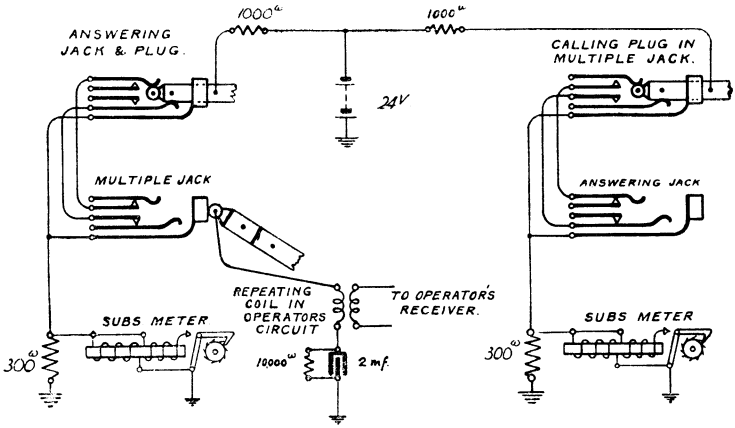


FIG. 21.—ENGAGED TEST.

Meter Circuits.—When meters are fitted, each subscriber's line has its own meter on which originated calls are recorded. The " Effective " position meter is also operated in conjunction with the subscribers' meters, and records the aggregate of all the calls recorded on individual subscriber's meters.

The " Ineffective " meter records the ineffective calls only.

The Subscribers' and " Effective " meters are operated when and " A " operator, on the completion of a call, depresses the meter key associated with the cord circuit used for connecting one subscriber to another. The " Ineffective " meter is operated when an operator depresses the " Ineffective " meter key fitted on the position keyboard.

Fig. 22 illustrates the subscribers' and position meter circuits. When the "Effective" meter key is depressed, current flows (at a P.D. of 30 volts) from the exchange main battery, supplemented by 4 special cells, *viâ* the meter relay, "Effective" meter key, sleeve conductor of cord circuit, bush of answering jack, and 500Ω coil of subscriber's meter in parallel with a 300Ω resistance to earth. The strength of this current initially is such that the subscriber's meter is operated, but the meter relay is not energised sufficiently to close its armature. Immediately the subscriber's meter operates and records a call, however, the 500Ω coil is

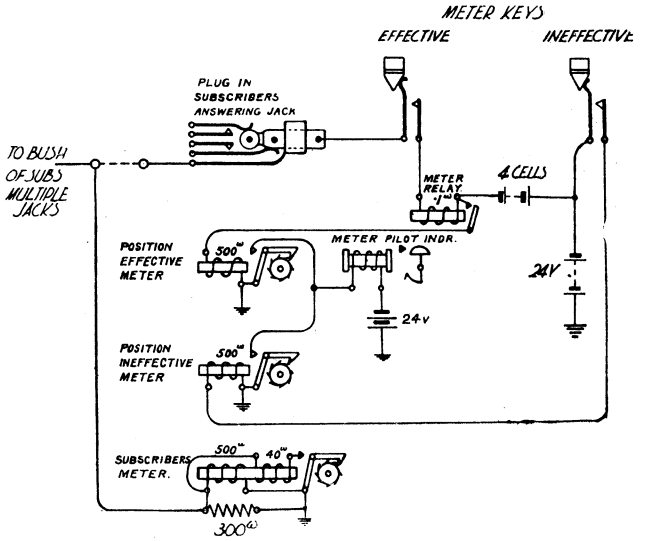


FIG. 22.—SUBSCRIBER'S AND POSITION METER CIRCUIT.

shunted by the 40Ω coil, and the reduction in the resistance of the meter results in an increased current which operates the meter relay. When the meter relay armature us thus closed, the circuit of the effective position meter is completed and an effective call is recorded. The operation of the "Effective" meter closes the circuit of the Meter Indicator, through the coil of which current flows from the main battery, and *viâ* the contact and armature of the effective meter to earth. It will be seen that this is a step by step arrangement, and that the operation of the meter indicator is dependent ultimately on the satisfactory operation of the subscriber's meter.

If a wanted subscriber's line is engaged, the calling subscriber is informed of the fact, and the operator depresses the "Ineffective" meter key. Current then flows from the main battery *vid* the key and the "Ineffective" position

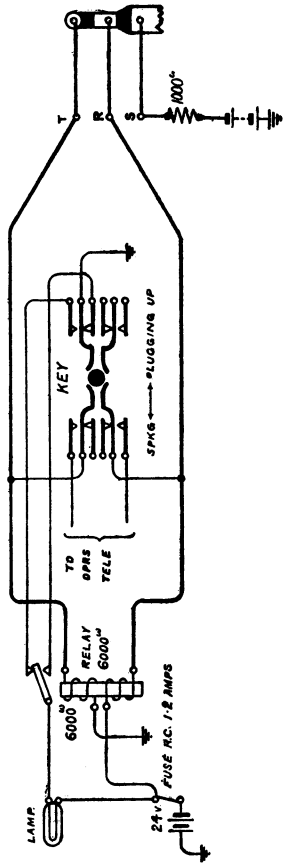


FIG. 23.—PLUGGING-UP CORD CIRCUIT.

meter to earth, operating the meter and thus recording an ineffective call. The circuit of the meter indicator is also completed and the indicator is operated.

Fig. 23 illustrates the **Plugging Up cord circuit** which is provided on each switchboard position. The 17th ordinary

cord circuit is modified for the purpose. The answering plugs are thrown out of use and the calling plugs are connected to a special relay and key, the latter of which replaces the ordinary ringing and listening key.

It will be noticed that the lamp circuit is controllable by the movement of the springs on the right-hand side of the key.

When a circuit has been reported faulty and the necessary advices have been issued, it is " plugged up " at a multiple jack on one of the switchboard positions, and if the fault is one which gives rise to a permanent calling signal the key associated with the plugging up circuit is thrown to the " plugging up " side. Current flows from the main battery, or from the line, through one or both coils of the relay, according to the nature of the fault; the relay is operated and the armature to which the lamp is connected is closed, but the lamp does not glow, as the lamp circuit is broken at the key. Immediately the current through the relay ceases in consequence of the removal of the fault, the lamp circuit is completed and the glow indicates that the line has been restored to a normal condition.

If the fault is a disconnection, the key is not thrown when the plug is inserted and no current passes through the relay. When, however, the fault is cleared the relay circuit is completed *viâ* the subscribers' lines and the lamp glows, indicating that the fault has been removed.

The engaged test circuit connections are retained on the " Plugging Up " cord circuit, consequently any circuit that is plugged up will test engaged.

The connection of the operator's instrument to the left hand side of the key is a convenience which enables the operator to come in circuit on a line that is plugged up.

Howler Cord Circuit.—In order to provide a means of attracting the attention of a subscriber who has left his receiver off the rest, a Howler cord circuit is fitted at each exchange. An ordinary cord circuit, the 16th, on the last position of the switchboard, is modified for the purpose. The answering plug is thrown out of use and the calling plug is connected, as shown in Fig. 24, to a special relay and key. The latter replaces the ordinary listening and ringing key on the keyboard.

A Howler, in the case of secondary cell exchanges, or a Buzzer in that of primary battery exchanges, is associated with the key, and the use of the ordinary supervisory lamp and engaged test connections is retained.

To use the Howler cord circuit, the plug is inserted in the subscriber's multiple jack and the key is thrown, operating the springs on the right-hand side and producing a loud " tone " in the subscriber's receiver. The replacement of the receiver results in the lighting of the Howler cord circuit lamp.

The operation of the Howler cord circuit is as follows :—

Considering first the key, it will be observed that when the springs on the right-hand side are operated :—

(*a*) the earth connection on the upper long auxiliary spring is transferred from the inner to the outer short spring ;

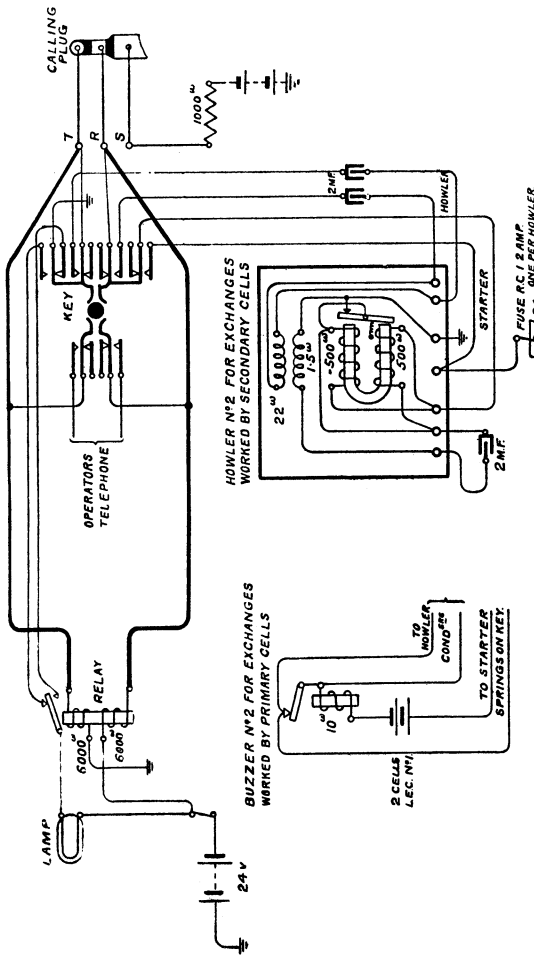


FIG. 24.—HOWLER CORD CIRCUIT.

(*b*) the primary circuit of the Howler or Buzzer is completed *viâ* the lower long and outer auxiliary springs ;

(*c*) the Howler secondary or the Buzzer circuit is connected *viâ* condensers to the tip and ring of the plug.

When current passes through the Howler coils, the armature vibrates very rapidly, and the Howler condenser is charged and discharged on each break and make of the armature contact. The alternating current passing through the primary winding of the Howler induction coil, due to the charging and discharging of the condenser, reacts on the secondary winding.

If the Buzzer is used, it is connected directly to the tip and ring condensers. When the battery circuit is completed through the starter springs of the key, as in the case of the Howler, the driving current passes through the Buzzer armature and coil, and the armature vibrates at a high rate. If the circuit through the tip and ring condensers is completed, the condensers are charged and discharged at each break and make of the armature contact.

When the plug is inserted in the jack of a subscriber's line, the receiver on which has not been replaced on the rest, current from the main battery passes through one coil of the relay, the *B* line, through the receiver, the *A* line, and the other relay coil to earth. The relay is operated, but the lamp circuit is not completed by the closing of the armature as it is broken at the key. Consequently, the lamp does not glow. As the result of the reaction between the primary and secondary windings of the Howler induction coil, an alternating current of higher voltage, but of the same frequency as the alternating current charging and discharging the Howler condenser, is superposed on the battery current passing through the subscriber's receiver. If a Buzzer is fitted, the alternating current due to the charge and discharge of the tip and ring condensers passes through the receiver. In either case the alternating current causes the receiver diaphragm to vibrate and thus to produce the " tone " referred to previously.

If the " tone " attracts the attention of the subscriber and he replaces the receiver, the line circuit is disconnected, with the result that the current through the relay ceases, the armature of the relay is released, the lamp circuit is completed through the back contact of the relay and the springs of the key, and the lamp glows signifying to the operator that the circuit is again in a normal condition.

JUNCTION CIRCUITS.

The circuit arrangements on **junctions between C.B.S. exchanges and between C.B.S. and C.B. exchanges** provide that the signalling shall conform to regular C.B. working with the supervisory relay in the tip side of cord circuits, and are such that automatic calling and through clearing from subscribers to the " A " operator are provided for. Similar facilities are also provided on junctions incoming at C.B.S. exchanges from Trunk exchanges. The arrangement of junctions between C.B.S. and Magneto exchanges is dealt with later.

The apparatus at C.B. exchanges on junctions incoming from, or outgoing to, C.B.S. exchanges and at Trunk exchanges on junctions outgoing to C.B.S. exchanges, differs from the apparatus fitted on the junctions at C.B.S. exchanges (on similar circuits between two C.B.S. exchanges), but the functions performed by the apparatus at both ends of the circuits are almost identical. The signalling over such junctions may therefore be taken to be, for practical purposes, the same as on junctions between two C.B.S. exchanges.

On examining the figures given later, relative to circuits over which full signalling facilities are afforded, it will be observed that, as a general principle, current is sent from the calling exchange to the called exchange over the *B* lines of the circuit and from the called exchange to the calling exchange over the *A* lines. This principle is adopted in order that varying line conditions may cause as little interference as possible with the signalling arrangements.

Economy in primary battery consumption is secured by the battery distribution arrangements, which are such that the voltage applied to each junction circuit will result in the current sent to line being the minimum necessary for the reliable operation of the relay at the distant end. At exchanges where secondary cells are installed, the 22-volt battery is used as the line battery, as well as for other purposes.

In all cases the operator at the originating exchange controls the call, and the signalling arrangements in general are such that, on the completion of a call, the controlling operator receives a clearing signal from the distant end of the circuit as well as from the local subscriber.

Fig. 25 illustrates the circuit arrangements at both ends of a junction between two C.B.S. exchanges, and the outgoing end shows the arrangements at a C.B.S. exchange on junctions outgoing to C.B., Trunk, or Magneto exchanges with, in

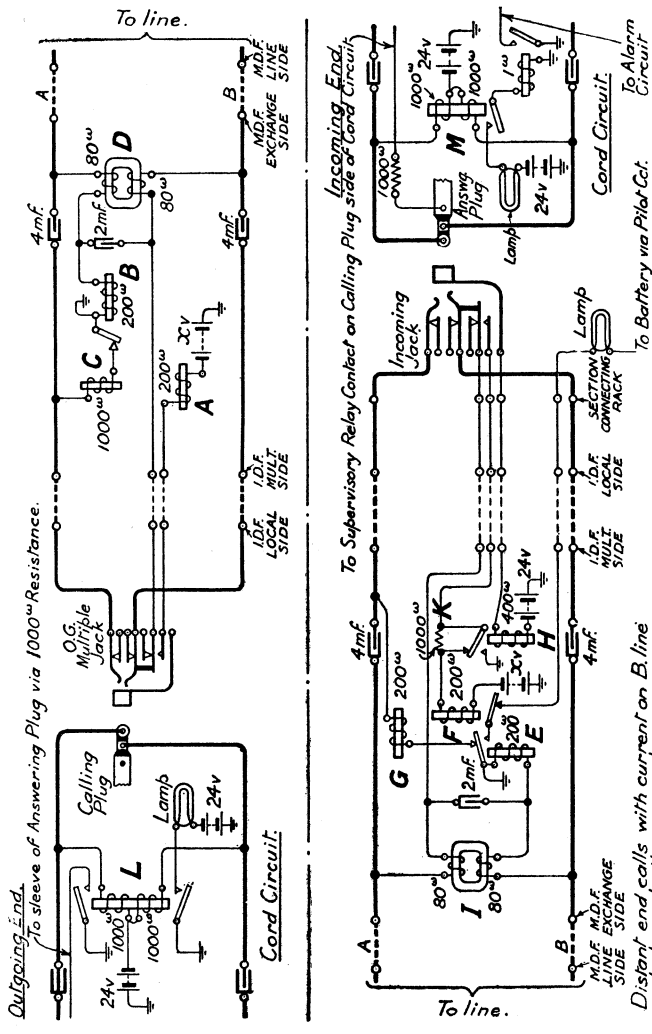


FIG. 25.—ONE-WAY JUNCTION BETWEEN C.B.S. EXCHANGES.

the case of Magneto Exchanges, a condenser in the bell circuit at local subscribers' stations. The incoming end shows the arrangements at a C.B.S. exchange on junctions incoming from a C.B. or Trunk exchange.

The standard " A " position cord circuit is used for junction working. The purpose of the condensers in the A- and B-wires of the junctions is to prevent battery currents flowing to line *viâ* the tip and ring conductors of the cord circuit.

The electrical balance of the junction circuit is maintained by the device of bridging the line with the 80Ω + 80Ω retardation coils, the coils of which have high impedance, battery and earth being connected to the coils through other impedances in the form of relays and retardation coils. The condenser connected across the terminals of the 80Ω + 80Ω retardation coil is a further aid in securing the balance which might be disturbed by any differences in effective impedance between the coil windings of the apparatus on each of the two lines.

The circuit as shown in Fig. 25 is operated between C.B.S. exchanges as follows :—

Outgoing Junction.—The operator at the outgoing end, referred to hereafter as the " A " operator, calls the distant exchange by inserting a calling plug into an outgoing multiple jack. Current flows from battery *viâ* the bridging coil *A*, contacts of jack, one winding of retardation coil *D* along the " B " line to the distant exchange, thence through one winding of retardation coil *I* and relay *E* to earth. Relay *E* is actuated and the line lamp glows. Until the operator at the distant exchange, referred to hereafter as the " B " operator, answers the call, the supervisory relay *L* is energised, and current passes through it to earth *viâ* the bridging coil *C* and the armature of relay *B*, causing the supervisory lamp in the cord circuit to glow.

Incoming Junction.—When an incoming junction calling lamp glows, the " B " operator inserts an answering plug in the junction jack. Current then flows from battery *viâ* relay *F*, armature of relay *H*, junction jack, one winding of retardation coil *I* and A-wire of the junction to the calling exchange, thence *viâ* one winding of retardation coil *D* and the relay *B* to earth. Relays *F* and *B* are energised. The armature of relay *F* breaks the circuit of the calling lamp which ceases to glow. The armature of relay *B* removes the earth from the bridging coil *C*, and extinguishes the glow on the

supervisory lamp on the cord circuit at the calling exchange. The " A " operator is thus made aware that the " B " operator has plugged in, and therefore throws the listening key and passes details of the call to the " B " operator. The " B " operator completes the connection to the required number. The supervisory relay associated with the " B " operator's calling plug is controlled by the called subscriber's receiver switch arm, and that relay in turn controls the supervisory relay *L* in the " A " operator's cord circuit through the medium of relay *H*, the armature of which, when attracted short-circuits the A-wire current. After the " B " operator releases her ringing key and until the subscriber lifts his receiver, the three relays in question are energised and the lamps associated with both calling plugs glow. The three relays are de-energised, and both lamps cease to glow when the wanted subscriber removes his receiver from its rest. Both " A " and " B " operators are therefore able to recognise when the call has become effective.

On the replacement of his receiver by the called subscriber at the finish of the call, the calling plug side supervisory lamps on the " A " and " B " operators' cord circuits again glow as a clearing signal.

The signal to the " B " operator to clear the junction is given when the " A " operator withdraws the plug from the jack at the outgoing end of the junction. On the withdrawal of the plug, relay *E* is de-energised and earth is reconnected to coil *G*. Consequently relay *M* is energised and the lamp on the answering plug side of the " B " operator's cord circuit glows as a junction clearing signal.

Bothway Junctions.—The terminal arrangements on such junctions comprise a combination of the arrangements at the outgoing and incoming ends of a junction worked in one direction only and, in addition, arrangements for providing an engaged test when a plug is in the incoming jack.

Fig. 26 illustrates the circuit arrangements at a C.B.S. exchange on a Bothway Ringing Junction between C.B.S. exchanges, or a C.B.S. exchange and a C.B. or Trunk exchange. The junction lines are connected to the Outgoing Junction Multiple and to an Incoming Junction jack by means of cross-connections on the I.D.F., as indicated by the dotted lines. Incoming calls are dealt with at one position only and there is only one incoming termination.

Fig. 26 shows only one end of the circuit. If the other end is at a C.B.S. exchange the arrangements there are identical ;

if at a C.B. exchange the arrangements, although not the same, produce practically the same results in respect of the signalling.

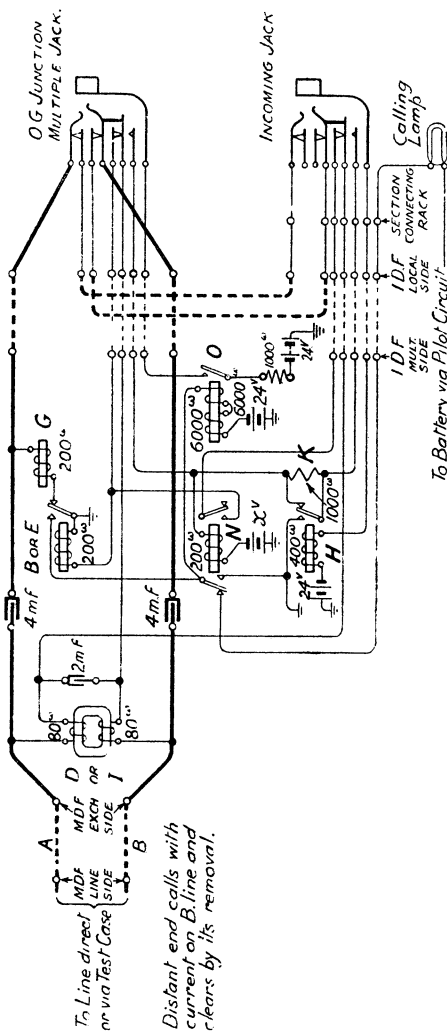


FIG. 26.—BOTHWAY JUNCTION.

Bothway working involves the use of the relay *O* (Fig. 26) in connection with the engaged test; and relay *N*, which has a double armature, is used in place of the single armature relay *F* and the retardation coil *A* shown in Fig. 25, in order that functions additional to those required of relay *F* and coil *A* may be performed. The coil *G* functions for either outgoing or incoming calls in the same way as coils *G* and *C* in Fig. 25.

The items of apparatus shown in Fig. 26, which perform the same functions as items shown in Fig. 25 have been given the same distinguishing letter.

The manner in which calls are put through and supervised over "Bothway" junctions is the same as in the case of the junction illustrated in Fig. 25. At an exchange where a call originates, relay *N* is energised whenever a plug is inserted in an outgoing junction multiple jack. The attracted left armature of the relay performs two functions. Firstly, it breaks the circuit of the calling lamp associated with the incoming jack and prevents the lamp lighting up as it otherwise would do when the distant exchange answers the call owing to the energising of relay *E*. Secondly, it completes the circuit of relay *O*, and the armature of that relay when attracted connects the engaged test circuit to the bushes of the multiple jacks. This latter function, however, is superfluous at the outgoing end of the circuit, as the engaged test circuit is also connected *viâ* the sleeve of the calling plug inserted in the multiple jack (see Fig. 15).

The right armature of relay *N*, when attracted, connects the relay *B* to the A-wire of the junction, thus providing a path to earth for the A-wire current when the distant exchange answers.

At the exchange where the call is incoming, relay *N* is energised when a plug is inserted in the answering jack *in response to a call*. In this case the attracted left armature breaks the circuit of the calling lamp, which therefore ceases to glow and also closes the circuit of relay *O*, thus providing for the connection of the engaged test circuit to the outgoing multiple jacks. The right armature of relay *N* at the incoming end of the circuit performs no useful function and its attraction has no resultant effect.

Junctions between C.B.S. and Magneto Exchanges.

There are two types of Magneto exchange to be dealt with, namely—

(1) Magneto exchanges with a condenser in the indicator circuit of the connecting cords and in the bell circuit at the local subscribers' stations, and

(2) Magneto exchanges without condensers either in the connecting cords or at the subscribers' stations.

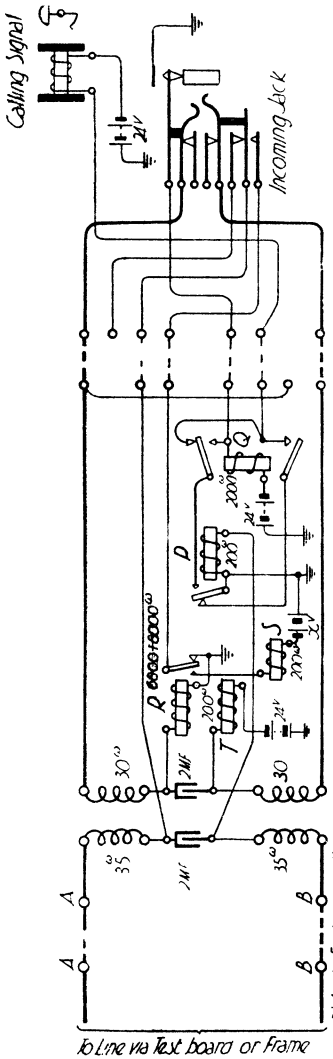


FIG. 27.—INCOMING JUNCTION AT A CONDENSERED MAGNETO EXCHANGE.

The two types of exchange will be referred to hereafter as **Condensered** Magneto exchanges and **Uncondensered** Magneto exchanges respectively.

Junctions between C.B.S. and Condensered Magneto exchanges.

The equipment at C.B.S. exchanges on junctions outgoing to an incoming from Condensered Magneto exchanges and on Bothway junctions between C.B.S. exchanges and Condensered Magneto exchanges is precisely the same as on similar junctions between C.B.S. and C.B. or other C.B.S. exchanges and is, therefore, represented by Figs. 25 and 26. Fig. 27 shows the circuit arrangements at the Magneto exchange on an incoming junction.

On the insertion of a plug in the outgoing jack at the C.B.S. exchange current flowing along the " B " line causes relay *P* to operate and the calling signal to be actuated. On the insertion of a plug in the junction jack at the Magneto exchange the cut-off relay *Q* operates and the calling signal is disconnected.

When a Magneto subscriber is connected with the junction the A- and B-wires of the junction are extended to the subscriber's station where the circuit is completed through the condensered bell when the receiver is on the rest or looped through the subscriber's induction coil when the receiver is removed from the rest. The subscriber's switchhook, therefore, controls the action of relay *R* (Fig. 27) and hence the connection of battery *viâ S* (Fig. 27) or earth, to the A-wire of the junction *viâ* the armature of relay *R*. Consequently the subscriber's switchhook ultimately controls the supervisory and clearing signals at the distant C.B.S. exchange.

The Magneto exchange cord circuit does not provide for the receipt of clearing signals. On that account the connections of relay *Q* (Fig. 27) are so arranged that the calling signal re-appears as a clearing signal on the release of relay *P* (Fig. 27).

The similarity of the signalling arrangements to those which prevail on the same type of junction between two C.B.S. exchanges will be recognised.

At the finish of a call and on the replacement of the Magneto subscriber's reciver, a clearing signal is transmitted to the C.B.S. exchange and a generator ring-off is received on the cord circuit at the Magneto exchange in the ordinary way. When the C.B.S. operator has received the clearing signal for the local subscriber, she withdraws the plug from the outgoing junction jack, whereupon relay *P* (Fig. 27) is

de-energised and the calling signal at the Magneto exchange re-appears as a clearing signal to the Magneto exchange operator.

Fig. 28 shows the circuit arrangements on a junction outgoing from a Condensered Magneto exchange to a C.B.S. exchange, where the junction equipment is as shown by the incoming portion of Fig. 25. The apparatus at the Magneto exchange is provided in order that the C.B.S. subscriber's supervisory and clearing signal may be transmitted to a distant automatic exchange in the event of another junction incoming at the Magneto exchange being extended to the C.B.S. exchange. As already stated, the Magneto exchange cord circuit is not arranged for the receipt of supervisory and clearing signals. When, therefore, a call originated by a Magneto subscriber is completed over the junction the

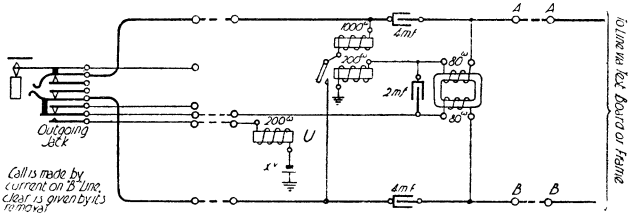


FIG 28.—OUTGOING JUNCTION AT A CONDENSERED MAGNETO EXCHANGE.

apparatus at the Magneto exchange performs no useful function so far as receipt of signals from the C.B.S. end of the circuit is concerned. The insertion of a plug in the outgoing jack at the Magneto exchange controls the connection of battery to the "B" line *via* the coil *U* (Fig. 28) and, therefore, the action of the calling relay *E* (Fig. 25) at the C.B.S. exchange. Relay *E* in turn controls relay *M* in the C.B.S. cord circuit (*see* Fig. 25). Consequently, when relay *E* is de-energised on the withdrawal of the plug from the outgoing jack at the Magneto exchange, relay *M* is actuated and the C.B.S. operator receives a clearing signal on the cord circuit lamp.

The circuit arrangements at a C.B.S. exchange on a bothway junction between a C.B.S. exchange and a Condensered Magneto exchange are shown by Fig. 26, and are a combination of the arrangements provided on an outgoing and an incoming junction with the addition of a 6,000Ω + 6,000Ω relay the function of which is to connect the engaged test to the outgoing junction jacks when an incoming call is received at the C.B.S. exchange.

At the Magneto exchange, the circuit arrangements are similarly a combination of the outgoing and the incoming junction equipment *plus* provision for an engaged test on the outgoing junction jacks.

The operation of the circuit in either direction is the same as in the case of junctions working in one direction only.

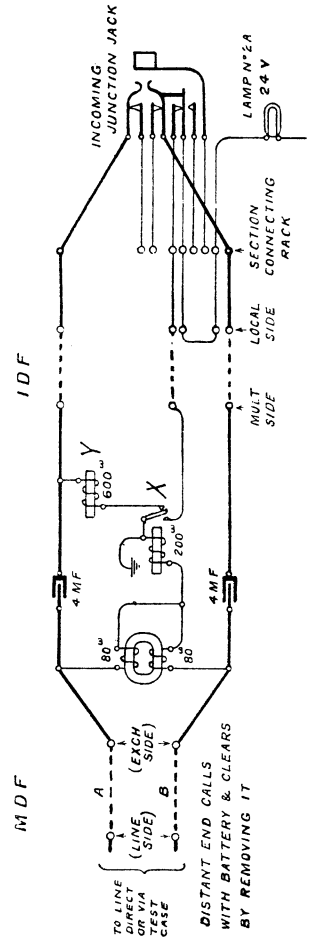


FIG. 29.—INCOMING JUNCTION FROM MAGNETO EXCHANGE.

Junctions between C.B.S. and Uncondensered Magneto Exchanges.

In the absence of condensers in the cord circuits at the Magneto exchange and in the bell circuit at local magneto

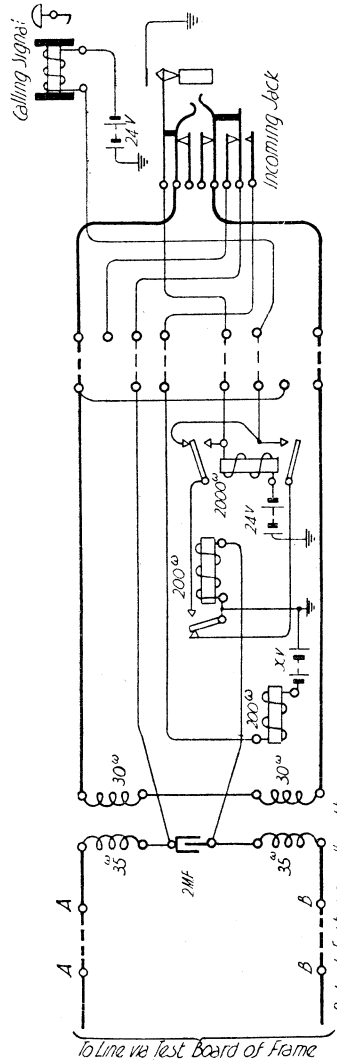


FIG. 30.—INCOMING JUNCTION AT AN UNCONDENSERED MAGNETO EXCHANGE.

subscribers' stations, the junction signalling is controlled by the operators at each end of the junctions.

At a C.B.S. exchange the equipment of an *Outgoing* junction and of a *Bothway* junction is the same as on similar circuits between a C.B.S. exchange and a Condensered Magneto exchange. The circuit arrangements at the C.B.S. exchange on the class of junction referred to are, therefore, shown by Fig. 25 (outgoing portion) and Fig. 26, respectively.

The circuit arrangements at a C.B.S. exchange on a junction incoming from an Uncondensered Magneto exchange are shown by Fig. 29.

Fig. 30 shows the circuit arrangements at an Uncondensered Magneto exchange on a junction incoming from a C.B.S. exchange. On comparing this figure with Fig. 27, it will be seen that relay *R* and coil *T* in Fig. 27, which enable the Magneto subscriber to control the supervisory clearing signal at the C.B.S. exchange, are omitted from Fig. 30. Otherwise the arrangements are the same and the explanation of the

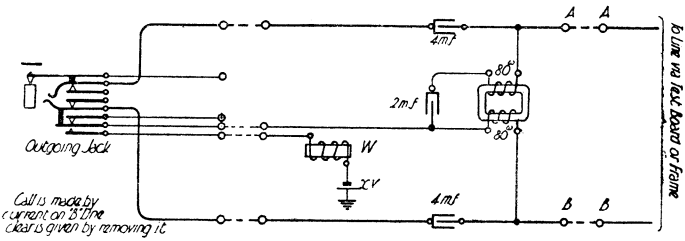


FIG. 31.—OUTGOING JUNCTION AT AN UNCONDENSERED MAGNETO EXCHANGE.

calling and final clearing arrangements given in respect of a junction outgoing from a C.B.S. exchange to a Condensered Magneto exchange apply in this case. This will be seen readily if the outgoing portion of Fig. 25 is considered in conjunction with Fig. 30.

Fig. 31 shows the circuit arrangements at an Uncondensered Magneto exchange on a junction outgoing to a C.B.S. exchange.

Fig. 31 should be considered in conjunction with Fig. 29. On the insertion of a plug in the outgoing jack at the Magneto exchange current flows *viâ* coil *W* (Fig. 31) along the junction 'B" line actuating the calling relay *X* (Fig. 29) at the C.B.S. exchange. The armature of relay *X* when attracted closes the circuit of the calling lamp. That circuit is broken and the calling lamp darkens when the C.B.S. operator inserts a plug in the junction jack in response to a call. The armature

of relay *X* when attracted also disconnects earth from coil *Y* (Fig. 29), preventing the lighting up of the C.B.S. cord circuit answering supervisory lamp (*see* Fig. 15). Relay *X* is actuated as long as the plug remains in the outgoing junction jack at the magneto exchange. At the finish of a call completed over the junction no clearing signal is received at the Magneto exchange from the C.B.S. end of the circuit, and the Magneto operator withdraws the plug from the junction jack, on receipt of a ring-off signal from her own subscriber. On the withdrawal of the plug from the outgoing junction jack current on the junction B-wire ceases, and relay *X* (Fig. 29) is de-energised, the relay armature falls back and earth is reconnected to coil *Y* (Fig. 29). The re-connection of the earth to coil *Y* completes the circuit of the relay in the cord circuit associated with the answering plug (*see* Fig. 15) and the clearing lamp lights as a signal to the C.B.S. operator that the connection may be taken down.

The circuit arrangements at the Magneto exchange on a bothway junction between a C.B.S. exchange and an Uncondensered Magneto exchange are a combination of the arrangements shown by Figs. 30 and 31, with the addition of a 6,000Ω + 6,000Ω relay, the function of which is to connect the engaged test to the outgoing junction jack whenever a plug is inserted in the incoming jack. The circuit arrangements at the C.B.S. exchange are shown by Fig. 26 as previously stated.

The operation of the circuit in either direction is the same as in the case of junctions working in one direction only.

Bothway Ringing Junctions to small Exchanges.—If the traffic between a C.B.S. multiple exchange and a small outlying exchange is not sufficiently great to warrant the provision of full junction signalling facilities, the junctions are operated on subscribers' circuit principles, provided the resistance of the junctions is comparatively low.

Fig. 32 illustrates the circuit arrangement at the C.B.S. exchange on a junction to a small exchange. It will be seen that the line is connected to the outgoing junction multiple and to a subscriber's answering jack.

At the small exchange, the junction line is terminated on an equipment arranged for operation by a generator ring and, normally, the A-wire is earthed through a resistance which is the equivalent of the bell associated with a C.B.S. subscriber's telephone.

The C.B.S. multiple exchange rings the small exchange by means of the generator and the small exchange calls the multiple exchange by looping the A- and B-wires when a plug is

inserted in the junction jack. The insertion of the plug at the small exchange removes the earth connection from the A-wire, and the effect produced at the multiple exchange by the withdrawal of the plug is the same as that produced by the replacement of a subscriber's receiver on its rest at the finish of a call.

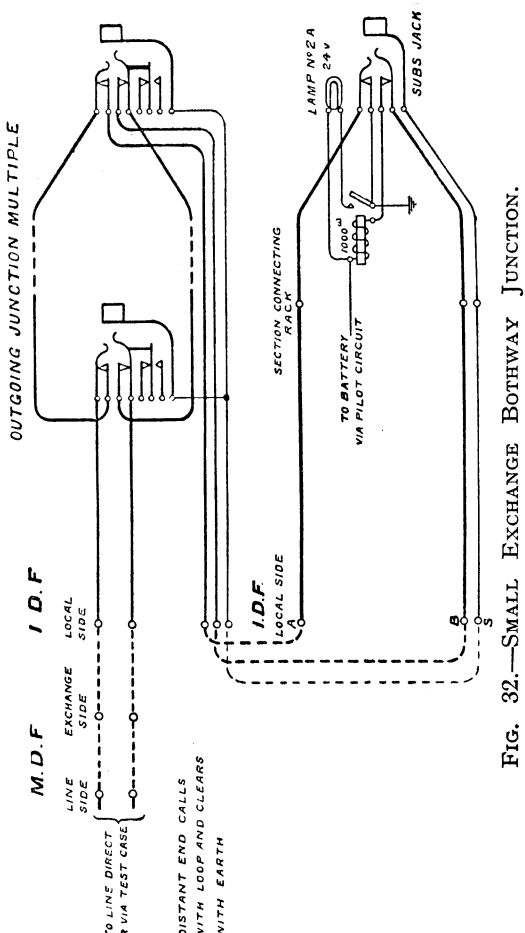


FIG. 32.—SMALL EXCHANGE BOTHWAY JUNCTION.

Engaged Tests on Junctions.—So long as a plug remains in an outgoing junction multiple jack, the line will test engaged at the outgoing end. On a " Bothway " junction, if there is a plug in the answering jack, the line will test engaged throughout the outgoing junction multiple until the line is cleared by the operator at the outgoing end of the circuit.

TRUNK CIRCUITS.

Trunk circuits terminated in C.B.S. multiple exchanges are connected to incoming junction jacks on " A " positions and the associated apparatus enables the circuits to be worked on a trunk signalling basis by means of the " A " operator's standard cord circuit.

Fig. 33 illustrates the circuit arrangements on a Trunk at a C.B.S. exchange. As is usual on trunk circuits, a P.C. battery is connected to the line (on the line side of the repeating coil) in opposition to a battery similarly connected at the distant end of the circuit.

Calling is effected by generator. When the distant exchange rings, the alternating current passing through one half of the repeating coil at the C.B.S. exchange is reproduced inductively in the other half. The induced current circulates through the line and inner springs of the jack and one of the coils of the 1,000Ω + 1,000Ω calling relay. As is usual when generator ringing is employed, provision has to be made whereby the transient alternating current sets up a condition in which the calling signal is displayed permanently until the call is answered. This object is achieved by the use of the other coil of the calling relay which acts as a retaining coil. A momentary attraction of the armature permits a direct current to traverse the retaining coil and lock the armature. The attracted armature closes the circuit of the calling lamp which glows accordingly. The insertion of a plug in the jack breaks the retaining coil circuit and the lamp ceases to glow. The insertion of the plug also completes the circuit of the cut-off relay which operates, disconnecting the battery and earth and joining the clearing relay across the lines.

An equivalent arrangement exists at the opposite end of the trunk circuit. When, therefore, plugs are in the jacks at both ends of the circuit no permanent current flows to line. If the plug at the controlling exchange be withdrawn, current from the P.C. battery at that exchange passes round the trunk loop and operates the clearing relay at the other exchange. The armature of the clearing relay connects earth to the A-wire on the exchange side and allows current to flow from the battery *via* one coil of the cord circuit relay to earth

(*see* Fig. 15), energising the cord circuit relay. The cord circuit lamp therefore glows, indicating that the connection should be cleared.

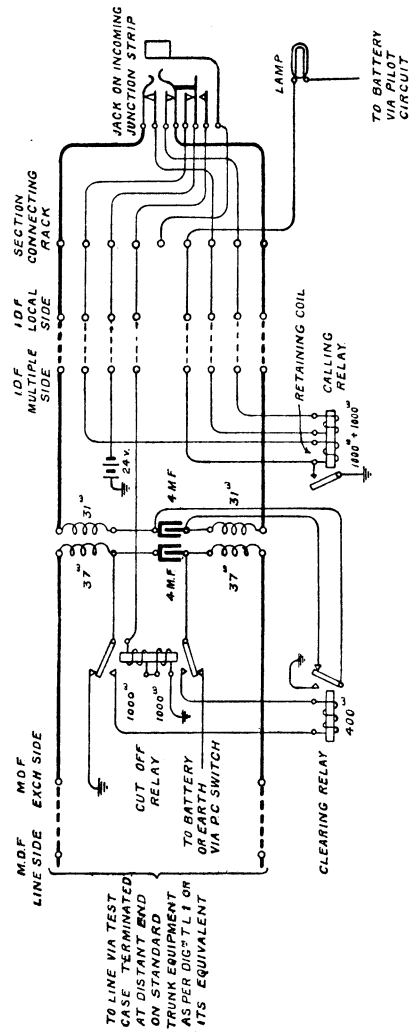


FIG. 33.—TRUNK CIRCUIT.

Ringing over the trunk circuit from the C.B.S. exchange is effected by using an earthed generator. The insertion of the plug in the trunk jack causes the energisation at the cut-off relay and, there being no plug in the jack of the distant exchange, the 400Ω relay is energised by current from the distant P.C. battery. The earthed ringing circuit is completed by the attracted armature of the 400Ω relay. The ringing current which passes through one winding only of the repeating coil, acts inductively on the secondary windings and is transformed into a loop ringing current.

The 400Ω relay offers high impedance to alternating and rapidly varying speech currents which therefore pass *vid* the condenser inserted between the 37Ω windings of the repeating coil. The condenser between the 31Ω windings of the repeating coil is unnecessary for speaking, but is required for clearing signal purposes.

RINGING DEVICES.

Each switchboard position is equipped with a hand generator connected to the cord circuit ringing keys *vid* the ringing reversing key (*see* Fig. 15). These hand generators are used for ringing on trunk circuits in the circumstances mentioned below and for ringing on all circuits during very slack periods. At other times they are held in reserve for use during an emergency and ringing current is provided by means of a power ringer which may be a motor generator, a dynamotor or a vibrator as required by traffic considerations. The power ringer is connected to the ringing keys similarly to the hand generators *vid* the ringing reversing key. When a vibrator is provided the hand generators are used for trunk ringing.

Details of the various power ringers used are given in pamphlet G.2.

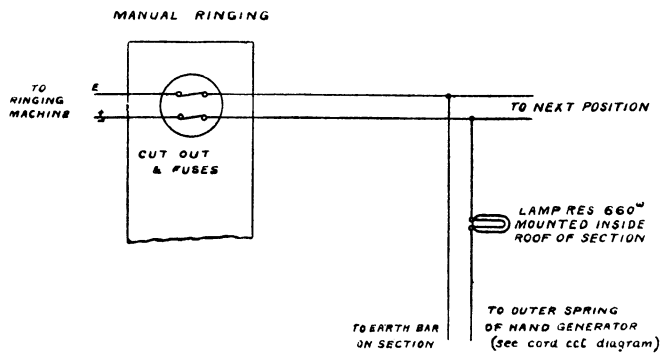


FIG. 34.—RINGING DISTRIBUTION.

RINGING DISTRIBUTION.

Fig. 34 illustrates the method adopted for the distribution of ringing power to the switchboard. The power ringer, which may be a ringing vibrator, a small motor generator or a dynamotor, according to the local conditions, is connected to main fuses from which common leads are taken to the switchboard. The position leads are terminated on the connecting board at the rear of each section, from which point leads are taken to the ringing keys. A ringing resistance lamp (660Ω) is inserted in the live lead close to the point of connection between the common and the position leads.

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