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Subject:

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C.B. EXCHANGES—40 VOLTS

(D.12).

The following pamphlets in this series are of kindred interest :—

D.1. Elementary Principles of Telephony.
D.2. Telephone Transmission. "Loading." Telephone Repeaters and Thermionic Valves.
D.3. Principles of Telephone Exchange Signalling.
D.8. C.B. Exchanges, No. 9 type.
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D.10. C.B. Exchanges, No. 12 type.
D.11. C.B. Exchanges, 22 volts.
D.14. Telephone Exchange Maintenance.
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D.18. Distribution Cases, M.D.F. and I.D.F.
D.19. Cord Repairs.
D.21. Call Offices.
F.1. Subscribers' Apparatus, C.B.
F.4. Private Branch Exchange, C.B.
F.5. Private Branch Exchange, C.B. Multiple No. 9.
G.1. Secondary Cells, Maintenance of.
G.2. Power Plant for Telegraph and Telephone Purposes.
G.3. Maintenance of Power Plant for Telegraph and Telephone purposes.

TABLE OF CONTENTS.

C.B. EXCHANGES—40 VOLTS.

DESCRIPTION AND LAY-OUT OF EXCHANGE PLANT.

The Common Battery No. 1 Exchange 40-volt system is similar to a 22-volt No. 1 Exchange as regards lay-out. As the title implies, it is provided with a battery of higher voltage to supply current for signalling and speaking purposes. The advantages claimed for this increased voltage are :—

1. The resistances of the various circuits may be higher to obtain the same working current, thereby economising in cost of copper.

2. The relays used in the various circuits may be of one standard design, of the cut-off type, thereby tending to cheapen construction costs.

3. The various relays require less attention in adjustment owing to greater margin of working current, thereby reducing maintenance costs.

4. A separate meter battery is not required with the 40-volt system, thereby simplifying the switching gear on the power board.

A No. 1 type switchboard is installed when the anticipated number of subscribers will exceed 2,000 during the life of the exchange. Two sizes of switchboards have been designed—one with a 6,400-line capacity and the other with a 10,000-line capacity. The estimated ultimate number of subscribers determines the size to be installed.

Twenty years is taken as the average life of an exchange, and this is the period usually planned for. Sufficient floor space in Switchroom, Apparatus-Room, and Operators' Quarters is arranged for this period accordingly, either in the initial building or with an adjacent site available, so that the building may be extended when necessary.

In determining the position of the switchboard sections and the various frames and racks in the exchange the ultimate requirements are always kept in view.

In arranging the lay-out of the sections, desks, frames and racks each exchange is treated individually, as the size and shape of the rooms and the position of the doors and windows have to be taken into account when determining the location of the apparatus.

The following frames are provided to support the apparatus to form a complete No. 1 Exchange :—

Subscribers' or " A " Sections.
Incoming plug-ended junction or " B " Sections.
Cable Turning Sections.
Monitors' Desk.
Supervisors' Desks.

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Meter Cabinet.
Main Frame.
Intermediate Distributing Frame.
Relay Racks.
Meter Rack.
Repeating Coil and Condenser Rack for incoming junctions.
Fuse Board.
Travelling Ladders.
Test Desk.
Power Plant, including charging machines, ringing machines, batteries and power board.

The Subscribers' or "A" Switchboard Section is constructed for three operators' positions, and with eight panels for jacks and lamps.

Each panel is divided into two parts by means of a space or rail. The upper portion is arranged to accommodate the subscribers' multiple in strips of twenty.

The subscribers are multipled every nine panels, that is to say, the whole of the subscribers' multiple jacks are repeated every nine panels, so that the maximum reach of any operator will be four panels on either side of her.

In cases where the percentage of calls to be plugged into the subscribers' multiple is considerable, the multiple on A sections is repeated every eight panels instead of every nine in order to reduce the reach.

The lower portion of each panel is arranged to accommodate the outgoing junction jacks in strips of twenty, and also the subscribers' answering jacks in strips of ten, together with the subscribers' lamp jacks, also in strips of ten. The latter are placed immediately below the strips of answering jacks with which they are associated. Each answering jack on a strip is provided with a label, on which the subscriber's telephone number is engraved.

The total capacity provided in the lower portion of each panel is divided between the subscribers' answering equipment and the outgoing junctions in accordance with the traffic requirements, depending on the operator's load and the number of outgoing junctions necessary to carry the traffic.

The outgoing junctions are multipled every six panels in order to keep the operator's reach as short as possible, and to enable an operator to take up an allotted junction quickly.

For convenience in operating, the answering equipment is placed at the bottom of the panels, with the outgoing junctions above, separated by two or three spacing strips.

Below the answering equipments are the pilot-lamp rails. In the centre of each, immediately below the answering jacks, is placed the line-lamp pilot lamp, which glows each time a calling lamp lights in the panel above.

Below each second, fifth and seventh panel four additional pilot lamps are provided. These are (1) the junction-fee lamp, which glows when an outgoing order-wire key to a distant exchange to which a fee is chargeable is depressed, (2) the instruction circuit lamp, which glows when an operator is required by the supervisor to speak on the instruction circuit, (3) the meter lamp, which gives visual indication that a call has been registered, and (4) the dial guard lamp which gives visual indication when the dial switching key has been left in the dialling position.

Each plug shelf and keyboard on a subscribers' position has capacity for sixteen connecting cord circuits, each consisting of :—

2 three-way plugs and cords,
1 meter key, for registering effective calls,
2 supervisory lamps, and
1 speaking and ringing key, combined.

In addition to the above, each keyboard has capacity for :—

1 meter key for registering ineffective calls,
80 outgoing order wire keys, in strips of 10,
1 order wire ringing key and dialling key combined.

Owing to the present practice of wiring Party Lines with one multiple jack per Party Line station, the ringing reversing key is not required. The lines are reversed on one of the multiple jacks to provide the reversed ringing.

In some exchanges the junctions connecting outlying exchanges are composed of small groups, two or three junctions only from one exchange, with a light traffic load. In such cases it is frequently more economical to use these junctions for both incoming and outgoing traffic, terminating the junction for incoming calls on a jack with calling lamp associated; the line also being jumpered to the outgoing junction multiple jacks for outgoing calls.

A line of this description is called a " jack-ended junction."

The answering equipments for the jack-ended junctions, usually about thirty lines per position, are placed in the lower portion of the jack panels. The connecting cord circuit apparatus on the keyboard is similar to that on a subscribers' position, so that at any future date a subscribers' position may be readily converted to a jack-ended junction position or *vice versâ*.

The keyboards of all positions are hinged and open upwards for convenience in clearing faults on the keys, wiring, etc. The keys also are wired individually, so that any key may be removed from the keyboard without interfering with the remainder.

Below the keyboard, in the lock rail, are fitted the operator's instrument jacks by means of which the operator may connect her breastplate transmitter and headgear receiver to the instrument circuit. A double instrument jack, with the two jacks wired in parallel, is provided on each position for this purpose, so that the relief operator can connect up her transmitter before the relieved operator leaves, thereby ensuring an uninterrupted service.

This double jack is also used for the training of new operators, an additional headgear receiver being provided, the plug of which is inserted in the second jack. The learner can then listen to the operating of the experienced operator seated at the position.

Single instrument jacks are, in addition, fitted every ninth position for the switchboard supervisor's circuit. A single lamp jack is fitted in the space above the subscribers' multiple so that the monitor can call the attention of any of the switchboard supervisors.

This completes the description of the front of the switchboard section. In the rear of the section are placed the multiple cables, the cord fasteners, the apparatus for the cord circuits and the cables from the I.D.F. to the answering jacks, and also the various cables and wires supplying battery current to the cord circuits.

The multiple cables, each containing sixty-three wires, are carried in iron racks from the I.D.F. in the apparatus room, through a hole in the switchboard floor, to a Cable Turning Section fitted at the commencement of each line of switchboards.

A cable turning section is provided in order to close in the cables as they pass from the hole in the floor to the switchboard. The iron cable rack inside the cable turning section is carried some four or five inches higher than the level of the bottom row of multiple jacks in order to provide sufficient slack in the multiple cables to enable the jacks in the first panel to be raised when necessary to clear faults.

Inside the switchboard the cables are laid on an iron shelf covered with linoleum to keep the cables from contact with the iron, otherwise "sweating" might take place and the insulation resistance of the cables would suffer.

The cables are arranged on the shelf in rows, the cables serving the lowest row of jack strips on the bottom, and so on. As the thickness of the cable is approximately the same as the thickness of a strip of jacks, the cables serving the top row of jack strips will be at the same level as the jacks.

The cables are formed out to the jacks in their proper order, and sufficient length is left in the form to allow the jacks to be removed for the clearance of faults. The formed out portion of the cable is termed the "skinner."

The shelf on which the subscribers' multiple cables are laid completely divides the interior of the section into upper and lower portions, and forms a fire screen in case fire breaks out in either of the portions.

Immediately below the multiple shelf is placed a smaller shelf to carry the multiple cables for the outgoing junctions. These cables are formed out to the jacks in a similar manner to the subscribers' cables.

Below the outgoing junction cables is placed the cord shelf on which are fitted the cord fasteners, a set of three for each cord. The forked tag ends of the cords are connected to the cord fasteners by means of screws, thus facilitating the changing of faulty cords.

Between the outgoing junction multiple shelf and the cord fasteners are placed a continuous series of removable fire screens composed of uralite sheets running in iron grooves. These screens form a protection for the outgoing junction cables in case of fire breaking out in the cords.

The end of each section is provided with an iron panel placed vertically in order completely to close in the space above the multiple cable shelf. This panel is cut to fit close upon the multiple cables and forms a fire-resisting bulkhead.

In the lower portion of the rear of the section are situated the apparatus racks and the connecting racks. The apparatus rack is an iron framework on which the relays and resistances for the connecting cord circuits are mounted. The connecting rack is constructed of hard wood, and on it are fitted U-shaped connecting tags to which the cord circuit cables and the various battery leads are connected.

The floor of the sections forms a continuous closed-in run in which are placed the answering jack cables from the I.D.F. and the battery leads. The answering jack cables are carried in this run to their allotted position and are then passed up behind the connecting rack to the answering jacks and lamps.

The rear of each section is closed in by means of sliding iron doors.

The various positions on the subscribers' or "A" line of boards are arranged in the following order :—

(a) Cable turning section.

(b) Three-panel dummy section or a regular three-position section with the first position equipped with multiple only.

(c) Regular subscribers' sections equipped for jack-ended junctions, if required.

(d) Regular subscribers' sections.

(e) Regular subscribers' section equipped for testing operator and plugging up cords.

The dummy section or unequipped position referred to in (b) is provided so that the first working position may have the advantage of the full multiple to the left and right of the operator.

The jack-ended junction positions, if provided, are placed next in order, as the rate of growth of these junctions will not be so great as the rate of growth of the subscribers' sections.

In a No. 1 Exchange either one or two test positions and one or two plugging-up positions are provided, depending on the number of lines equipped.

The test and plugging-up positions are always placed at the end of the line of boards, so that any tests carried out from these positions will pass through the whole length of the multiple.

When the switchboard is extended by the addition of sections, the apparatus on the test and plugging-up positions is transferred to the last section installed.

The equipment of each Test Position consists of a testing voltmeter and set of testing keys, lines from the Monitors' Desk and lines to and from the Test Desk.

Supervisory test and plugging-up cords are also provided for plugging up faulty lines; each cord is provided with a key, a jack and a lamp. The key is used to set the circuit either for a disconnected line or a crossed line. As soon as the fault is put right the lamp glows as an indication to the testing operator, who then brings the line into use again.

The arrangements for testing and a complete description of the plugging-up cord circuit will be found in Pamphlet D.15.

The **incoming plug-ended junction** or "B" sections are usually placed in a separate line of boards on the opposite side of the switchroom.

The junction section is similar in construction to the subscribers' section, being composed of eight panels and arranged for three operators' positions. The space below the subscribers' multiple cable shelf is, however, not so great as on the subscribers' sections, as answering jacks and lamps are not required on these sections. The multiple shelf is, therefore, placed lower in the panels, thereby giving a greater capacity for the subscribers' multiple jacks. This additional capacity is necessary to allow the subscribers' multiple to be repeated every six panels instead of every nine as on the "A" switchboard.

If outgoing junctions are required on the "B" line of boards, the multiple jacks are fitted immediately below the subscribers' multiple cable shelf as in the case of the "A" sections.

Each plug shelf and keyboard on a plug-ended keyless junction position has capacity for thirty-four single-cord circuits, each consisting of :—

1 three-way plug and cord,
1 supervisory lamp, and
1 clearing lamp.

In addition to the above, each keyboard has capacity for :—

40 outgoing order wire keys in strips of 10,
1 order wire ringing key,
1 coupling key and order wire lamp (pilot lamp) resetting key, combined.

The cord circuit apparatus, relays, resistances, condensers, etc., are placed on special racks, either in the apparatus room or at the back of the junction line of boards, as there is insufficient space on the apparatus rack in the section itself.

Separate multiple cables are provided for the "B" line of boards. They are carried through a hole in the floor in an iron cable run to the I.D.F., and are there connected to the same connection strips as the multiple for the "A" line of boards.

A cable turning section is provided for the "B" line of boards in order to cover in the cables as they pass from the hole in the floor to the switchboard sections.

A **meter cabinet** is provided and installed in the switchroom to accommodate both the effective and the ineffective position meters.

In order to provide for the efficient supervision of the service and operating, the following desks are installed in the switchroom :—

Monitors' Desk,
Chief Supervisor's Desk, and
One or more Assistant Supervisors' Desks.

The **Monitors' Desk** is composed of sections each arranged for two monitors' positions, and each position is equipped with—

(1) lines to and from the switchboard, used for enquiries made by subscribers or operators at distant exchanges;
(2) intercepting circuits, used for intercepting calls to and from subscribers who have made serious complaints of the service; and
(3) listening-in lines to each of the operators' telephone circuits and to each of the outgoing order wires.

The above circuits terminate on jacks fitted in the panels of the desk.

Each position is provided with a keyboard equipped with eight connecting cords similar in operation to the subscribers' cord circuits on the switchboard. Calls coming in over the enquiry lines or the intercepting lines can, therefore, be completed and supervised by the monitor.

In the upper portion of each section, on either side of the jack panels, are provided pigeon holes for fault dockets, etc., and also spaces for books and records.

The various circuits are wired from the jacks and keys to connecting racks at the rear of the desk, and from these they are cabled to the I.D.F. or fuse board, as the case may be.

The rear of the desk is provided with a shelf, which is used by the exchange clerical staff.

Supervisor's Desk.—The Chief Supervisor is usually provided with a two-position desk, the left hand position being equipped for the supervisor and the right hand position for a clerk or an observation officer, as required by the traffic conditions.

The supervisor's position is equipped with both-way lines to the Switchboard and Test Desk and also a line to the Operators' Dining Room. These lines terminate on speaking keys situated in the upper portion of the desk.

Below the keys are placed jacks for listening-in lines to the operators' telephone circuits.

The right hand position, when used by an observation officer, is equipped with jacks and lamps for observing service on any subscriber's line, the connection being made by means of special clips to the connection strips on the I.D.F.

The rear of the desk may be provided with a shelf for clerical work.

The Assistant Supervisors, if the size of the exchange requires them, are provided with single position desks similar in construction to the desk just described.

Lines to and from the switchboard terminating in keys, and also listening-in lines, are provided in the panels of these desks as required.

In the Apparatus Room are situated the Main Frame, the Intermediate Distributing Frame, the Relay Racks, the Meter Rack, the Repeating Coil and Condenser Rack, the Fuse Board, the Battery Charging Machines, the Ringing Machines, the Power Board and Test Desk.

The **Main Frame** serves a three-fold purpose, viz. :—

(1) A convenient point at which to terminate the underground cables.

(2) A point at which to insert the fuses and protectors in all circuits to protect the exchange from accidental high voltage currents and lightning discharges.

(3) A point at which, by means of cross connecting or jumper wire, the various circuits are arranged in numerical order, so that the subscribers' and outgoing junction lines may be cabled direct to the I.D.F. and thence to the multiple jacks on the switchboard.

The framework consists of a series of vertical angle irons spaced at $6\frac{3}{4}$ in. centres. The whole structure may be readily extended in length, by the addition of vertical members, as the exchange grows in size.

Horizontal members of channel iron are provided on each vertical to support the apparatus.

The horizontal members on the line side of the frame carry eleven fuse mountings, each having capacity for twenty circuits, with a fuse in each "A" and "B" line. The horizontal members on the exchange side of the frame are provided with ten protector and heat coil strips, each having capacity for twenty circuits, with a carbon protector and a heat coil in each "A" and "B" line.

Thus it will be seen that the total capacity of each vertical on the line side is 220 circuits, and the total capacity of each vertical on the exchange side is 200 circuits. The excess capacity on the line side is provided to allow for the spare wires in underground cables. The exchange may be equipped for 4,000 subscribers' lines, but the underground cables from the various D.P.'s may have sufficient circuits in them for 4,400 subscribers' lines.

A description of the line fuses and the protectors and heat coils, and of the principle on which they operate, will be found in Pamphlet A.5.

Iron rings, covered with vulcanite insulation, are provided on each horizontal member for the jumper wires to pass through.

The **Intermediate Distributing Frame**, like the Main Frame, is composed of a series of vertical angle irons, spaced at $6\frac{3}{4}$ in. centres. The whole structure may be readily extended in length by the addition of vertical members as the exchange grows in size.

Horizontal members of flat bar iron are provided on each vertical to support the apparatus.

Like the Main Frame, it consists of two sides, one side being termed the multiple side and the other the local or answering jack side.

The connection strips on the multiple side are each fitted with twenty sets of three connecting tabs passing through a central retaining strip of vulcanite, thus providing six connecting points for each of the twenty circuits—"A" and "B" lines (usually termed tip and ring) and sleeve connection in each circuit. Each vertical member carries ten of these connection strips. Two cables are connected to one side of each connection strip; one cable, containing forty-two wires, is carried on ironwork over the top of the frame to the corresponding strip on the main frame, and the other cable, containing sixty-three wires, is carried to the switchboard in an iron cable run suspended from the ceiling, and is there connected to the multiple jacks.

The connection strips on the local side of the I.D.F. are similar to those on the multiple side, but each strip is fitted with twenty sets of four connecting tabs. Three of these tabs are required for the "A" and "B" lines (tip and ring) and the sleeve connection, and the fourth is wired to the subscriber's

calling lamp. Two cables are connected to one side of each connection strip; one cable, containing eighty-four wires, is carried over the top of the frame to the line and cut-off relays on the relay rack, and the other cable, also containing eighty-four wires, is carried in an iron cable run, suspended from the ceiling, to the answering jacks and calling lamps on the switchboard.

The connection strips on the multiple side are arranged in numerical order to correspond with the multiple jacks on the switchboard, and the connection strips on the local side are arranged in the order in which the answering jacks are placed in the panels of the switchboard. The connection between the multiple side and the local side is made with a three-way jumper wire, and it is at this point that the traffic load given to each operator to handle is equalised. Subscribers No. 1 to 100 might be exceptionally busy subscribers, and if they were jumpered in numerical order to the hundred answering jacks on the first operator's position the operator on that position would be overloaded, but if subscribers No. 1 to 100 were cross-connected so that they were distributed over a number of operators' positions, and other less busy subscribers intermixed with them, each operator would be able to handle the same number of subscribers as her neighbour, and the number of calls per day or busy hour handled by each operator would be approximately equal.

Insulated rings are also provided on this frame for the jumper wires to pass through.

The **Relay Racks**, two in number, are placed parallel to each other and also parallel to the I.D.F. They are constructed of H-iron uprights spaced at 1 ft. $8\frac{1}{4}$ in. centres to form bays in which the mounting plates for the line and cut-off relays are fitted.

The spacing of the uprights just equals the space occupied by three verticals of the I.D.F. The connection strips for 600 circuits on the local side of the three verticals, therefore, can be cabled conveniently over the top of the frame to one opposite bay on each of the relay racks, the next three verticals being cabled to the second bay on each rack, and so on.

The line relays and the cut-off relays are mounted in pairs, ten pairs on each mounting plate. The line relay (the top relay of the pair) is a single make relay, that is to say, when it operates the contact springs make one contact. The cut-off relay, the bottom relay of the pair, is a double break relay, the springs of which break or open two contacts when the relay is operated. The action of these relays is shown in the diagram of the subscriber's line circuit (Fig. 1).

The **Meter Rack** is of similar construction to the relay rack and is usually placed parallel to it. The service meters, one for each subscriber's line, are mounted in strips of ten. They

are arranged in numerical order and are cabled over the top of the rack to the multiple side of the I.D.F., and are connected to the sleeve tabs on the connection strips.

The **Special Apparatus Rack** is of similar construction to the relay rack, and is usually placed adjacent to, and in line with, it. On this rack are placed the relays, resistances, etc., in the incoming junction cord circuits, there being insufficient space available on the apparatus rack inside the section. The apparatus for miscellaneous circuits, plugging-up cord circuits, etc., is also located on this rack.

The **Fuse Board** is constructed of one or more slate panels bolted to an iron framework. Copper bus bars connected to the main battery by a cable are fitted on the face of the slate panel, and, at a short distance away, parallel to each bus bar, is placed a row of copper fuse posts. Between these posts and the adjacent bus bar are fitted the alarm fuses, one end being screwed to the bus bar and the other end to the fuse post.

When a fuse blows contact is made with an alarm bar, the pilot lamp associated with the particular row of fuses on which the blown fuse is fitted glows, and the alarm bell rings.

The fuse posts are each provided with a screwed bolt which passes through the slate panel to a soldering tab at the rear of the panel. Power wires are connected to the tabs and are run to feed the various cord circuits, lamps, etc., on the switchboard.

A **Repeating Coil and Condenser Rack** is provided for the repeating coils and condensers fitted in the incoming junction cord circuits.

For economy of space the repeating coils for two junction circuits are mounted on one base, and, for convenience of wiring, the condensers associated with the two junctions are mounted on one base and are placed adjacent to the coils.

In some earlier types of repeating coil rack the coils were placed in the lower portion of the rack and the condensers in the upper portion.

In order that the relays, etc., mounted on the various racks may be accessible for maintenance purposes, each frame and rack is provided with one or more **travelling ladders.** The head of each ladder is provided with a trolley running on an iron track suspended from the ceiling. The foot of each ladder is provided with rubber-tyred wheels and also a guide which keeps the ladder from fouling the apparatus on the rack. The ladders will travel the full length of the racks, so that any piece of apparatus is accessible.

The Apparatus Room equipment is completed by the **Power Plant.** Two motor generators, driven from the Town supply mains, are provided for charging the accumulators.

Two ringing dynamotors to supply ringing current to the switchboard are also provided; one is driven from the Town supply and one from the accumulators. Each dynamotor is provided with high and low speed interrupters, the former providing the tone or buzz used in the busy back circuit and also on the bush of the jack of a line which is plugged up on account of a fault. The latter causes the tone produced by the high-speed interrupter to be sent out intermittently to the operator at the distant exchange when a required line is engaged. The low-speed interrupter also interrupts the ringing current supply to the machine or keyless ringing on the plug-ended "B" positions.

A Power Board is installed, near the machines if possible, on which are mounted the starting switches for the machines and also the voltmeters and ammeters for indicating the voltage and current of the charging circuit, and the discharge of the accumulators.

The accumulators are always placed in a separate room, as the gas given off by the cells would cause corrosion of the metal parts of any apparatus in the same room.

Two sets of twenty accumulators are provided in each exchange of this type, one set discharging to the exchange while the other set is being charged. This arrangement permits the use of ordinary commercial type charging generators without

causing noise on the talking circuits. In some exchanges one set of accumulators only has been installed, necessitating a special type of charging generator with a commutator composed of a large number of segments, in order to overcome noise when the battery is charging and discharging simultaneously.

The capacity or size of each battery depends on the amount of current to be taken from them. This amount is calculated for each exchange and is dependent on the number of calls to be dealt with per day and busy hour and the duration of each call. In addition to the calculated amount of current to be consumed per day a factor of safety is allowed in case of a stoppage of the Town supply for a short period.

Power plant for telephone purposes is fully dealt with in Pamphlet G.2.

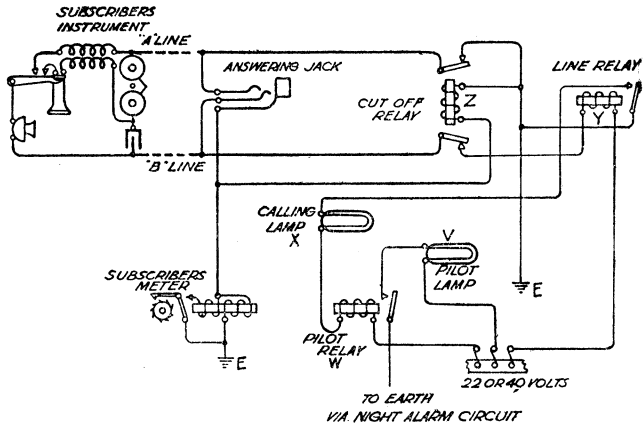


Fig. 1.

A **Test Desk** of one, two or more positions is provided in the Apparatus Room from which tests of all circuits can be readily made by means of test sets, each composed of a high resistance voltmeter and a set of testing keys. The circuits and the methods of testing are described fully in Pamphlet D.15.

The above completes the description of the lay-out of a No. 1 C.B. Exchange.

The principles on which the various circuits operate are described in the "Principles of Telephone Exchange Signalling," Pamphlet D.3.

FUNDAMENTAL CIRCUITS.

The following is a short description of the chief fundamental circuits.

The **subscriber's line circuit** is shown in skeleton form in Fig. 1.

It will be seen that the "A" and "B" lines pass from the subscriber's instrument to the answering jack and through the contacts of the cut-off relay *Z*, the "A" line to earth and the "B" line through the line relay *Y* to a fuse and battery.

When the receiver of the subscriber's instrument is on the hook the instrument circuit consists of a 1,000 ohm bell and a 2 m.f. condenser in series, so that there is no path for the current from the exchange battery through the line relay *Y*. When, however, the receiver is removed from the hook a loop is placed across the lines through the transmitter, switch-hook and induction coil. Current is now drawn through relay *Y* which actuates and lights the calling lamp *X*. It will be seen that the current supplying the lamp passes through the pilot relay *W*, which lights the pilot lamp and at night time rings the night bell.

The operator answers the call by inserting the answering plug of one of the cord circuits (shown in Fig. 2) in the answering jack. The cut-off relay *Z* operates with the current on the sleeve of the answering plug, the contacts are broken and line relay *Y* returns to the normal position, thus putting out the calling lamp and the pilot lamp. The subscriber's meter is not actuated by the insertion of the plug in the answering jack, as there is insufficient current to operate it until the meter key shown in Fig. 2 is depressed.

The **subscriber's cord circuit** is shown in Fig. 2. It will be seen that the circuit is divided into two portions by means of the condensers. This arrangement permits the supervisory lamp signals to operate independently.

There are two supervisory lamps, *Y* and *Z*, in connection with the answering and calling cord respectively. Each is controlled by a supervisory relay *X* and *W* inserted between the earth side of battery and the tip of each plug. Between the ring of each plug and the battery is placed an impedance coil of the same impedance as the supervisory relay, in order to preserve the balance of the line.

When the answering plug is inserted in the answering jack of the calling subscriber, current passes from the battery through impedance coil *V*, over the line and through the induction coil and transmitter of the subscriber's instrument, and returns *viâ* the line and supervisory relay *X* to the earth side of the battery.

This provides speaking current for the subscriber's instrument and actuates the supervisory relay *X*, the relay contact being broken the whole time the subscriber has the receiver off the hook. The supervisory lamp *Y* is disconnected by the supervisory relay *X* and does not glow under these conditions.

When the calling plug is inserted in the multiple jack of the required subscriber, supervisory relay *W* is not operated, as the telephone is on the hook until the required subscriber answers. The operator rings the required subscriber by moving the com-

C.B. Nos. 1 & 10 EXCHANGES
4 O.V. SYSTEM
SUBSCRIBERS CORD CIRCUIT & POSITION METER CIRCUIT

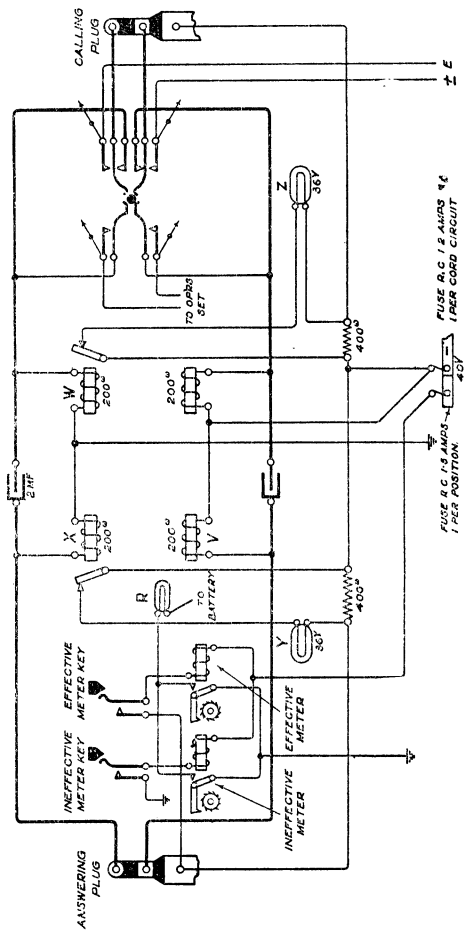


Fig. 2.

bined speaking and ringing key into the ringing position. As soon as the subscriber removes the receiver from the hook the supervisory relay *W* operates and the supervisory lamp *Z* is extinguished. When the conversation is finished and both subscribers replace their receivers, both supervisory relays are released and both supervisory lamps glow, thus indicating to the operator that the call is finished and the connection may be taken down. Before the plugs are withdrawn, however, the operator presses the meter key associated with the cord circuit in use; this operates the position meter and the calling subscriber's meter in series, thereby registering an effective call to the operator and a call to be charged to the calling subscriber.

Should the operator be unable to complete a call owing to the required subscriber being engaged or out of order, the ineffective meter key is depressed instead of the meter key associated with the cord circuit; this records a call on the operator's ineffective meter, but the subscriber's meter in this case does not operate.

The operation of either the effective meter or the ineffective meter causes a meter pilot lamp to glow, indicating to the operator that the call has been recorded. This lamp is provided with an opal cap engraved "R."

The **jack-ended junction cord circuit**, shown in Fig. 3, is used for answering and connecting calls on the incoming jack-ended junction positions. It is suitable also for answering and connecting calls on a subscribers' position; team working is, therefore, possible between a jack-ended junction position and a subscribers' position.

The apparatus is similar to the subscriber's cord circuit shown in Fig. 2, except that a repeating coil, instead of condensers, is used for dividing the circuit into two positions. The repeating coil is introduced to eliminate noise which might occur should an unbalanced subscriber's line be connected to a long junction or *vice versâ*.

The operation of the circuit is similar to that of the subscriber's cord circuit.

The **"A" operator's telephone circuit** is shown in Fig. 4. The induction coil consists of two primary windings, two secondary windings and a non-inductive winding. It is wired on the Wheatstone Bridge principle, the receiver taking the place of the galvanometer. The non-inductive resistance of 360 ohms, approximately that of an average subscriber's line, reduces *side tone*, that is, the hearing of the operator's own voice in her receiver.

The retardation coil in the primary circuit acts as a choke coil, and prevents current variations passing to and from the battery.

C.B. Nos. 1 & 10 EXCHANGES
40 VOLT SYSTEMS
JACK-ENDED JUNCTION CORD CIRCUIT
With 36 Volt Lamps

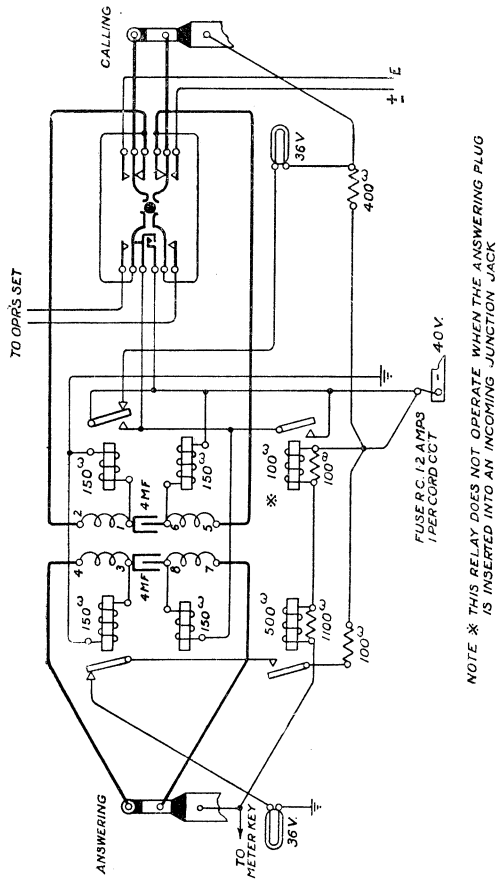


Fig. 3.

The telephone circuit is connected to the outer springs of the cord circuit speaking keys *viâ* the contacts of the cut-off relay *A* and also to the outer springs of the outgoing order wire keys *viâ* the order wire ringing key (*see* Figs. 4 and 5). The operator can speak on any cord circuit or on any outgoing order wire by operating the relative key.

The **outgoing order-wire circuit** is shown in Fig. 5. The order-wire keys are mounted in strips of ten, and are fitted to the left-hand side of each keyboard. The tops of the keys are

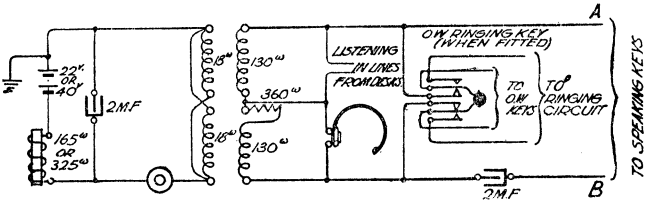


Fig. 4.

engraved with the code of the exchange to which each order wire works.

On depressing the key the operator's telephone circuit is connected to the order wire, on which an operator at the distant end is listening. The operation of the outgoing order wire key also actuates the cut-off relay *A* (Fig. 5) which disconnects the operator's telephone circuit from the cord circuit speaking key and prevents the subscriber hearing the call passed over the order wire. The operation of this key also causes the junction fee lamp to glow if a call to a particular exchange to which the order wire works is liable to a junction fee. If no fee is chargeable to any of the exchanges the relative order wire keys are wired so that the lamp does not glow. At night-time, or when an operator is not stationed at the distant end, the order-wire ringing key is used to ring on the order wire, a relay is operated at the distant end, and a pilot lamp on the incoming junction position glows.

Each outgoing order wire is wired through two break jacks situated on the first or dummy position. By means of a connecting cord, shown in Fig. 5, a faulty order wire can be conveniently crossed out, temporarily, and a junction to the same exchange can be brought into use as a temporary order wire.

The operation of the cut-off relay when the line plug is inserted in an outgoing junction supplies battery to line to operate the line relay at the incoming end of the junction picked up for the temporary order wire.

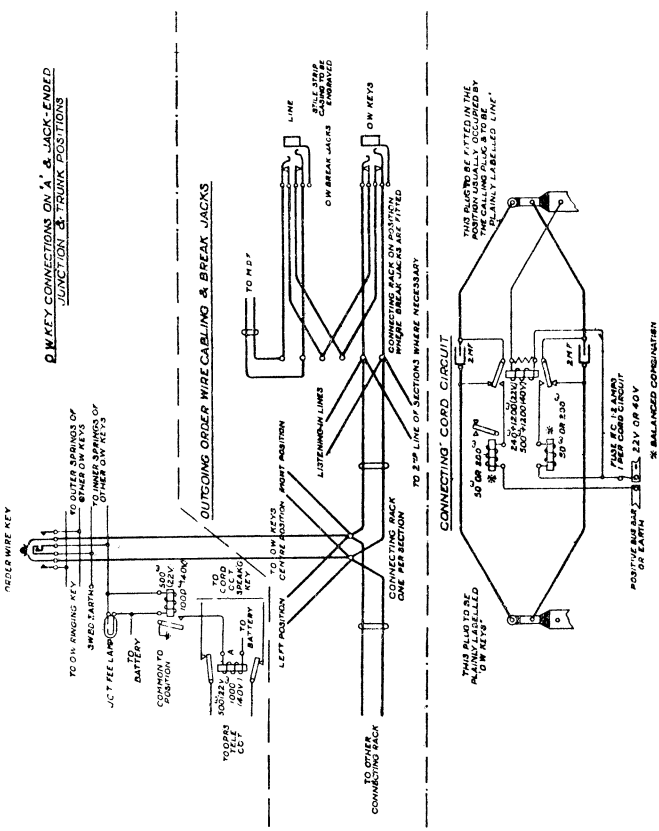
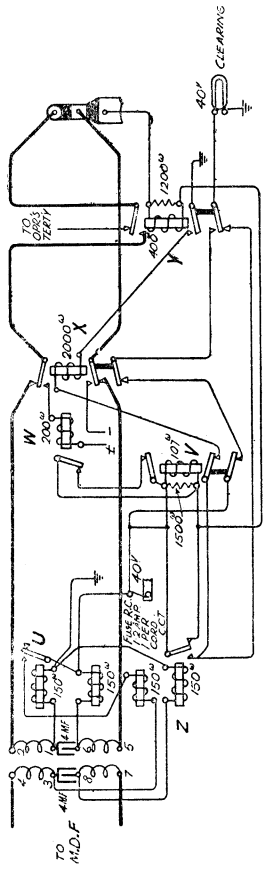


Fig. 5.

A typical **incoming junction circuit** is shown in Fig. 6. **The class** of circuit shown is an incoming order-wire junction arranged for keyless ringing. The operation of the call **is as** follows :—



Note: The 200ω relay marked *W* should be inserted in the "B" line so that ringing current is applied to the ring of the plug.

Fig. 6

An operator "A" at a distant exchange receives a request for a subscriber in the exchange under description. She depresses the outgoing order-wire key marked with the code of the exchange required and passes the call to the operator " B "

listening on the incoming end of the order wire. Operator " B " then allots a disengaged junction and tests the line to ascertain if the required subscriber is disengaged, and, if so, plugs into the multiple jack, and so far as she is concerned the call is completed. Meanwhile operator " A " plugs into the outgoing junction allotted by operator " B," and by means of relays in the incoming junction circuit the required subscriber's bell is rung.

The operation of the circuit during the above actions is as follows :—

When operator " A " plugs into the multiple jack of the allotted outgoing junction, relay *Z* operates by means of the current on the calling plug of the cord circuit at the distant exchange.

When operator " B " plugs into the multiple jack of the required subscriber, relay *Y* operates, the circuit being completed through the contact of relay *W* and the cut-off relay of the subscriber's line circuit. The operation of relay *Y* completes the circuit of relay *X* (through the contacts of relays *Z* and *V*) which operates, and by means of the relay contacts connects ringing current to the tip and ring of the plug, and so to the subscriber's instrument bell. The ringing current passes through relay *W*, but owing to the high resistance of the instrument-bell circuit it does not operate. When, however, the subscriber answers, the resistance of the instrument is reduced, and relay *W* operates. The operation of relay *W* breaks a contact and removes a short-circuit from relay *V*, which now operates, and disconnects relay *X*. Relay *X* returns to normal, disconnects the ringing current, and joins the lines through to the tip and ring of the plug, and thence to the required subscriber's line. The call is now through.

Relay *V* then remains actuated while the plug at the distant end is in the outgoing junction jack, and it will be seen that in the event of the required subscriber hanging up the receiver before the conversation is finished, the act of withdrawing and immediately reinserting the calling plug at the distant end releases relay *V*, again operates relay *X*, the ringing is again set up and the subscriber is re-called.

While the required subscriber has the receiver off the hook, relay *U* is operated by reason of the loop at the instrument, but on the receiver being placed on the hook, relay *U* returns to normal, removes battery from the " A " line, and allows the supervisory relay in the calling-cord circuit at the distant end to operate; the corresponding supervisory lamp lights, and if the calling subscriber has also cleared the operator withdraws both plugs.

Relay *Z* returns to normal when the plug is withdrawn from the outgoing junction jack at the distant end, the relay contacts placing a short-circuit on relay *V*, which returns to normal,

and the clearing lamp glows through contacts of relays *Y*, *X* and *V*.

The **operator's telephone circuit on a " B " position** is similar to that on an " A " position, except that an additional induction coil connected to the tip of the plugs *viâ* the contacts of relay *Y* (Fig. 6) is used in connection with the engaged test.

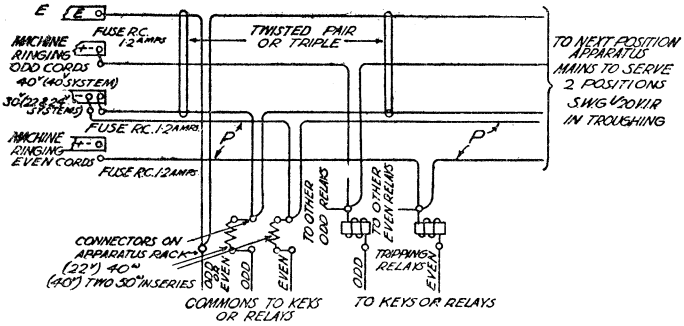


FIG 7A MANUAL RINGING

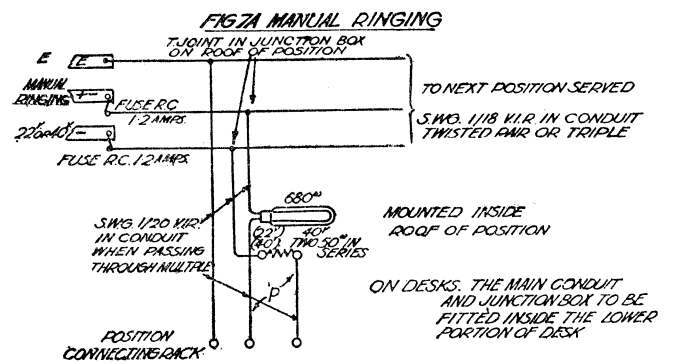


Fig. 7.

The **ringing distribution circuit** is shown in Fig. 7.

The manual ringing leads are V.I.R., No. 18 S.W.G., carried from the fuses on the fuse-board to the switchboard sections and along the top of the switchboard sections in conduit. Two sets of leads are provided, and they serve alternate positions, so that, in the event of a break-down on one set of leads, the service may be carried on with alternate positions working. One set of leads will serve eighteen positions.

The 660 ohms resistance lamps and the resistance spools, one

per position, are fitted inside the upper portion of the switchboard sections above the multiple.

The leads for machine and keyless ringing are carried to the "B" switchboard in a similar manner to the manual ringing leads, but in this case alternate cords are fed from the sets of leads instead of alternate positions. By this means, if one set of leads breaks down, alternate cords only are affected, thus enabling approximately half the junctions in each group to be kept in service.

WIRING ARRANGEMENTS.

The wiring arrangements of the chief circuits just described are as follows:—

Subscriber's Line Circuit. Fig. 1.—The "A" and "B" lines in the underground cable are terminated on the fuses of the Main Frame, and from there they are cross-connected by means of twin wire to the protectors and heat coils on the exchange side of the Main Frame. From the protector and heat coil strips they are cabled to the connection strips on the multiple side of the I.D.F. by means of forty-two wire switchboard cable. From the same side of the connection strips the two lines and the test are cabled to the multiple jacks with sixty-three wire cables. The other side of the connection strip is cross-connected with triple wire to the local or answering side of the I.D.F., and from there, together with the calling lamp wire, they are cabled to the answering jacks with eighty-four wire cable, and also to the line and cut-off relays with eighty-four wire cable.

The subscribers' meters, one for each line, are cabled to the multiple side of the I.D.F. with twenty-one wire cable.

The battery leads from the fuses on the fuse board to the pilot relays on the rear of the switchboard sections, and the pilot lamps are contained in the switchboard cable from the fuse board to the cord circuits.

The battery leads to the line relays are also separate leads of V.I.R., No. 18 S.W.G., one lead per 100 relays.

Subscriber's Cord Circuit. Fig. 2.—All the apparatus shown on this diagram, with the exception of the fuses, is fitted on the switchboard section. The wiring between the cord fasteners, keys, supervisory relays, supervisory lamps and resistance spools is carried out with switchboard wire laced up into cable form. The tip, ring and sleeve wires from the plugs are wired to connectors on the connecting rack at the rear of the section, and from there they are wired to the supervisory relays.

The operators' position meters are cabled from the meters mounted in the meter cabinet to connectors on the connecting rack of every tenth position with thirty-three wire cable, and from there they are distributed by means of smaller cables to their respective positions. The battery leads from the fuse boards are carried direct to the meters with a switchboard cable of 36-lb. wire.

Operator's Telephone Circuit. Fig. 4.—The whole of the apparatus shown on this diagram, with the exception of the fuses, is situated on the switchboard section, and the wiring between the induction coil, instrument jack, condensers and retardation coil is carried out with switchboard wire laced up into cable form. The battery leads from the fuse board are contained in the cables supplying the battery to the cord circuits.

Outgoing Order Wire Circuit. Fig. 5.—The outgoing order wire keys on each position are wired with switchboard wire to connectors on the connecting rack at the rear of the section, each set being teed on to the next position by means of a cable of suitable size.

From the end section they are cabled to the connectors for the outgoing order wire break jacks usually fitted on the first or dummy position. The outgoing order wire lines are cabled direct from the Main Frame to the connectors for the break jacks with forty-two wire switchboard cables. The connecting cord circuit is fitted on the plug shelf of the position on which the break jacks are located.

Plug Ended Incoming Junction Circuit. Fig. 6.—The whole of the apparatus shown on this diagram, with the exception of the plug and clearing lamp, is situated in the Apparatus Room. The relays and resistances are fitted on the special apparatus rack, the repeating coils and condensers on the repeating coil rack and the fuses on the fuseboard.

The incoming junction lines are cabled from the Main Frame to the repeating coils, from the repeating coils to the relays, and from the relays to the connecting rack at the rear of the switchboard section with switchboard cable. The wiring is continued from the connecting rack to the cord fasteners by means of switchboard wire laced up into cable form.

The battery leads from the fuse board to the relays are in rubber-covered or V.I.R. wire.

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[*Continued on page iv. of Cover.*

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