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POST OFFICE
ENGINEERING DEPARTMENT

TECHNICAL PAMPHLETS FOR WORKMEN

Subject:

C.B. Exchanges—No. 10 Type

ENGINEER-IN-CHIEF'S OFFICE
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C.B. EXCHANGES, No. 10 TYPE

(D. 9).

The following pamphlets in this series are of kindred interest:

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C.B. EXCHANGES, No. 10 TYPE.

DESCRIPTION AND LAY-OUT OF EXCHANGE PLANT.

The Common Battery No. 10 Exchange was designed some ten years ago to provide for exchanges in which it was anticipated that the subscribers' multiple would not exceed 2,000 lines during the life of the exchange. Twenty years is taken as the average life 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 the original design of a No. 10 Exchange the subscribers' line relays and the cord circuit repeating coils were mounted inside the switchboard sections, and the subscribers' cut-off relays were mounted on a combined Relay Rack and Intermediate Distributing Frame usually situated, for convenience of cabling, in the switchroom.

Just prior to the transfer of the National Telephone Company's undertaking the above arrangement of relays, etc., was departed from and a system was adopted, which, with the exception of a few minor details, is the present standard for exchanges of this type.

The chief differences between the standard No. 10 Exchange and the No. 1 C.B. Exchange are shown in the following table :—

	No. 10 C.B. Exchange.	No 1 C.B. Exchange.
Switchboard Sections ...	Each with one operator's position.	Each with three operator's positions.
Ultimate capacity of Subscribers' multiple	2,000.	6,400 or 10,000. Two sizes of section are provided.
Subscribers' lines multipled over	Four panels on "A" or "B" sections.	Nine panels on "A" sections six panels on "B" sections, or eight panels if "A" and "B" sections in one line of boards.

	No. 10 C.B. Exchange.	No. 1. C.B. Exchange.
Main Frame	Combined in one Frame.	Separate.
Intermediate Distributing Frame		Separate.
Relay Rack	Combined in one Rack.	Separate.
Meter Rack		Separate.
Monitor's Desk... ...	Usually combined in one desk.	Usually separate.
Supervisor's Desk ...		Usually separate.

The apparatus fitted on the No. 10 section, with the exception of the jacks, lamp jacks, plugs and cords which are of a larger type, is identical with the apparatus fitted on a No. 1 section. The single position sections, however, are more conveniently handled and are more economical as regards floor space where right angle turns in a suite of sections are necessary.

The apparatus fitted on the frames and racks in the apparatus room is identical with the apparatus used in a No. 1 Exchange. The combined Main and I.D.F. and the combined Relay and Meter Rack, however, result in a saving of floor space and are more economical from a cabling point of 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, etc., are provided to support the apparatus to form a complete No. 10 Exchange :—

Subscribers' or "A" sections.
Incoming Plug-ended junction or "B" sections.
Cable Turning sections.
Combined Supervisor and Monitor's Desk.
Combined Main and Intermediate Distributing Frame.
Combined Relay and Meter Rack.
Repeating Coil and Condenser Rack.
Fuse Board.
Test Desk.
Power plant, including charging machines, ringing machines, batteries and power board.

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The **Switchboard Sections** are of the same design for subscribers or junctions, and each is constructed for one operator's position. Two jack panels per section are provided, each being divided into two parts by means of a space or rail. The upper portion of each panel is arranged to accommodate the subscribers' multiple jacks in strips of 20. The subscribers are multipled every four panels, that is to say, the whole of the subscribers' multiple jacks are repeated every four panels, so that the maximum reach of any operator will be three panels. The lower portion of each panel is arranged to accommodate the outgoing junction jacks in strips of 20, the outgoing junction designation strips with labels engraved with the code of the exchange at which the junction is terminated, and also the subscribers' answering jacks in strips of 20 together with the subscribers' lamp jacks in strips of 20. The latter are placed immediately below the strips of answering jacks with which they are associated. A designation strip, with labels engraved with the subscribers' telephone numbers, is fitted above each strip of answering jacks.

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

Below the answering equipments are the pilot lamp rails, in each of which are fitted two single lamp jacks. The lamp in the centre of the rail below each panel is the line lamp pilot lamp and the remaining two 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, and (2) the meter lamp, which gives visual indication that a call has been registered.

The plug shelf and keyboard on a subscribers' section are equipped with 17 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;
20 outgoing order-wire keys in strips of 10;
1 order-wire ringing and ringing reversing key, combined.

The plug-shelf and keyboard on a plug-ended junction position have capacity for 33 single-cord circuits, each consisting of :—

1 three-way plug and cord;
1 supervisory lamp;

1 clearing lamp, and

1 speaking and ringing key, combined. (This key is not required if keyless junctions worked by order wire are installed.)

In addition to these, each keyboard has capacity for :—

10 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 above keyboard arrangement provides for incoming junctions worked on a plug-ended system, but in several No. 10 Exchanges the junctions from 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 termed a jack-ended junction.

The answering equipments for these jack-ended junctions, usually about 30 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 sections 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 operators' instrument jacks, by means of which the operator may connect her breastplate transmitter and headgear receiver to the instrument circuit. A double instrument jack is provided for this purpose, with the two jacks wired in parallel, 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.

This completes the description of the front of the switchboard. 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 63 wires, are carried in iron racks from the I.D.F. in the apparatus room, through a hole in the switchroom floor (or if the apparatus room is on the

same floor as the switchroom, through a hole in the wall), to the Cable-Turning Section fitted at the commencement of the 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 to facilitate the changing of faulty cords.

In the lower portion of the rear of the section are situated the apparatus rack and the connecting rack. 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 and the various battery leads are connected.

The floor of the sections forms a continuous 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 section and passed up behind the connecting rack to the answering jacks and lamps.

The rear of the section is closed in by means of a lift-out door.

In a No. 10 Exchange the number of plug-ended junction sections required is usually small and, for this reason, they are usually placed in the same line of boards as the subscribers' sections. A saving in floor space is thus effected, as a wider room would be required for two separate lines of boards. With one line of boards there is also a saving in multiple cables.

The plug-ended junction sections are placed at the commencement of the line of boards because there is less likelihood of an extension of this class of section being required. An unequipped section is sometimes installed to allow for future growth, but, if this is not done, it is a comparatively simple matter to convert the adjacent section to a plug-ended junction section by changing the plug shelf and keyboard.

Adjacent to the plug-ended junction sections are fitted the jack-ended junction sections, followed by the subscribers' sections. The last subscribers' section, equipped as a test position, is placed at the end of the line of boards, so that any tests carried out from this position will pass through the whole length of the multiple. When the switchboard is extended by the addition of sections, the apparatus on the test position is moved to the last section installed.

The equipment of the test position consists of a testing voltmeter and set of testing keys, lines from the monitor's 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 being 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 are contained in Pamphlet D.15.

The switchroom desks provided in a No. 10 Exchange are not so numerous as they are in a No. 1 Exchange, but their functions and circuit arrangements are identical. One Supervisor and one Monitor are usually sufficient to deal with the supervision and enquiries in an exchange of this size, and for convenience and economy of floor space they are accommodated at one desk called a **Combined Supervisor's and Monitor's Desk.** The right-hand position is equipped as a Supervisor's Position and provision is made for Bothway Lines to the switchboard and Test Clerk, terminating on speaking keys fitted in the right-hand panel of the desk immediately in front of the Supervisor. One plug and cord is also provided so that the Supervisor can listen in on the telephone circuit of each operator at the switchboard, and also on each of the outgoing order wires.

The left-hand position for the Monitor is equipped with lines to and from the switchboard. These lines are used for enquiries made by subscribers or operators at distant exchanges. Intercepting circuits, used for intercepting calls to and from subscribers who have made serious complaints of the service, are provided, and also " listening in " lines to each of the operators' telephone circuits and each of the outgoing order wires. The above circuits terminate on jacks fitted in the left-hand panel of the desk.

A keyboard is provided on this position, 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 circuits can therefore be completed and supervised by the Monitor.

In the upper portion of the desk on either side of the jack panels are arranged drawers for a card index of subscribers and junction lines, and also a set of pigeon holes for fault dockets, etc.

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

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

The Combined Main and I.D.F.—The lower portion, the Main Frame, is composed of two sides (1) the Line side on which the underground cables are terminated, and (2) the Exchange side which is cabled in numerical order to the I.D.F. portion.

The main frame serves a threefold 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 five fuse mountings, each having capacity for 20 circuits with a fuse in each *A* and *B* line. The exchange side is provided with four protector and heat coil strips, each having capacity

for 20 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 100 circuits and the total capacity of each vertical on the exchange side is 80 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 1,000 subscribers' lines, but the underground cables from the various D.P.'s may have sufficient circuits in them for 1,200 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.

Above the main frame portion, and on the same vertical members, a further set of horizontal members is provided to carry the connection strips to form the Intermediate Distributing Frame. This I.D.F. portion is also composed of two sides; the side above the line side of the main frame is termed the local or answering jack side, and the side above the exchange side of the main frame is termed the multiple side.

The connection strips on the multiple side are each fitted with 20 sets of three connecting tabs passing through a central retaining strip of vulcanite, thus providing six connecting points for each of the 20 circuits—*A* and *B* lines (usually termed tip and ring) and sleeve connection in each circuit. Each vertical member carries four of these connection strips to correspond with the protector and heat coil strips on the Main Frame below. Two sets of cables are connected to one side of each connection strip, one cable containing 42 wires is carried down the horizontal members to the corresponding strip on the main frame, and the other cable containing 63 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 except that each strip is fitted with 20 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 subscribers' calling lamp. Two cables are connected to one side of each connection strip, one cable containing 84 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 84 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 100 answering jacks on the first operator's position that operator 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 the I.D.F. portion of the frame for the jumper wires to pass through.

The Combined Relay and Meter Rack is usually placed parallel to, and about 2 ft. 10 ins. away from, the combined Main and I.D.F. It is constructed of H-iron uprights spaced at 1 ft. 8¼ in. centres to form bays in which the mounting plates for the line and cut-off relays and for the service meters are fitted.

The line relays and the cut-off relays are mounted in pairs, 10 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 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 service meters are also mounted in strips of 10, and in order to keep these within easy reach for taking readings, the lowest strip is fitted about 2 ft. 4 ins. from the floor and the top strip about 5 ft. from the floor in each bay. A service meter is on the Veeder cyclometer principal actuated by the electromagnet; the index reads from 0 to 9999 and repeats.

The cables from the local side of the I.D.F. are carried on ironwork overhead to the relay rack, down the H-iron verticals and are formed out to the terminals of the relays.

It is the practice now, since the majority of subscribers are on the measured rate service, to provide a service meter for each line. The meters are, therefore, arranged in numerical order. They are cabled to the multiple side of the I.D.F. and are connected to the sleeve tabs on the connection strips.

In some exchanges of the No. 10 type the meters have been placed on a separate rack, the location being governed by local conditions of lighting, etc.

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 plug-ended junction cord circuits, there being insufficient space available on the apparatus rack inside the

"B" section. The apparatus for other 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, a row of copper fuse posts is placed. 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.

Repeating Coil and Condenser Rack.—In exchanges worked on the 22-volt repeating coil system, each subscriber's cord circuit requires a repeating coil. These coils are placed on an iron rack, situated in the apparatus room, preferably adjacent to the Fuse Board.

Exchanges worked on the Stone system (condensers and impedance coils) do not require repeating coils in the subscribers' cord circuits, but a similar rack is provided for the necessary repeating coils and condensers in the 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.

Power Plant.—The Apparatus Room equipment is completed by the Power Plant. This consists of two motor generators, driven from the town supply mains, for charging the accumulators. In smaller exchanges one charging motor generator only is installed, but in such cases a spare armature is provided in case of breakdown.

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 provides the tone or buzz used in the busy back circuits 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 accumulators are now provided in each exchange, 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. One set of accumulators only has been installed in some exchanges. In such cases it is necessary to have 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 number of cells making up the battery varies with the system on which the exchange works. In a 22-volt repeating coil system 11 cells are provided in each set. A 24-volt condenser and retardation coil system requires 12 cells in each set and a 40-volt condenser and retardation coil system requires 20 cells in each set.

The 22 and 24-volt systems also require an additional battery of 4 or 3 cells respectively to provide the additional voltage for the meter circuit and for the 30-volt transmission on the incoming junctions.

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.

A **Test Desk** of one or two 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 layout of a No. 10 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.

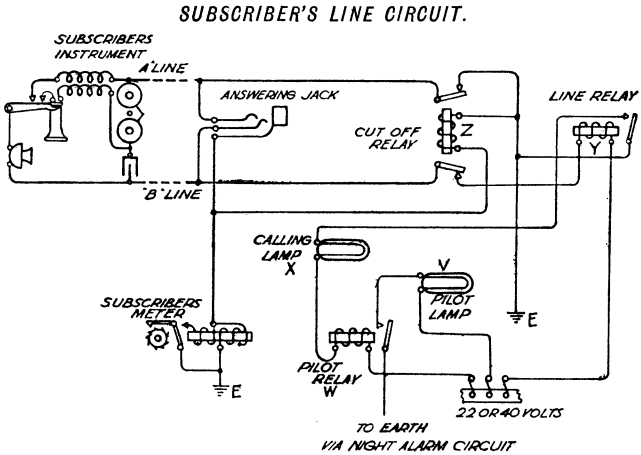


Fig. 1.

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** for a 22-volt repeating coil system is shown in Fig. 2. It will be seen that the circuit is divided into two portions by means of the repeating coil. This arrangement permits the supervisory lamp signals to operate independently and also provides a feeding point for the battery.

There are two supervisory lamps (*Y* and *Z*) in connection with the answering and calling cord respectively; each is controlled by a supervisory relay in series with the wiring to the plugs. Each relay is shunted with a non-inductive resistance in order to obviate loss of speaking current due to the impedance of the relay winding.

When the answering plug is inserted in the answering jack of a calling subscriber, current passes from battery through one coil of the repeating coil, through supervisory relay *W*, over the line and through the transmitter and induction coil of the subscriber's instrument and returns *viâ* the second coil of the repeating coil to the earth side of the battery. This provides speaking current for the subscriber's instrument and actuates the supervisory relay *W*, the relay contact being made the whole time the subscriber has the receiver off the hook. The supervisory lamp *Y* does not glow under these conditions owing to the 40^{w} resistance placed across the lamp terminals by the operation of the supervisory relay.

When the calling plug is inserted in the multiple jack of the required subscriber supervisory relay *X* is not operated, as the telephone is on the hook until the required subscriber answers. The operator rings the required subscriber by moving the combined speaking and ringing key into the ringing position. As soon as the subscriber removes the receiver from the hook the supervisory relay *X* operates and the supervisory lamp *Z* is extinguished by the 40^{w} shunt. 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.

Page 14. *2nd para. from bottom of page.*

Line 5. *Delete:* speaking and ringing key. *Insert:* SPEAK and RING key.

Line 14. *Amend:* the position meter *to read* the Total Calls meter.

Line 16. *Delete:* to the operator. *Insert:* on the position.

Last Para. Line 4. *Amend:* the operator's ineffective meter, *to read* the Total Calls and ineffective meter.

Delete existing fig. 2. Insert :—

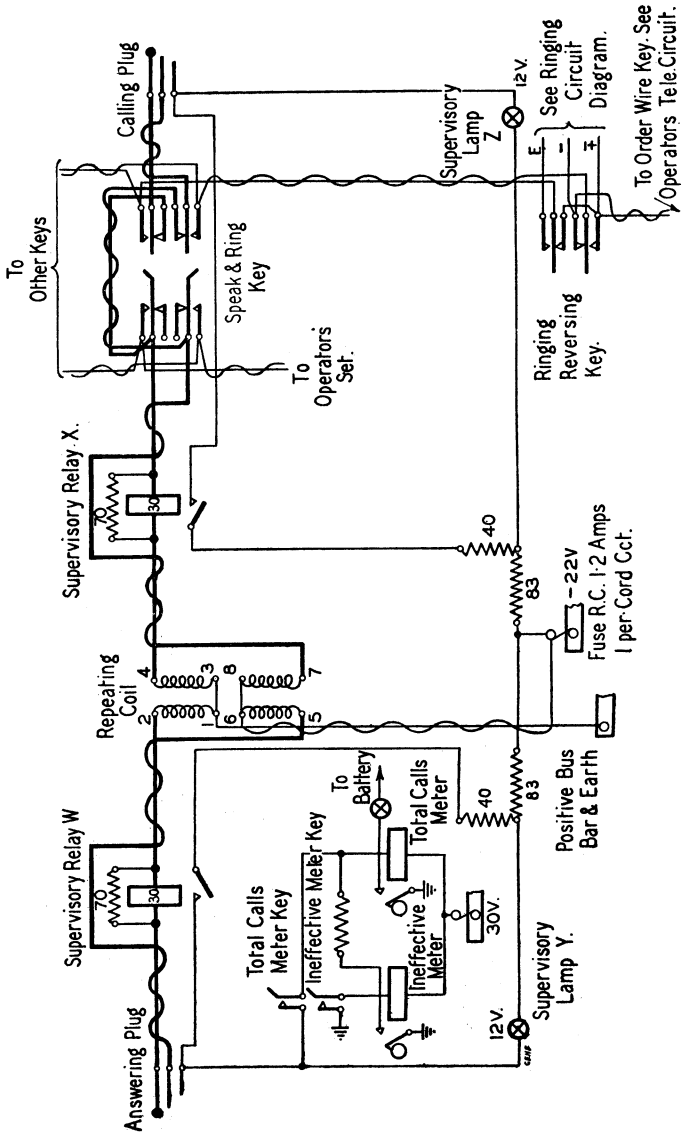
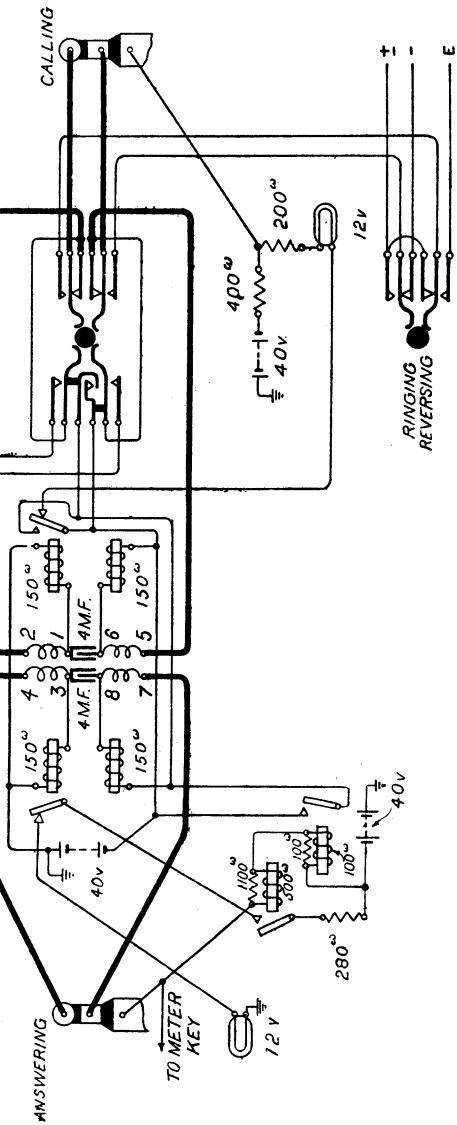


FIG. 2. C.B. Nos. 1 and 10 Exchanges.
Subscribers Cord Circuit and Position Meter Circuit : Repeating Coils 22v.

C.B. Nos. 1 AND 10 EXCHANGES, 40 VOLT SYSTEMS.
JACK-ENDED JUNCTION CORD CIRCUIT WITH 12 VOLT LAMPS.



NOTE.—This relay does not operate when the answering plug is inserted into an incoming junction jack.

Fig. 3.

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 cord circuit in a " Stone " system is similar to the above but, instead of a repeating coil to separate the answering portion from the calling portion, condensers are employed. Retardation coils are also placed in the opposite line to the supervisory relays in order to preserve the balance of the circuit.

The **jack-ended junction cord circuit** shown in Fig. 3 is used for answering and connecting calls on the incoming jack-ended junction position. 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 circuit is similar in action to the subscriber's cord circuit shown in Fig. 2. The supervisory relays are balanced by retardation coils. Instead of being placed in series with the wiring from the plugs to the repeating coil, the supervisory relays are connected across the condenser. This arrangement allows for considerable variation between the impedance of the supervisory relay and the impedance of the retardation coil without destroying the balance of the line. This circuit is, therefore, suitable for working on the longest junction line without introducing noise.

The battery feed to the repeating coil is taken from the 30-volt bus bar, the extra voltage being necessary to overcome the impedance of the apparatus and the additional length of line on a junction circuit.

C B. Nos. 1, 10 AND 12 EXCHANGES.
OPERATOR'S TELEPHONE CIRCUIT ON SUBSCRIBER'S JACK-ENDED JUNCTION, JACK-ENDED TRUNK TESTING AND PLUGGING UP POSITIONS 22 VOLT AND 40 VOLT SYSTEMS.

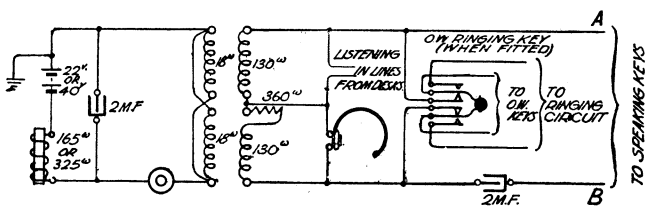


Fig. 4.

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.

The telephone circuit is connected to the outer springs of the cord circuit speaking keys and also to the outer springs of the outgoing order-wire keys (see Fig. 5), the operator, by operating the relative key, can speak on any cord circuit and also on any outgoing order wire.

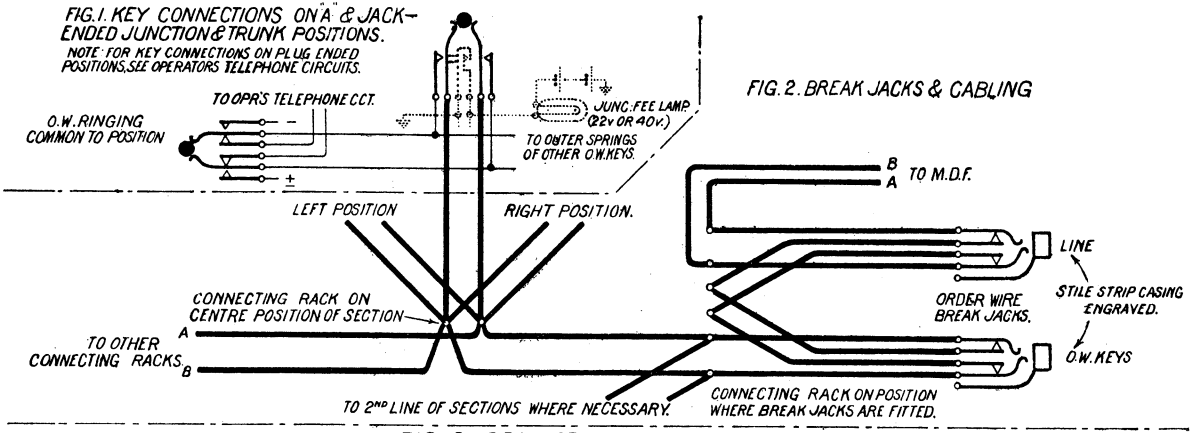
The **outgoing order-wire circuit** is shown in Fig. 5. The order-wire keys are mounted in strips of ten, and are fitted to the left-hand side of each keyboard. The tops of the keys are engraved with the code of the exchange to which each order wire works.

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. 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 section. 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.

C.B. Nos. 1, 10 AND 12 EXCHANGES, 22 VOLT, AND 40 VOLT SYSTEMS OUTGOING ORDER-WIRE CIRCUIT.



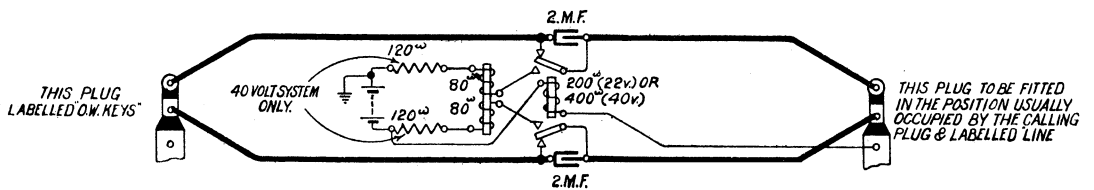


Fig. 5.

C.B. Nos. 1, 10 AND 12 EXCHANGES.
INCOMING, LONG O.W. KEYLESS JUNCTIONS, 22 VOLT SYSTEMS.

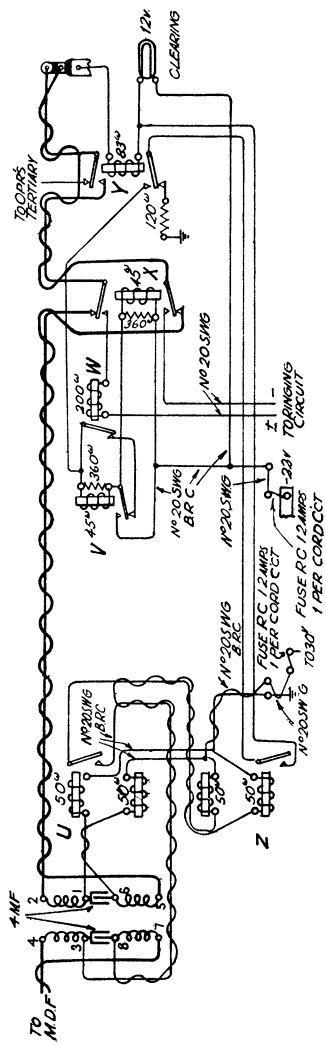


Fig. 6.

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 :—

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 action 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 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 *V* and *W*), 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 short circuits 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 re-inserting 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 contact is broken, thereby removing battery from one side of the clearing lamp and the clearing lamp light. It should be noted that while the plug at the distant end is in the jack the clearing lamp does not glow because both terminals are at the same potential, that is to say, there is battery on both lamp terminals; on one one terminal direct and on the other *viâ* the contacts of relays *Y* and *Z*.

It will also be noticed that the battery feed to the repeating coil is served from the 30-volt battery. This extra voltage is necessary to overcome the impedance of the additional apparatus and the additional length of line on a junction circuit.

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

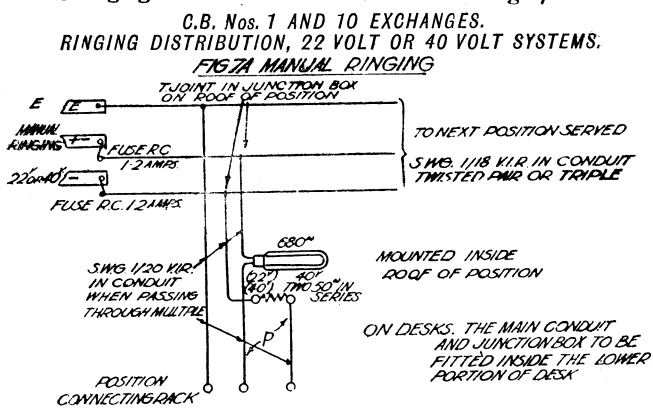


Fig. 7.

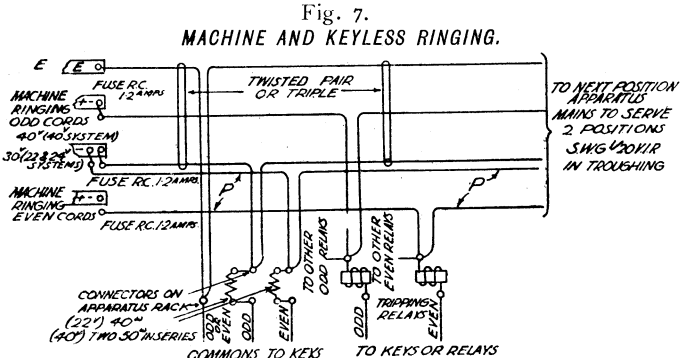


Fig. 7B.

Page 22. *Line* 1. *Delete* operate. *Insert* release.

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 breakdown on one set of leads, the service may be carried on with alternate positions working. One set of leads will serve 18 positions.

The 660w 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 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 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 42-wire switchboard cable. From the same side of the connection strips the two lines and the test are cabled to the multiple jacks with 63 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 jack with 84 wire cable and also to the line and cut-off relays with 84 wire cable.

The subscribers' meters, one for each line, are cabled to the multiple side of the I.D.F. with 21 wire cable.

The battery leads from the fuses on the Fuse Board to the pilot relays on the rear of the switchboard sections and to the pilot lamps are contained in the switchboard cable from the repeating coils to the cord circuits.

The battery leads to the line relays are 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 repeating coil and 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 and sleeve wires from the

supervisory relays are wired to connectors on the connecting rack at the rear of the section and from there they are cabled to the repeating coils with 105 wire switchboard cable.

The operators' position meters are cabled from the meters, which, in a No. 10 Exchange, are usually mounted in the face of the cable turning section, to connectors on the connecting rack of every tenth position with 33 wire cable, and from there they are distributed by means of smaller cables to their respective positions. The battery leads from the Fuse Board are carried direct to the meters with a switchboard cable of 36-lb. wire.

Operator's Telephone Circuits. 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 section 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 section 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 section. The outgoing order wire lines are cabled direct from the Main Frame to the connectors for the break jacks with 42 wire switchboard cable. The connecting cord circuit is fitted on the plug shelf of the position on which the break jacks are located.

Plug-ended Incoming Junction Circuits. 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, there being insufficient space available on the rear of the switchboard. The relays and resistances are placed on the Special Apparatus Rack, the repeating coils and condensers on the Repeating Coil Rack and the fuses on the Fuse Board.

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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