



WS No. 19 Mark III

**This file has been down loaded from
The Wireless-Set-No19 WEB site.**

**All files from this WEB site are free of charge.
If you have been charged for this file then please
contact the person you obtained it from as he/she
has illegally obtained both the file and money they have
charged you.....**

Post Office Engineering Department

**TECHNICAL PAMPHLETS
FOR WORKMEN**

Subject :

**C.B.S. EXCHANGES—NON-MULTIPLE
TYPE.**

ENGINEER-IN-CHIEF'S OFFICE.

1919.

*(Reprinted, March, 1926, including
Correction Slips to date.)*

(Reprinted, March, 1929, including Correction Slips to date.)

LONDON :

PRINTED AND PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE.

To be purchased directly from H.M. STATIONERY OFFICE at the following
addresses :

Adastral House, Kingsway, London, W.C.2 ; 120, George Street, Edinburgh ;
York Street, Manchester ; 1, St. Andrew's Crescent, Cardiff ;
15, Donegal Square West, Belfast ;
or through any Bookseller.

1929.

Price 6d. Net.

43-9999.

=====
LIST OF
=====
Technical Pamphlets for Workmen.
=====

GROUP A.

1. Magnetism and Electricity.
2. Primary Batteries.
3. Technical Terms.
4. Test Boards.
5. Protective Fittings.
6. Measuring and Testing Instruments.
7. Sensitivity of Apparatus.

GROUP B.

1. Elementary Principles of Telegraphy and Systems up to Morse Duplex.
2. Telegraph Concentrators.
3. Wheatstone. Morse Keyboard Perforators.
4. Quadriplex. Telegraph Repeaters, Sx., Dx., and Quad.
5. Hughes Type-printing Telegraph.
6. Baudot Multiplex.
7. Western Electric Multiplex. Murray Multiplex. Other Systems.
8. Fire Alarm Systems.

GROUP C.

1. General Principles of Wireless Transmission and Reception.

GROUP D.

1. Elementary Principles of Telephony.
2. Telephone Transmission. "Loading." Telephone Repeaters and Thermionic Valves.
3. Principles of Telephone Exchange Signalling.
4. Magneto Exchanges—Non-Multiple Type.
5. Magneto Exchanges—Multiple Type.
6. C.B.S. No. 1 Exchanges—Non-Multiple Type.
7. C.B.S. Exchanges—Multiple Type.
8. C.B. Exchanges—No. 9 Type.
9. C.B. Exchanges—No. 10 Type.
10. C.B. Exchanges—No. 12 Type.
11. C.B. Exchanges—22 Volts.
12. C.B. Exchanges—40 Volts.
13. Trunk Telephone Exchanges.
14. Telephone Exchange Maintenance.
15. Telephone Testing Equipment.
16. Routine Testing for Telephone Exchanges.
17. Internal Cabling and Wiring.
18. Distribution Cases, M.D.F. and I.D.F.
19. Cord Repairs.
20. Superposed Circuits, Transformers, etc.
21. Call Offices.

[Continued on page iii of Cover.]

C.B.S. EXCHANGES—NON-MULTIPLE TYPE.**(D. 6.)**

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

- D 8.—Principles of Telephone Exchange Signalling.
 D 7.—C.B.S. Exchanges—Multiple Type.
 D14.—Telephone Exchange Maintenance.
 D15.—Telephone Testing Equipment.
 D16.—Routine Testing for Telephone Exchanges.
 D17.—Internal Cabling and Wiring.
 D18.—Distribution Cases, M.D.F. and I.D.F.
 D19.—Cord Repairs.
 D20.—Superposed Circuits, Transformers, etc.
 F 2.—Subscribers' Apparatus C.B.S.

TABLE OF CONTENTS.

	PAGE.
General Principle	3
Switchboard, Wall, Junction and Local, $\frac{2+4}{10}$...	3
Subscriber's Line Circuit	4
Cord Circuit	5
Junction Circuit	5
Switchboard, Wall, Junction and Local, $\frac{5+20}{45}$...	6
Subscriber's Line Circuit	8
Cord Circuit	8
Junction Circuit	10
Switch Section, Junction and Local, $\frac{20+60}{140}$...	10
Subscriber's Line Circuit	12
Cord Circuit	12
Junction Circuit	12
Junction Working	17
Full Signalling	17
Restricted Signalling	22
Test Cases	29
Batteries	29
Ringin ^g Devices	31
Protection	31
Wiring and Cabling	33

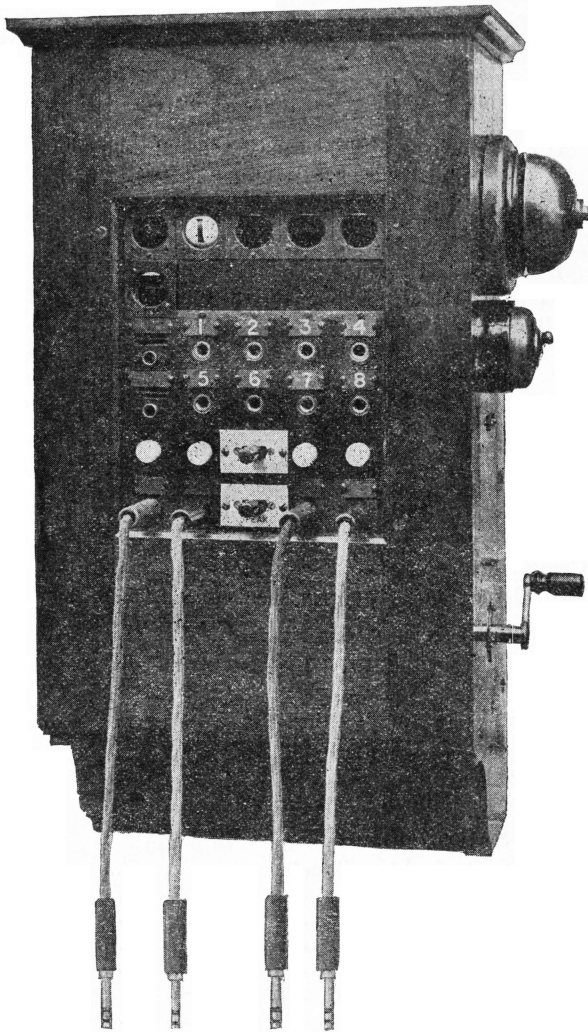


Fig. 1.—Switchboard, Wall, Junction and Local, $\frac{2+4}{10}$

C.B.S. EXCHANGES—NON-MULTIPLE TYPE.

GENERAL PRINCIPLE.

The No. 1 Common Battery Signalling or "C.B.S. No. 1" system is designed to afford all the operating facilities of the Common Battery system in so far as signalling is concerned, but makes use of local batteries at the subscribers' stations to furnish current for the transmitters. The basis of C.B.S. No. 1 Signalling is "loop" call and "earth" clear. When a subscriber removes his receiver from the switchhook to originate or answer a call, the 60^o receiver and the 25^o secondary winding of the induction coil are bridged across the line in series, thus constituting the "calling loop." When the receiver is replaced on the switchhook, this loop is removed and the 250^o magneto bell is connected between the A line and earth. The earthed connection operates the clearing signal at the exchange. The exchange calls the subscriber by applying an earthed ringing current to the A line which rings the earthed bell in the subscriber's telephone. As C.B.S. working is restricted to moderate sized systems the exchange equipment is designed on economic lines, simplicity of circuit arrangements and apparatus being one of the main considerations.

It is usual to limit the use of non-multiple switchboards to exchanges where not more than two operators' positions are required.

SWITCHBOARD, WALL, JUNCTION AND LOCAL, $\frac{2+4}{10}$

This is a wall type double cord switchboard supplied with the equipment shown in Fig. 1 but with capacity and wiring for eight subscribers' lines and two junctions. As this type of board is fitted in small exchanges which are frequently remote from the maintenance centre, loose cords fitted with plugs at both ends are used to enable the operators to change faulty cords and so to avoid the necessity for special visits for this purpose by the maintenance staff. Two such cords constitute one pair of connecting cords. One end of each cord is normally plugged into a jack on the switchboard, leaving the free ends for use in the ordinary manner. These jacks, which take the place of cord fasteners, are seen in Fig. 1 at the bottom of the jack panel. The pair on the left hand side belongs to one connecting cord circuit, and the pair on the right hand side to another. Between the two sets of jacks is a double throw speaking key which connects the operator's set to either pair of cords. Immediately above the jacks are ringing keys, one for each cord, with a

ringing reversing key in the middle for use in connection with party line working. Above these are two strips of jacks. Those numbered 1 to 8 accommodate subscribers' lines and the two unnumbered jacks on the left provide for the termination of two junction lines. A slot indicator is associated with each junction line jack. The subscribers' calling signals (eyeballs) are mounted above, and in alignment with, the subscribers' jacks. The two eyeballs at the extreme left above the junction jacks are associated with the cord circuits. The front of the switchboard is hinged and carries the indicators, jacks, keys, bell and bell switch. The connection strips which link the external to the internal wires, and the remaining items of the switchboard equipment are fixed to the back board and are exposed to view when the switchboard is opened.

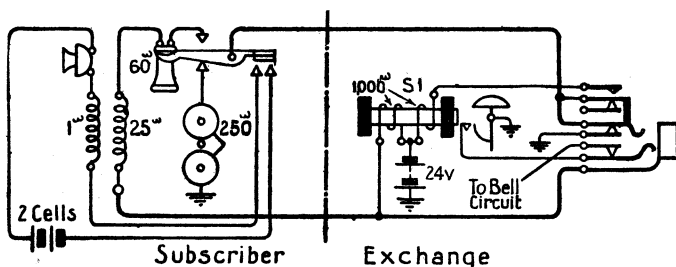


Fig. 2.—Subscriber's Line Circuit, $\frac{2+4}{10}$ Switchboard.

The **Subscriber's Line Circuit** is shown in Fig. 2.* The battery is normally connected to the *B* line through one winding of the 1,000 ω +1,000 ω calling indicator S1, the other winding being disconnected. At the subscriber's end the *A* line is connected through a 250 ω magneto bell to earth and the *B* line is disconnected. When the subscriber lifts his receiver to call the exchange, current flows through one winding of the calling indicator to the *B* line, through the subscriber's induction coil and receiver *via* the top switchhook contact to the *A* line and to earth on the inner spring of the jack at the exchange. This current operates the calling indicator.

When the operator plugs in to answer, the second winding of the indicator is connected to the *A* line *via* the extra contact on the jack. This leaves the line indicator bridged across the line

*Note.—Certain relays, indicators and retardation coils that are identical in Figs. 2, 3, 4, 18, 19 and 20 have been lettered and numbered alike in each figure to avoid confusion.

with its centre point connected to the battery. It remains inoperative in this condition until the subscriber replaces his receiver at the termination of a conversation, when the re-connection of the 250 ω earthed bell to the *A* line causes the indicator to operate. The line indicators thus serve both as calling and as supervisory signals. The *B* line is connected to the bush of the jack in order to leave the normal *B* line spring with its break contact available for controlling the night alarm bell.

The connecting **Cord Circuit** is shown in Fig. 3, and is quite simple and straightforward except in regard to the 1,000 ω eyeball signal *S2*. This is provided primarily to permit of the night bell being actuated by the line indicators when functioning

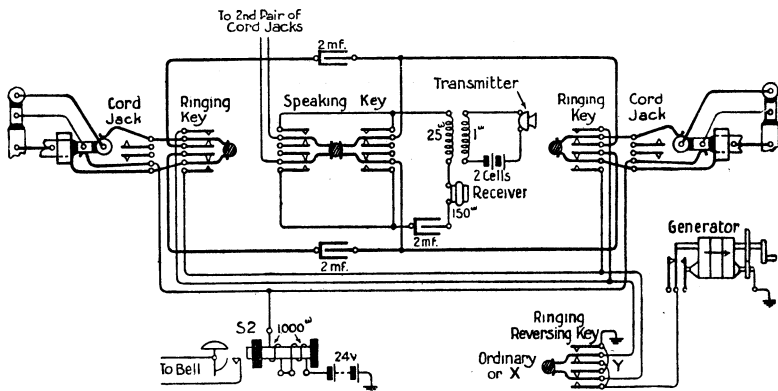


Fig. 3.—Cord and Operator's Circuit, $\frac{2+4}{10}$ Switchboard.

as supervisory signals. As will be seen later, the night bell contacts of the line indicators are necessarily extended *via* the ring conductor of the cords in order to provide for through signalling on junction calls. In these circumstances the line indicator itself does not actuate the night bell, but controls the eyeball signal in the cord circuit which, in turn, completes the night bell circuit. The two sides of the cord circuit are divided for signalling purposes by two 2 m.f. condensers, one in the *A* and one in the *B* line.

The **Junction Circuit** connections are shown in Fig. 4. The jack and the mechanically restored indicator are combined in one fitting and, as in the case of subscribers' lines, the *B* line of the junction is connected to the bush of the jack. The battery is connected to the normal *B* spring of the jack through a 2,000 ω relay *R1*, the function of which is to transmit the clear from a

subscriber to the far end of the junction. The precise manner in which this is effected will be described in detail under Junction Working.

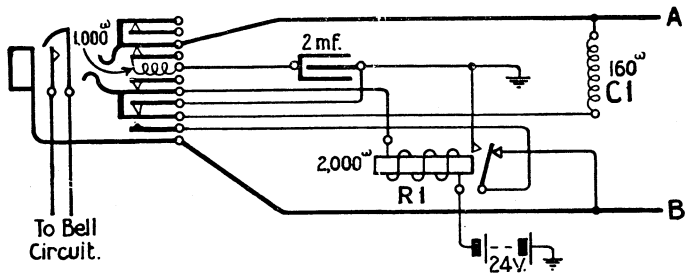


Fig. 4.—Direct Junction Line Termination, $\frac{2+4}{10}$ Switchboard.

Fig. 5 illustrates the circuit conditions when two subscribers on the same exchange are connected through to each other. The operation of the circuits can readily be followed.

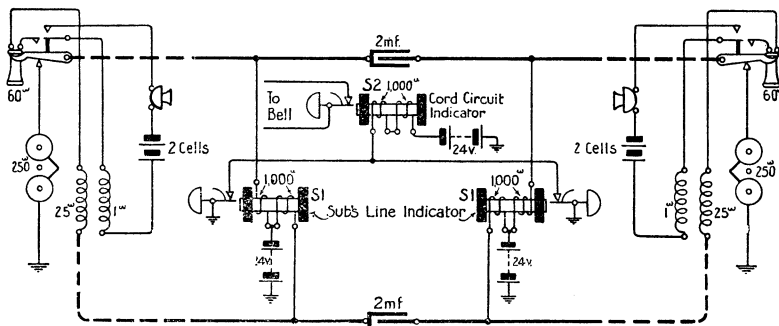


Fig. 5.—Subscriber through to Subscriber, $\frac{2+4}{10}$ Switchboard.

SWITCHBOARD, WALL, JUNCTION AND LOCAL, $\frac{5+20}{45}$

This switchboard (Fig. 6) is equipped for five junction lines and 20 subscribers' lines but is wired for 40 subscribers' lines. The connecting cords are arranged in pairs, terminated on cord fasteners and provided with cord weights in the usual manner. The boards are equipped initially with seven pairs of cords and are wired for ten pairs in all. Immediately above, and in alignment with the pairs of cords, are the speaking and ringing

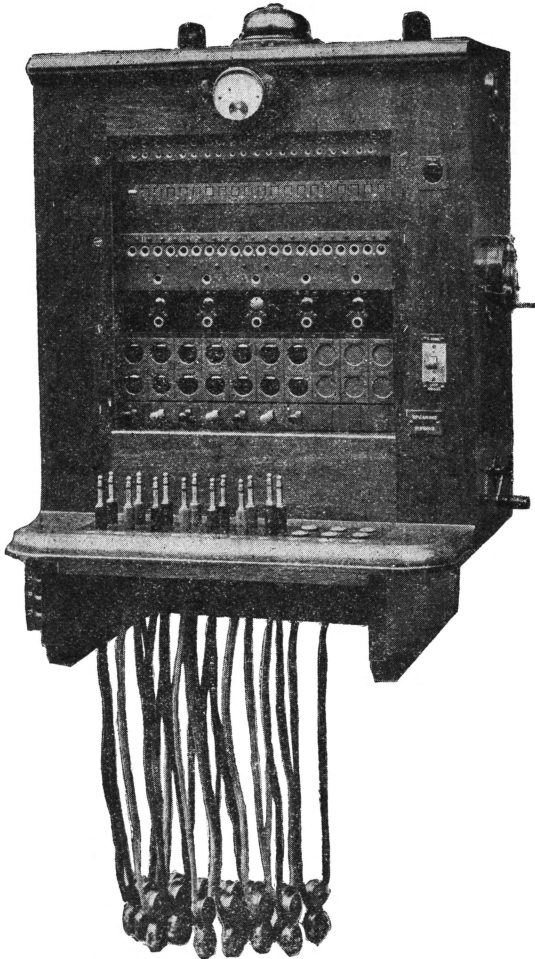


Fig. 6—Switchboard, Wall, Junction and Local, $\frac{5 + 20}{45}$.

keys and the supervisory signals, a pair of the latter (one for the calling and one for the answering cord) being provided for each connecting cord circuit. Above the supervisory signals is a strip of five combined jacks and mechanically restored eyeball signals for terminating incoming junction lines. A further strip of five jacks above these is provided for the accommodation of outgoing junctions. Above these again are fitted the jacks, designation strips and drum signals for subscribers' lines. On the face of the board at the top is mounted a milliampèremeter the function of which will be explained later. The key mounted to the right of the supervisory signals is a ringing reversing key for use in connection with party line ringing. Vertically above this key is the pilot indicator which operates in conjunction with subscribers' and junction calling signals. As in the case of the smaller switchboard previously described, the front of the switchboard, on which the normally visible fittings are mounted, is hinged and the back board carries the remaining items of the equipment.

The **Subscriber's Line Circuit** is shown in Fig. 7. A single coil line indicator is used. This is connected to the inner contacts of the jack so that it is entirely disconnected from the circuit when a plug is inserted. As the supervisory signals are fitted in the cord circuits, there is no need for special connections on the jacks to provide for through signalling on junctions; the *A* and *B* wires of subscribers' lines are therefore connected to the normal tip and ring springs on the jack, and the bush is left unconnected. When a subscriber removes his receiver to call the exchange, the current which operates the calling signal flows from the negative pole of the exchange battery through the milliampèremeter and 1,000 ω signal to the *B* line, through the subscriber's induction coil and receiver, back over the *A* line to earth on the inner springs of the jack. The local contacts on the calling signal complete the pilot indicator circuit, and the local contacts of the latter actuate the day or night alarm bell when required.

The connecting **Cord Circuit** is shown in Fig. 8. The two sides are separated for signalling purposes by two 2 m.f. condensers *K1* and *K2*, and the 1,000 ω +1,000 ω differentially wound eyeball indicators *S3* and *S4* are bridged across the answering and calling cords respectively with their centre points connected to battery. These indicators are operated when the subscriber connected to the relevant cord hangs up his telephone and connects the earthed bell to line. The indicator associated with the answering plug controls the night alarm so that the bell is rung when the calling subscriber hangs up. The local contacts of the signal on the calling plug connect earth through 2,000 ω to the sleeve of the answering plug. This is arranged to provide

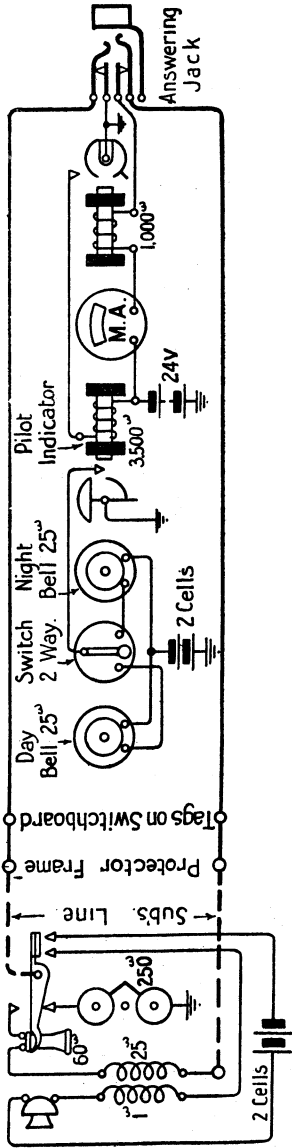


Fig. 7.—Subscriber's Line Circuit, $\frac{5 + 20}{45}$ Switchboard.

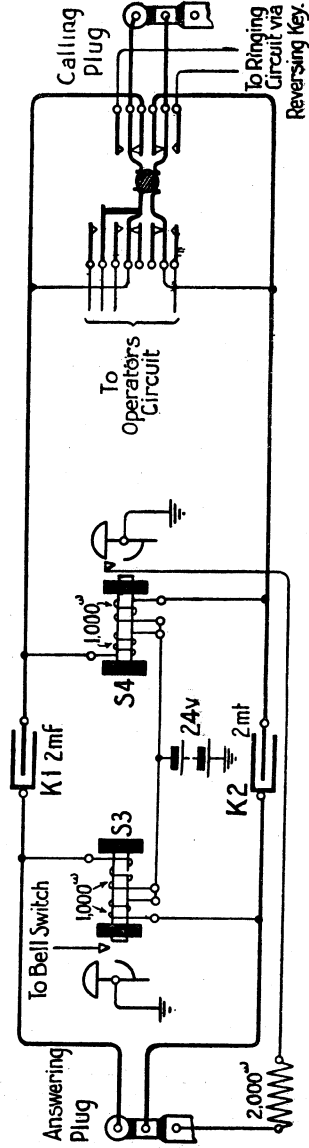


Fig. 8.—Cord Circuit, $\frac{5 + 20}{45}$ Switchboard.

through clearing on junction calls in a manner which will be described later. A ringing key is provided in association with the calling cord only. The speaking key enables the operator to speak or listen to both the calling and called subscriber simultaneously.

Fig. 9 shows the **Junction Circuit** termination consisting of a jack only for outgoing junctions and a combined jack and mechanically restored signal for incoming junctions. This signal is, in essentials, an ordinary drop indicator in which a revolving

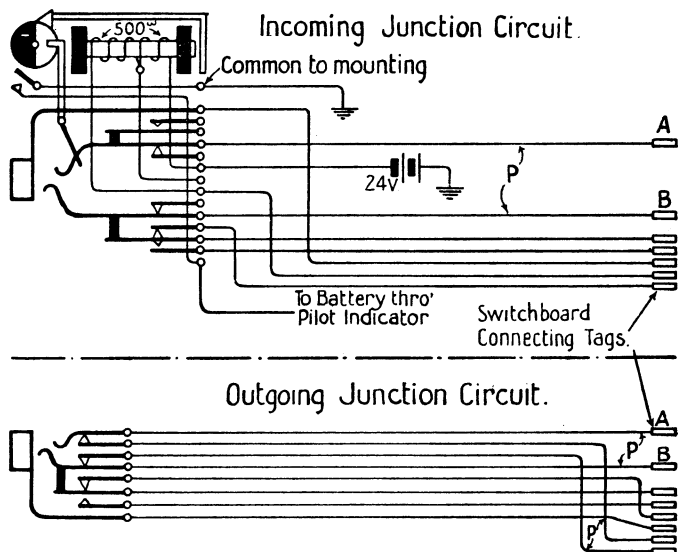


Fig. 9.—Junction Circuits, $\frac{5+20}{45}$ and $\frac{20+60}{140}$ Switchboards.

weighted eyeball replaces the shutter. A projecting tongue on the eyeball permits of the signal being automatically restored by the insertion of a plug in the jack. The operation of the junction circuits will be dealt with in detail later.

SWITCH SECTION, JUNCTION AND LOCAL, $\frac{20+60}{140}$

This is a floor type board supplied with equipment for 20 junction circuits (10 in and 10 out), 60 subscribers' lines and 14 connecting cord circuits. It is illustrated in Fig. 10. Wiring is provided for a total of 120 subscribers' circuits. With the

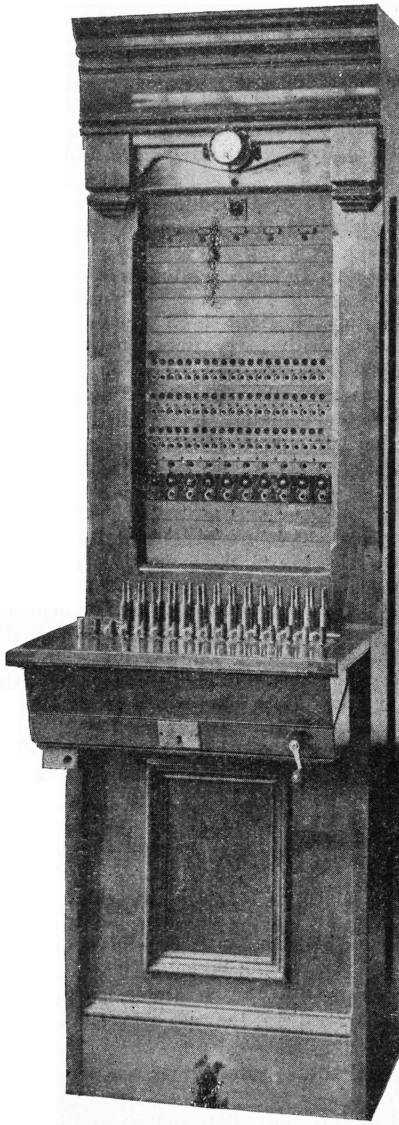


Fig. 10.—Switch Section, Junction and Local, $\frac{20+60}{140}$.

exception of the junction indicators, lamp signals are employed throughout. The cord circuit signals are interposed on the key-shelf between the keys and the cords, each pair of cords, with circuit supervisory lamps and associated speaking and ringing key, being mounted in alignment. The cords are furnished with cord weights and are terminated on cord fasteners in the usual manner.

In addition to the 14 combined speaking and ringing keys, an additional key is fitted at each end of the keyboard. The one on the left is a coupling key which permits of the cord circuits being connected to the operator's circuit on an adjacent section so that one operator can serve two positions during slack periods. The key on the right is a generator reversing key for use in connection with party lines.

The face equipment in the vertical panel commences with a row of combined jacks and mechanically restored signals for incoming junctions. Immediately above these is a strip of 10 jacks for outgoing junctions. This junction equipment is identical with that already described in connection with the $\frac{5+20}{45}$ wall board. Above the junction equipment, alternate strips of 20 jacks and 20 lamps are fitted for subscribers' line terminations. Near the top of the panel is a strip of five jacks provided to accommodate "Cord Test" and other miscellaneous circuits. Above this is the pilot indicator which operates in conjunction with the calling signals (subscribers' and junctions) and the clearing signals on the answering side of the cord circuits. On the top rail a milliampèremeter is fitted and in conjunction with it a lamp jack is provided for testing the current consumption of new lamps before they are substituted for faulty ones on the switchboard. The switch sections have loose slip-in doors at the back which, when removed, expose all the wiring, the rear of the apparatus fitted in the jack panel, the relays, etc. The connection strips are placed on the top of the section behind the cornice. They are enclosed in a box the top and back of which are hinged to afford easy access.

The **Subscriber's Line Circuit** is illustrated in Fig. 11. The circuit arrangements are similar in principle to those shown in Fig. 7 with the exception that a relay and lamp are utilised in place of the drum type calling signal.

The **Cord Circuit**, Fig. 12, is the same as that shown in Fig. 8 except in regard to the use of relays and lamps for supervisory signals.

The **Junction Circuit** terminations are identical with those shown in Fig. 9.

The connections of the pilot indicators, relays, and the milliampèremeter are shown in Fig. 18.

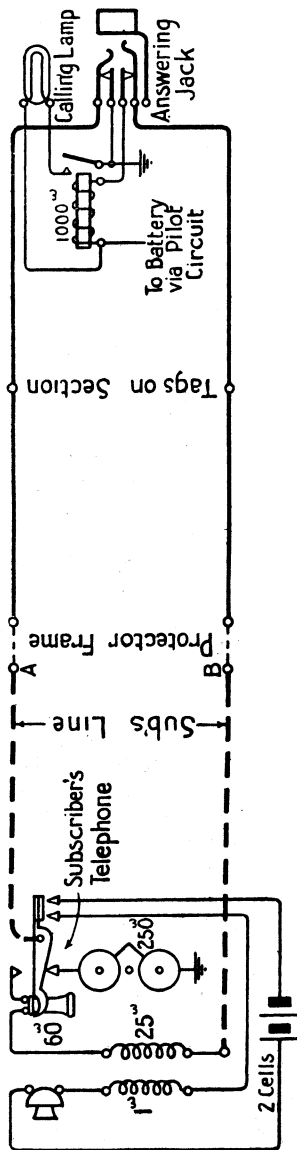


Fig. 11.—Subscriber's Line Circuit, $\frac{20 + 60}{140}$ Switchboard.

Milliampèremeter.—It will be noticed that on all boards except the $\frac{2+4}{10}$ type all battery connections feeding current to subscribers' lines are taken *via* the coils of a milliampèremeter. This instrument is provided to give a visual indication of the state of the insulation of subscribers' lines. The total leakage current on all lines can be read on the milliampèremeter at any time when the board is idle and no subscribers are calling. There will usually be some leakage and, consequently, a deflection on the milliampèremeter. The maximum allowable leakage current per

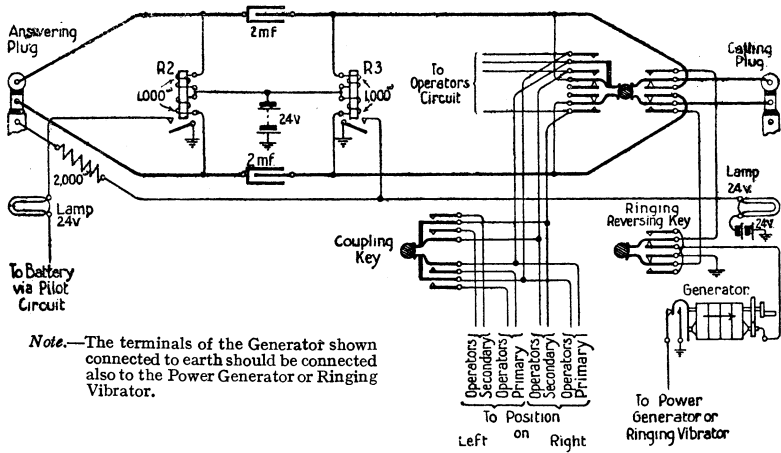


Fig. 12.—Connecting Cord Circuit, $\frac{20+60}{140}$ Switchboard.

mile of open wire (single) is 0.24 m.a. If, therefore, M = the total single wire mileage of open wire on subscribers' circuits connected to the switchboard, the maximum allowable leakage will be $M \times 0.24$ m.a.

The maximum allowable leakage is recorded on the milliampèremeter dial, and the operating staff is instructed to report as a fault any deflection beyond this maximum. Any abnormal leakage can be located to a particular line by plugging into all jacks in succession with an insulated plug and noting at which jack the excess deflection is removed.

Pilot Relays and Indicator.—The section is fitted initially with two pilot relays. One of these is associated with the first sixty subscribers' lines connected to the section, and the other with the supervisory lamps on the answering side of the cord

circuits. The third pilot relay is fitted only when the number of subscribers' lines connected exceeds sixty, and is then associated with the subscribers' lines comprising the group from 61 upwards. Each subscriber's calling relay in a group of 60 is connected in series with the pilot relay common to the group, and the latter is operated by the currents which operate the subscribers' calling relays. The answering supervisory lamps in the cord circuits are connected in series with the cord circuit pilot relay which operates whenever one of those lamps lights up.

The pilot indicator is connected on one side to the battery, and on the other to the local contact of each pilot relay and

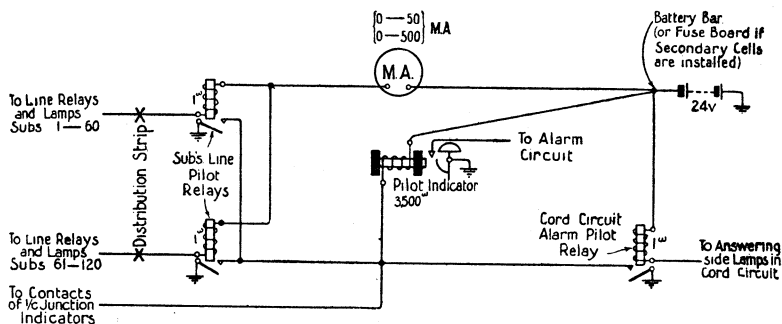


Fig. 13.—Milliampèremeter and Pilot Circuit, $\frac{20 + 60}{140}$ Switchboard.

the local contacts of the incoming junction indicators. The circuit of the indicator is closed whenever the armature of a pilot relay is attracted, or whenever one of the incoming junction indicators is actuated. The circuit in which the alarm bell is included is closed by the armature and contact of the pilot indicator, and the bell therefore rings when the pilot indicator is actuated.

Party Line Circuits are terminated at the exchange on ordinary subscribers' equipment. The connections outside the exchange are shown in principle in Fig. 14. All bells are condensed with the exception of the bell in the last instrument on the "X" side. The condenser is omitted in this case in order to provide an earth for operating the clearing signal at the exchange.

It will be noticed that the earthed bell at the terminal "X" station remains connected to the A line during a conversation from any other station. This, however, does not operate the

clearing signal in the cord circuit at the exchange during conversation since approximately equal currents flow to earth through each winding *viâ* the *A* line and distant "X" station bell in one case, and in the other *viâ* the *B* line, the engaged subscriber's instrument, *A* line and distant "X" station bell. As the signal is wound differentially, the opposing currents of nearly equal magnitude have no operating effect. As soon as the talking station replaces the telephone, current ceases to

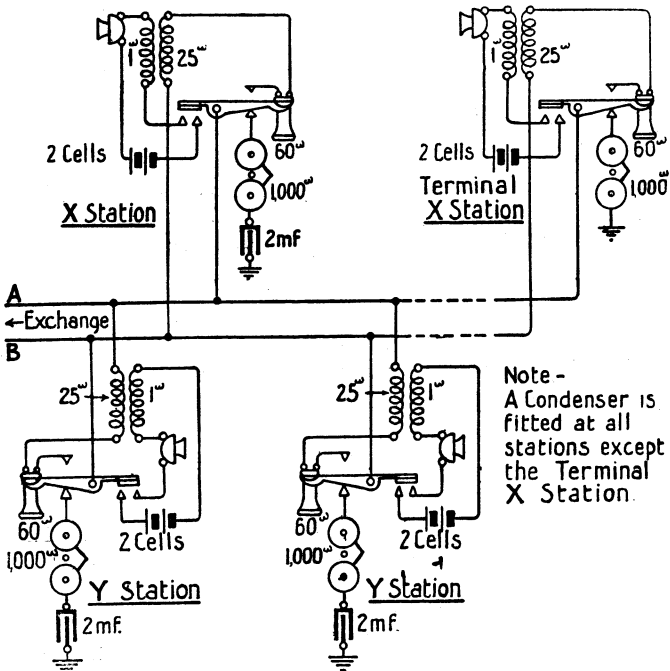


Fig. 14.—Party Line Circuit.

flow along the *B* line and the signal is operated by current in the winding connected to the *A* line. A party line subscriber calls the exchange by removing his telephone and thus looping the line in the same manner as an ordinary subscriber.

Generator calling is adopted on party lines as on ordinary lines. "X" stations are rung in the same way as ordinary subscribers, *i.e.*, by the application of earthed generator to the *A* line; "Y" stations are rung by the exchange applying the

earthed generator to the *B* line and earthing the *A* line. The reversal is effected by the use of the generator reversing key. Code ringing is employed when there is more than one "X" or one "Y" station on a line.

JUNCTION WORKING.

The signalling facilities provided on junction circuits depend on traffic conditions. If the amount of traffic is sufficient fully to occupy a junction during the busy hours, signalling in both directions is effected automatically, but if the amount of traffic is comparatively light, and one or both of the terminal exchanges is small, the signalling facilities are restricted and provide either for magneto working in one direction and automatic signalling in the other or for magneto working in both directions. The differences in the provision made are governed entirely by economic considerations.

The two classes of junctions will be dealt with under the headings of **Full Signalling** and **Restricted Signalling**.

FULL SIGNALLING.

Full Signalling facilities are provided by means of auxiliary apparatus suitable to each type of junction. The auxiliary apparatus is connected in circuit between the external line and the switchboard termination and comprises self-contained units consisting, in each case, of a small wallboard fitted with the requisite items of apparatus.

On all classes of junctions on which full signalling is adopted the circuit arrangements at the distant end are complementary to those provided at a C.B.S. Exchange.

The auxiliary apparatus units fitted at a C.B.S. Exchange are suitable for working to any type of distant exchange except in the case of the unit used on junctions incoming from a magneto exchange where provision is not made for the transmission of subscribers' clearing signals. In the case of the exception referred to, a simplified auxiliary unit is fitted at the C.B.S. Exchange.

In order to understand the operation of the junction apparatus at a C.B.S. Exchange, it is necessary to remember that full signalling is based fundamentally on the following conditions:—

- (1) On the insertion of a plug in an outgoing jack a current flows to the incoming end along the junction *B* line.
- (2) On the insertion of a plug in an incoming jack a current flows to the outgoing end along the junction *A* line.
- (3) When there is a plug in the outgoing jack, the absence of current on the junction *A* line causes a clear to be given at the outgoing end.

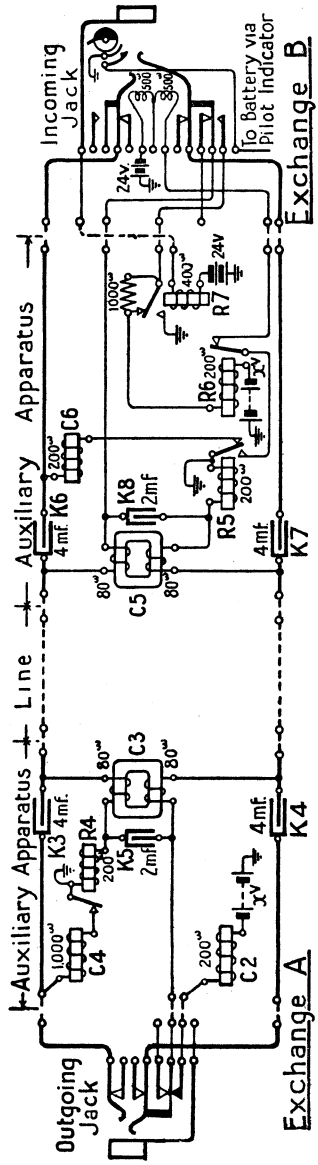


Fig. 15.—One-way Junction between C.B.S. Exchanges.

- (4) When there is a plug in the outgoing jack and the junction is extended to a subscriber at the incoming end, there is no current on the junction *A* line before the subscriber answers and after he has "cleared."

The foregoing conditions apply strictly to junctions between auto signalling exchanges, a magneto exchange equipped with condensers for through signalling being regarded as an exchange of that type in so far as its incoming traffic is concerned. In the case of junctions carrying traffic outgoing from such a magneto exchange to an auto signalling exchange, condition (4) does not apply, and the calling, clearing and supervisory signals on the junctions concerned are controlled by the insertion and withdrawal of plugs in and from the junction jacks respectively by the operators.

The signalling on junctions to magneto exchanges where no provision is made for through signalling will be dealt with after the signalling on junctions to other exchanges has been described.

One-way Junction Circuit.—Fig. 15 shows a junction between two C.B.S. Exchanges. The condensers *K3*, *K4*, *K6* and *K7* are inserted to prevent currents flowing to line from the cord circuits and interfering with the signalling currents on the junction lines. The retardation coils *C3* and *C5*, and condensers *K5* and *K8*, are bridged across the junction in order to afford a means of applying the special junction signalling currents with a minimum loss of speaking efficiency. The type of coil used contains a large quantity of iron and offers a very high impedance to speaking current, although each winding has only 80 Ω resistance. The combination of high impedance coils and bridged condenser preserves the electrical balance of the lines.

Operation of Signals on a One-way Junction.—Figs. 7, 8 and 15 will be referred to in tracing the currents by which the different signals are operated. Assume that a subscriber on a C.B.S. Exchange (*A*) requires a subscriber on a C.B.S. Exchange (*B*). Fig. 7 shows the connections of the subscribers' circuits, Fig. 8 the cord circuits, and Fig. 15 the junction circuit connecting the two exchanges. The subscriber (Fig. 7) on Exchange *A* calls, and the operator inserts the answering plug of a pair of cords (Fig. 8) in the subscriber's line jack. Having ascertained the requirements, the operator inserts the calling plug (Fig. 8) in the outgoing junction jack (Fig. 15). The indicator *S4* (Fig. 8) associated with the calling plug operates because a current flows through one of its coils and the coil *C4* (Fig. 15) to earth. A current also flows through the coil *C2* and one winding of the retardation coil *C3* to the "B" line of the junction, thence, at the incoming end, through one winding of the retardation coil *C5* and the relay *R5* to earth.

Relay *R5* operates and closes the circuit of the battery connected to the calling indicator, which consequently displays a calling signal. The operator at Exchange *B* replies to the call by inserting an answering plug (Fig. 8) in the incoming jack (Fig. 15). A current then flows through relay *R6*, one winding of retardation coil *C5*, "A" line, one winding of retardation coil *C3* and relay *R4* to earth. Relay *R6* operates, and the current through the indicator coil ceases. The visual signal is mechanically restored by the plug as it passes into the jack. Relay *R4* also operates, and the indicator *S4* on the calling cord (Fig. 8) at the outgoing end restores, thus informing the operator at Exchange *A* that Exchange *B* has answered. The operator at Exchange *B*, having ascertained the number of the wanted subscriber, places the calling plug (Fig. 8) in the line jack (Fig. 7) of that subscriber and rings. The indicator *S4* associated with the calling plug operates (except while ringing is taking place) until the subscriber answers, and during this period a current flows through relay *R7* (Fig. 15) and the 2,000^Ω resistance and local contact of indicator *S4* (Fig. 8) to earth. Relay *R7* operates, and its armature earths the signalling lead connected with the junction "A" line, preventing any current from the earthed battery *x* associated with relay *R6* from passing that point. Relay *R6* (Fig. 15) remains operated under these conditions and the disconnection of the calling indicator coil is maintained, but relay *R4* at the outgoing end is de-energised and the indicator *S4* (Fig. 8) at Exchange *A* is operated. When the called subscriber replies, indicator *S4* (Fig. 8) at Exchange *B* restores and relay *R7* (Fig. 15) is de-energised. A current again flows *via* relay *R6* over the "A" line, and relay *R4* is again operated, thus causing the supervisory indicator *S4* on the calling cords at Exchange *A* to restore. The call is now established.

The conversation having terminated, the two subscribers hang up their receivers, and the conditions are then as follows:—

(a) A clearing signal and a supervisory signal appear on the cords at Exchange *A*.

(b) A supervisory signal appears on the calling side of the cords at Exchange *B*.

The operator at Exchange *A* withdraws both plugs to clear the connection. Current no longer flows over the junction "B" line and the armature of relay *R5* (Fig. 15) falls back, thus causing the clearing indicator *S3* (Fig. 8) on the answering cord at Exchange *B* to operate, the current through the indicator reaching earth *via* the coil *C6* and the armature of relay *R5* (Fig. 15). The operator at Exchange *B* withdraws both plugs to clear the connection.

The 200^Ω relays in Fig. 15 should work well with 11½ m.a. and the 400^Ω relay with 8 m.a.

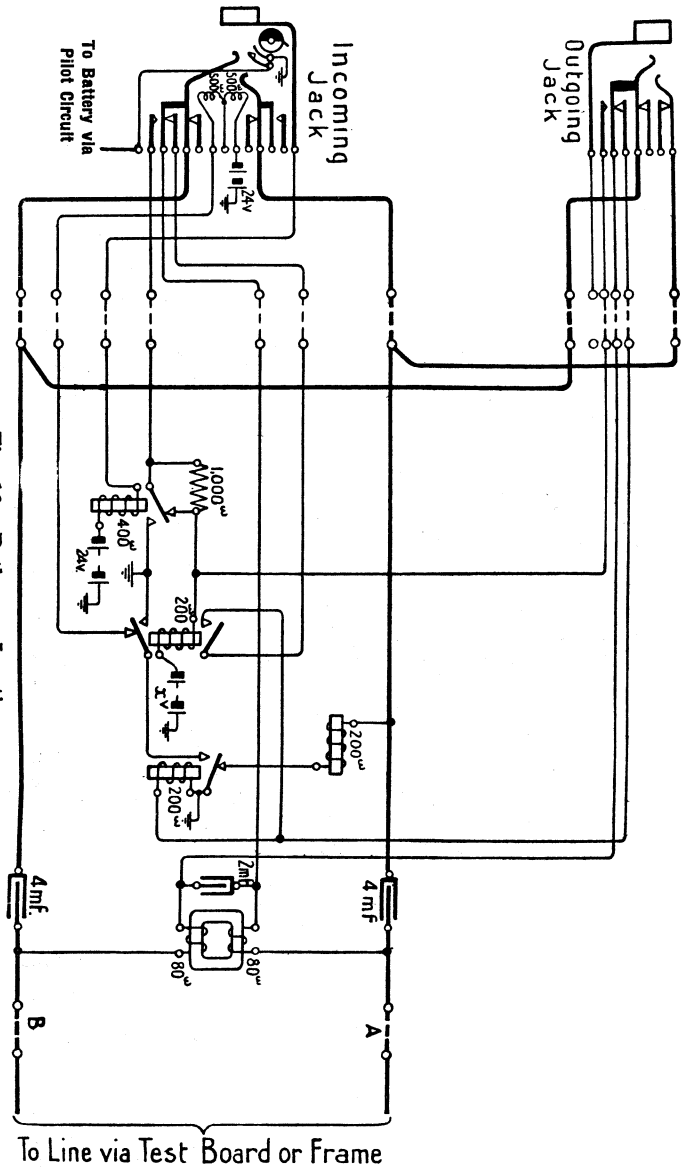


Fig. 16.—Both-way Junction.

To Line via Test Board or Frame

Both-way Junction.—This type of circuit is arranged to carry both inward and outward traffic. The circuit arrangement at one end of such a junction is shown in Fig. 16. The apparatus combines the functions of the equipment at the outgoing and incoming ends of the circuit shown in Fig. 15, and the principles of operation are identical.

SIGNALLING ON JUNCTIONS TO MAGNETO EXCHANGES WHERE NO PROVISION IS MADE FOR THROUGH SIGNALLING.

One-way Junctions outgoing at C.B.S. Exchanges and Both-way Junctions.—The circuit arrangements at C.B.S. exchanges are as shown by Fig. 15 (outgoing end) and Fig. 16. The signalling in each case is on precisely similar lines to that previously described, except that a subscriber connected to the line at the incoming end does not clear through to the outgoing end and, consequently, the signalling depends solely on the insertion and withdrawal of plugs at the outgoing and incoming ends of a junction.

One-way Junctions incoming at a C.B.S. Exchange.—The circuit arrangements are illustrated by Fig. 17. When the magneto exchange operator inserts a plug in the outgoing jack, battery is connected to the *B* line *via* coil *C7* and one winding of the retardation coil *C8*. The resulting current passes to earth at the C.B.S. Exchange *via* one winding of the retardation coil *C9* and relay *R8*, operating the latter and closing the circuit of the calling signal. When an answering plug is inserted at the C.B.S. Exchange in the incoming jack, the calling signal circuit is cut by the action of the jack springs, but relay *R8* remains operated. On the completion of a call the withdrawal of the plug from the junction jack at the magneto exchange releases relay *R8* and a clearing signal is displayed on the C.B.S. Exchange operator's cord circuit owing to the restoration of the earth connection on coil *C10*.

RESTRICTED SIGNALLING.

Although the physical composition of junctions connecting small subsidiary exchanges to other exchanges may admit of full automatic signalling being provided, simplified and less expensive arrangements are adequate in dealing with the comparatively small amount of traffic involved. The equipment and operation are based on the principles of C.B.S. subscribers' circuits. On a direct junction between two exchanges the equipment of the circuit reproduces the conditions that obtain on a subscriber's direct exchange line. On a multi-office line connecting several exchanges to an automatic signalling exchange, the conditions are similar to those of a subscriber's party line. At a C.B.S.

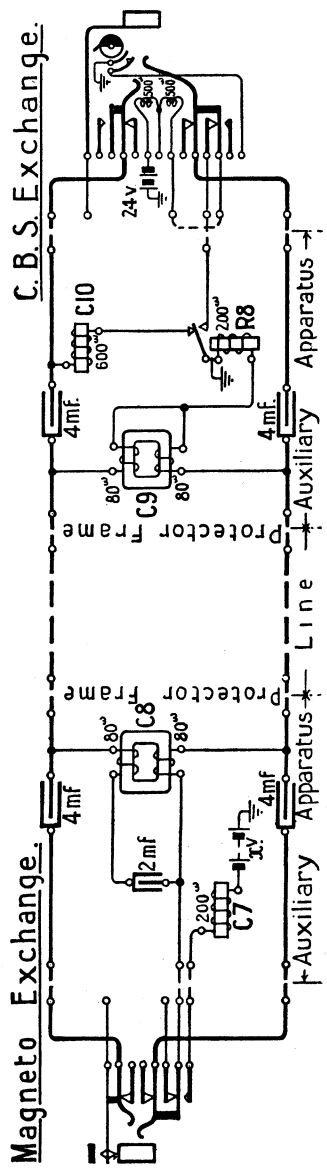


Fig. 17.—Junction Circuit incoming at C.B.S. Exchange from Magneto Exchange not provided with through signalling facilities.

exchange through which subsidiary exchanges obtain connection to the general telephone system, the switchboard would be one of the standard C.B.S. switchboards shown in Fig. 6 or 10. The junction, whether a direct or a multi-office line, would be terminated on an incoming junction jack arranged to function like the equipment on a subscriber's exchange line, or actually on that type of equipment, and the cord circuit shown in Fig. 8 or Fig. 12 would be used for junction calls. At a C.B. exchange the termination of the junction would be similar.

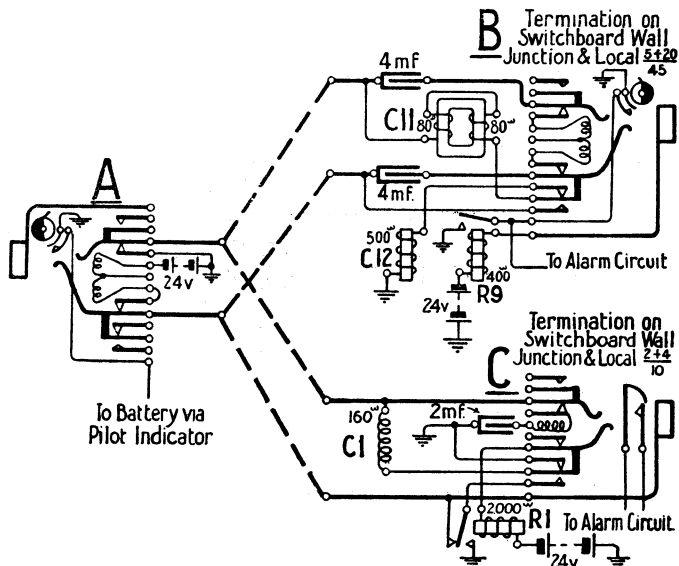


Fig. 18.—Direct Automatic Calling Junction with limited signalling facilities between two C.B.S. Exchanges.

A subsidiary exchange will usually be equipped with a Switchboard, Wall, Junction and Local $\frac{2+4}{10}$ or $\frac{5+20}{45}$. On the former the junction would be terminated on an incoming junction jack. On the latter a direct junction would be terminated on an incoming junction jack and a multi-office line on an outgoing junction jack. In each case certain items of auxiliary apparatus would be associated with the junction.

Fig. 18 illustrates the **Circuit Arrangements on a Direct Junction** from a main C.B.S. Exchange A to a subsidiary exchange B or C.

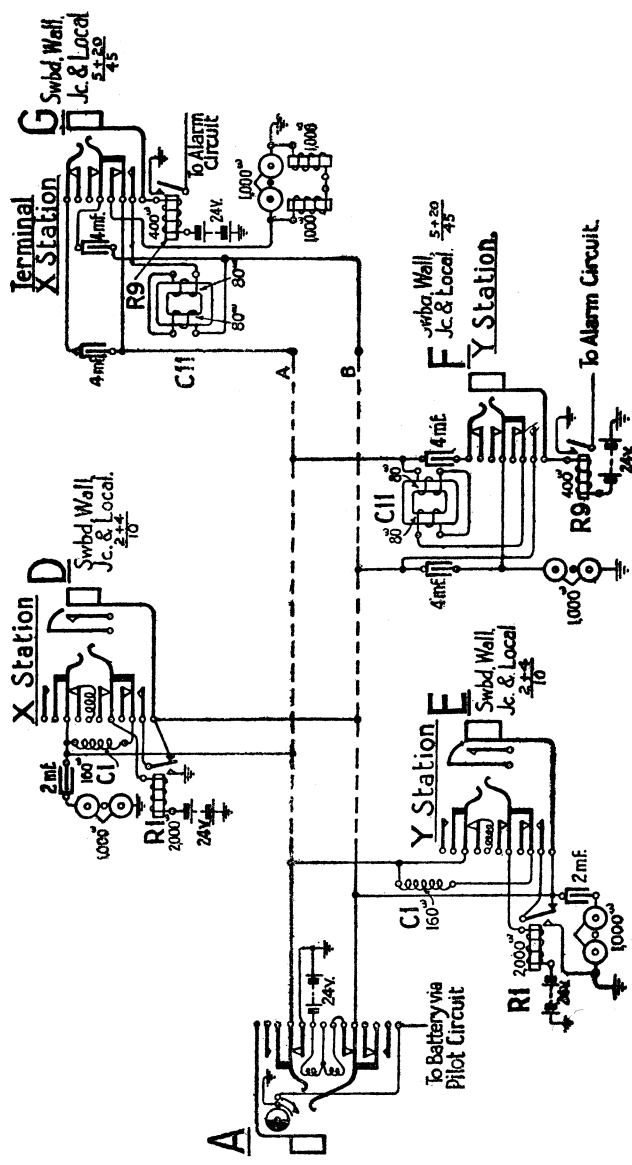


Fig. 19.—Multi-office Junction.

Fig. 19 illustrates the **Circuit Arrangements on a Multi-Office Line** connecting subsidiary exchanges *D*, *E*, *F*, and *G* to a main C.B.S. exchange *A*. The exchange most distant electrically from exchange *A* is made a terminal *X* station, and there the earthed bell is shunted by a 2,000 Ω resistance to ensure satisfactory clearing signals at the main exchange. The explanation given previously (page 15) in respect of subscribers' party lines also applies to multi-office junctions of this type, and it is only necessary to add that intercommunication between the subsidiary exchanges is obtained through the medium of the operator at exchange *A*, who, on request, rings the wanted exchange. This practice is, of course, in conformity with that which obtains on subscribers' party lines.

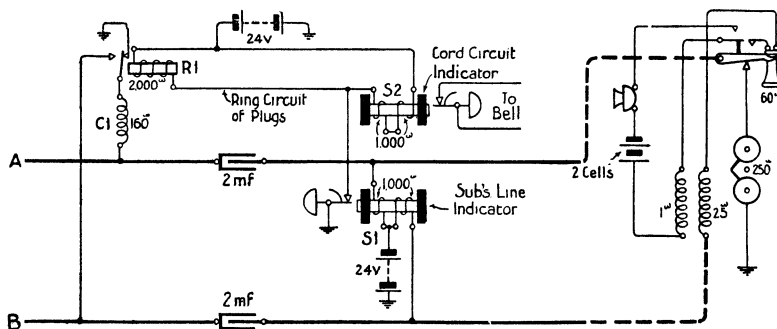


Fig. 20.—Subscriber through to Junction on $\frac{2+4}{10}$ Switchboard.

The circuit arrangements shown at *C* (Fig. 18) and *D* and *E* (Fig. 19) are those which are provided on Switchboards, Wall, Junction and Local $\frac{2+4}{10}$, and those at *B* (Fig. 18) and *F* and *G*

(Fig. 19) on Switchboards, Wall, Junction and Local $\frac{5+20}{45}$

On the former type of switchboard the cord circuit shown in Fig. 3 is used for junction calls, and the connection of a subscriber to a junction on that type of switchboard is illustrated by Fig. 20. On the latter type of switchboard the standard cord circuit shown by Fig. 8 is used to complete junction calls. The relay *R9* (Figs. 18 and 19) connected to the bush of the junction jack provides for an audible alarm signal at the finish of an inward call.

The signalling over the direct or multi-office type of junction at present under consideration is as follows:—

- (a) The main exchange calls the subsidiary exchange by applying an earthed generator to one of the lines and earthing the other line. In the case of a direct line the generator is applied to the *A* line, and in that of the multi-office line to the *A* or *B* line according to the “X” or “Y” termination of the circuit at the exchange required.
- (b) The subsidiary exchange calls the main exchange by looping the *A* and *B* lines when a plug is inserted in the junction jack through coil *C1* (Figs. 4, 18 and 19) or coil *C11* (Figs. 18 and 19) as the case may be.
- (c) The main exchange does not give a clearing signal to the subsidiary exchange.
- (d) The main exchange operator disconnects on the appearance of a clearing signal on both the local and junction sides of the cord circuit used for the completion of a junction call.
- (e) The subsidiary exchange operator disconnects on receiving the local subscriber's clearing signal whether the call be inward or outward.
- (f) In the case of a junction terminating on a Switchboard, Wall, Junction and Local, $\frac{2+4}{10}$, a subscriber connected thereto, in addition to giving a local clearing signal, also gives a through clearing signal to the main exchange. The manner in which this is effected is as follows:—

When the subscriber hangs up his receiver his line indicator *S1* (Figs. 2 and 20) is operated. The local contacts of this indicator complete the circuit of the cord circuit indicator *S2* (Figs. 3 and 20) and of the junction relay *R1* (Figs. 4, 18, 19 and 20). The operation of indicator *S2* causes the alarm bell to ring, and on the operation of relay *R1*, coil *C1* (Figs. 4, 18, 19 and 20) is earthed and disconnected from the junction “B” line. The application of earth *viâ* coil *C1* to the junction “A” line in the case of junctions terminated in a main C.B.S. exchange causes indicator *S3* or *S4* (Fig. 8) or relay *R2* or *R3* (Fig. 12) to operate according as the call is inward or outward at the main exchange and the clearing signal to be given to the operator there.

If the main exchange operator clears before the operator at the subsidiary exchange, a false calling

signal is not received at the main exchange as long as relay *R1* (Figs. 4, 18, 19 and 20) remains operated.

If the subsidiary exchange operator disconnects first, the through clearing signal on the cord circuit at the main exchange persists. This is provided for on a direct junction by the earthing of the coil *C1* (Figs. 4, 18, and 20) on the withdrawal of the plug from the junction jack, and on a multi-office line by the earthed bell at the terminal "X" station (Fig. 19).

- (g) In the case of a junction terminating at a subsidiary exchange on a Switchboard, Wall, Junction and Local $\frac{5+20}{45}$, a junction clearing signal is given to the main exchange on the withdrawal of the plug from the junction jack at the subsidiary exchange. This is provided for on a direct junction (Fig. 18) by the disconnection of coil *C11* from the "B" line and the connection of earth to the "A" line *via* coil *C12*, the springs of the junction jack and coil *C11*, and on a multi-office line by the earthed bell at the terminal "X" station (Fig. 19). While the main exchange operator may withdraw a plug from a local subscriber's jack on the receipt of the subscriber's clearing signal she should not withdraw from the junction jack before the subsidiary exchange operator has given the clearing signal as, otherwise, a false calling signal would result.
- (h) Should the main exchange be C.B., the clearing signal is dependent on the disconnection of coil *C1* in the case of the $\frac{2+4}{10}$ board (or *C11* in the case of the $\frac{5+20}{45}$ board) from the junction "B" line. The earthing of the "A" line plays no essential part in the operation of the clearing signal.

Transformer Circuits.—Automatic signalling facilities of any kind cannot be economically provided on junctions which are superposed or partly superposed on other circuits by means of transformers or repeating coils. In the great majority of cases superposed junctions connect several small exchanges to a larger exchange. Such circuits, whether direct or multi-office, are arranged for magneto working. They are worked in both directions and terminate in the more important exchange on an indicator jack joined up for the receipt of magneto rings. Magneto apparatus is fitted at the small exchanges and calling is effected by generator code rings.

TEST CASES.

A Test Case for the accommodation of junction and other important lines is provided at C.B.S. Non-Multiple exchanges if the number and the character of the circuits justify its provision.

The test cases used are known as *Case, Test, D 1930* $\frac{10}{20}$, and *Case, Test, D 1930* $\frac{20}{40}$. Both are described, and their purpose explained in Technical Pamphlet P.W.—A4. It is necessary to state, however, that in future batteries will not be connected to these test cases and the facilities for battery testing will therefore be omitted.

BATTERIES.

Each C.B.S. exchange is equipped with a Common Main "Working" battery to supply current for signalling purposes on subscribers' and junction lines. A reserve battery is usually installed except at the smallest class of exchange equipped with a 10-line board.

The size and type of battery depend on the daily current consumption at the exchange concerned. Secondary cells are used only at the larger non-multiple exchanges, and as their provision is exceptional only primary cell installations are treated in this pamphlet.

At each exchange where primary cells are installed the "Working" Main Battery consists of 20 Leclanché cells in series. Where the current consumption is large two or more such 20-cell sets are joined in parallel.

At exchanges equipped with the $\frac{2+4}{10}$ type of switchboard, one set of 20 cells, Leclanché No. 2A is provided. At the larger exchanges cells, Leclanché No. 1 or No. 0 are used according to the current requirements.

"Reserve" Main Batteries consist of one set of 20 cells of the same type as the "Working" battery, or of one set of 20 cells, Dry Z, if the "Working" battery comprises more than two sets of cells, Leclanché No. 0.

The "Working" Main Battery is used continuously, and the "Reserve" is held available for use in the case of a temporary breakdown of the "Working" battery. Both batteries are connected to the exchange *via* a two-way switch fixed on the switchboard in order that an operator may change over from the "Working" to the "Reserve" battery in an emergency.

Where secondary cells are provided the full voltage of the battery, nominally 22 volts, is used for signalling on junctions.

In the case of primary cells, however, the cost per unit of energy is considerable, and it may be economical to provide means for reducing the voltage on the junction circuits to a value which is just adequate to meet the working requirements of the apparatus at each end. The reduced voltage limits the current to the actual requirement and avoids an unnecessary drain on the expensive primary batteries. This reduction of voltage is accomplished by connecting a battery of five small secondary cells in opposition to the main battery. From these individual

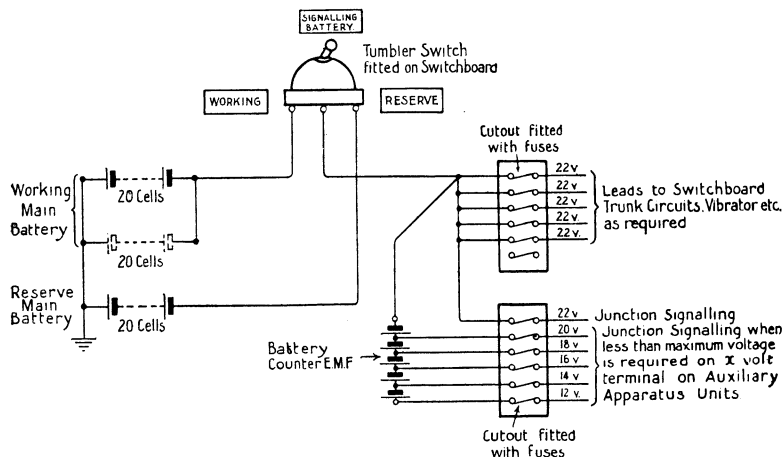


Fig. 21.—Distribution from Primary Main Batteries.

“counter E.M.F.” cells, taps can be taken off at voltages of 12, 14, 16, 18, or 20, whichever is suitable for the junctions concerned.

Fig. 21 illustrates the provisions made for the distribution of power from the Main Batteries.

The Battery, Counter E.M.F., and Fuses are placed in the switchroom.

In addition to the Main Batteries several small Batteries are provided to supply current for various individual circuits as follows:—

Operators' speaking	2 cells Leclanché No. 1.
Operators' reserve speaking	...	„	„
Alarm Bell circuit	...	„	„
For driving Vibrator (if provided)	5 cells,	Dry Z.	

RINGING DEVICES.

Each switchboard or switch section is equipped with a hand generator. On switchboards of the wall type this suffices to meet the ringing requirements, but on switch sections traffic conditions may make it necessary to provide the operator with means of ringing automatically on throwing the ringing key of a cord circuit. In these cases it is usual to instal a ringing vibrator which is connected to the cord circuit ringing keys *via* the ringing reversing key (*see* Fig. 12).

A description of the ringing vibrators used will be found in pamphlet G.2—Power Plant for Telegraph and Telephone Purposes.

When a vibrator is provided a hand generator is employed for ringing on trunk circuits and for use when the vibrator is suspended during slack periods.

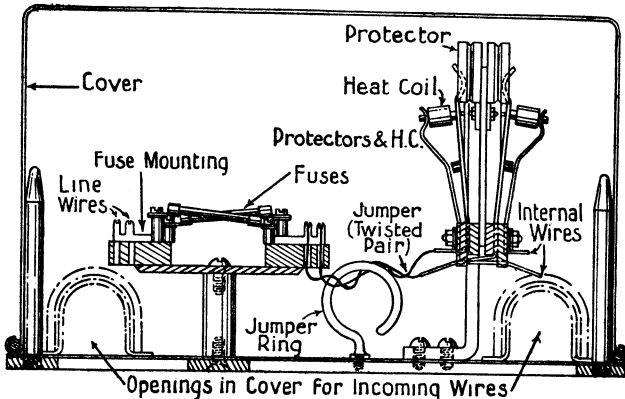


Fig. 22.—Protector, H.C. & F. $\frac{40}{40}$ and $\frac{N}{80}$. View showing connection from Fuses to Protectors.

PROTECTION.

Each line entering an exchange has a protector connected to it near the point of entry to prevent damage by lightning, and at each exchange where lines liable to contact with power wires enter and terminate, the *A* and *B* lines of each circuit are connected to a fuse and heat coil in addition to the protector. "Through" circuits which enter an exchange at an intermediate point for testing purposes are equipped with fuses and protectors only. Various types of fittings are provided for mounting the protectors, fuses, and heat coils, and the type used at any exchange depends upon the number of circuits entering it. The

subject of protective appliances is dealt with in Technical Pamphlets P.W. A5 and D18. The type of fitting used at exchanges of various sizes is given in the following table:—

<i>Ultimate Number of Circuits (loops), including Spares, entering exchange.</i>	<i>Protector Mounting used.</i>	<i>Protective Fitting used.</i>
Not exceeding 3	Protectors, H. C. & F., $\frac{2}{2}$	Protectors, Heat Coils and Fuses, included in mounting.
From 4 to 10 ..	Protectors, H. C. & F., $\frac{0}{10}$ or $\frac{0}{20}$	Protectors, H. C. & F., No. 201.
From 11 to 20 ..	Protectors, H. C. & F., $\frac{40}{40}$	Fuse mounting, No. 4002 and Fuses, Protectors, H. C. & F., No. 40B.
From 21 to 40 ..	“ “ $\frac{N}{80}$	} <i>If wall type switch-board:—</i> Fuse mounting No. 4002 and Fuses, Protectors, H. C. & F., No. 40B. <i>If floor type switch-board:—</i> Protectors, H. C. & Test, No. 40B.
From 41 to 80 ..	(two “ as “ and when required)	
From 81 to 120 ..	Frames, M.D. $\frac{0}{240}$	} Fuse mounting No. 4002 and Fuses, Protectors, H. C. & Test No. 40B.
From 121 to 360 where economy in floor space is desirable.	(up “ “ “ units)	
Exceeding 360, or in cases where number exceeds 120 if ample floor space is available.	Frames, M.D. $\frac{0}{480}$	

Protectors H. C. & F. $\frac{0}{10}$ or $\frac{0}{20}$ fitted with Protectors H. C. & F. No. 201 accommodate respectively five and ten circuits, and are practically larger editions of the Protector H. C. & F. $\frac{2}{2}$ illustrated in Technical Pamphlet P.W. A5.

The equipment of one circuit on Protectors H. C. & F. $\frac{40}{80}$ and $\frac{N}{80}$ is illustrated by Fig. 22.

The Protector H. C. & Test No. 40B (Fig. 23) is for use at exchanges where improved facilities are required for the division of circuits, for testing purposes, at the point of junction between the external and internal wires.

If Figs. 22 and 23 be compared, it will be seen that extra springs are provided on the Protector H. C. & Test. These springs enable a testing plug connected to an M.D.F. Testing set (such as is illustrated in Fig. 3 of Technical Pamphlet P.W.-D7) to be inserted without affecting the continuity of the circuit under test.

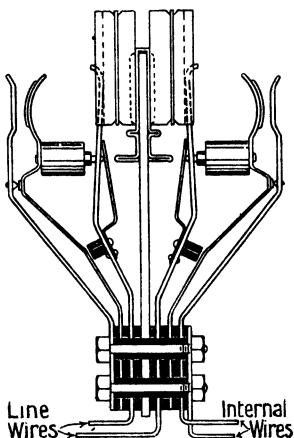


Fig. 23.—Protector, Heat Coil and Test.

WIRING AND CABLING.

Fig. 24 illustrates the cabling scheme at a larger C.B.S. Non-multiple exchange where a Test Case is installed.

The internal wiring between the M.D.F. and the Switchboard would consist of switchboard cables run overhead and supported on brackets. Similar cables would also be used between the M.D.F. and the Switchboard for the circuits connected *via* the Test Case and these, too, would be run overhead. The lead covered cables or wires used for battery leads are either supported on the brackets carrying the switchboard cables or are secured to the walls.

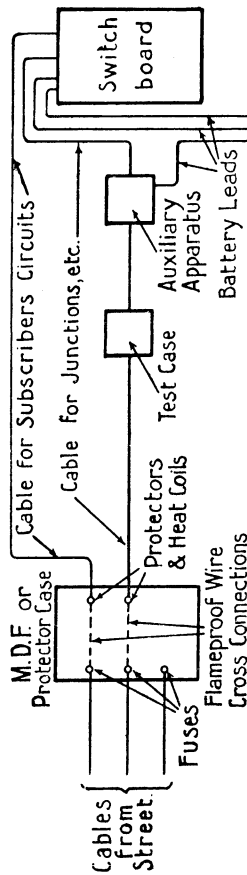


Fig. 24.—Wiring Scheme.

— LIST OF —
Technical Pamphlets for Workmen.

(Continued.)

GROUP E.

1. Automatic Telephony. Step by Step Systems.
2. Automatic Telephony. Coder Call Indicator (C.C.I.) Working.
3. Automatic Telephony. Keysending "B" positions

GROUP F.

1. Subscribers' Apparatus C.B.
2. Subscribers' Apparatus C.B.S.
3. Subscribers' Apparatus Magneto.
4. Private Branch Exchange—C.B.
5. Private Branch Exchange—C.B. Multiple, No. 9.
6. Private Branch Exchange—Magneto.
7. House Telephones.
8. Wiring of Subscribers' Premises.

GROUP G.

1. Secondary Cells, Maintenance of.
2. Power Plant for Telegraph and Telephone Purposes.
3. Maintenance of Power Plant for Telegraph and Telephone Purposes.
4. Telegraph Battery Power Distribution Boards.

GROUP H.

1. Open Line Construction, Part I.
2. Open Line Construction, Part II.
3. Open Line Maintenance.
4. Underground Construction, Part I.
5. Underground Construction, Part II.
6. Underground Maintenance.
7. Cable Balancing.
8. Power Circuit Guarding.
9. Electrolytic Action on Cable Sheaths, etc.
10. Constants of Conductors used for Telegraph and Telephone Purposes.

GROUP I.

1. Submarine Cables.

GROUP K.

1. Electric Lighting.
2. Lifts.
3. Heating Systems.
4. Pneumatic Tube Systems.
5. Gas and Petrol Engines.