WS No. 19 Mark III

P.W.—F.6.

POST OFFICE
ENGINEERING DEPARTMENT

TECHNICAL PAMPHLETS FOR WORKMEN

Subject:

Private Branch Exchange. C.B. Multiple No. 9.

ENGINEER-IN-CHIEF'S OFFICE
1919

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PRIVATE BRANCH EXCHANGE.

C.B. MULTIPLE No. 9.

(F. 5).

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PRIVATE BRANCH EXCHANGE.
C.B. MULTIPLE No. 9.

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PRIVATE BRANCH EXCHANGE. C.B. MULTIPLE No. 9.

DESCRIPTION AND LAY-OUT OF PLANT.

This type of switchboard caters especially for the larger private branch exchanges. The main advantages of C.B. working are obtained with a maximum of simplicity. The boards are made in one position sections, and lined up to form a continuous switchboard and multiple field. A cable turning section is fitted at the commencement of the line of boards, and at the end section an end panel usually suffices. If the number of sections renders it necessary owing to amount of cables, a cable turning section may also be used at the last section.

In the multiple, two panels per section are provided. There are no local jacks as usually understood, all calls being answered from the multiple. No I.D.F. is provided, and it is necessary, therefore, to arrange the calling signals initially in a suitable manner for the traffic needs. The calling signals are fitted above the jack multiple, the usual arrangement of the switchboard face equipment being as follows :—

Lowest in the Jack Panels are the extension line jacks in strips of 20, multipled every fourth panel. Above these are the exchange line jacks in strips of 10, multipled similarly. Fitted above the jacks are the extension calling signals (eyeballs) in strips of 20. Finally, above these, are the exchange line calling indicators (self-restoring) in strips of 10.

The calling equipment is usually arranged so that jack multiples occur on the same section as the calling signals. Cables are run from the main frame to the first multiple jacks, thence jack to jack, and are terminated on tags at the rear of the last or last two sections. The calling equipments are cabled to tags on their respective sections. The tags are connected together by cable according to the traffic requirements in blocks of strips of calling signals. Individual line jumpering is not provided for owing to no separate answering jacks being fitted. For tie lines generally exchange line jack and calling equipment is utilised. For private wires the exchange jacks and extension signals are usually adopted. On the keyboard, capacity exists for 17 sets of cord circuits. Equipment for 12 is usually provided with speaking and ringing keys and ringback keys, 3-way plugs being used. Fitted one per position are also position switching keys and generator switching keys. Provision is made on the keyboard for 2 supervisory signals per cord circuit. The cord circuit relays, coils retardation, condensers, etc., are fitted in the rear of the sections. Extra equipment for long lines, tie lines, private wires, etc., is catered for if necessary on a separate relay rack. Main frame provision is made as required, one or more frames being fitted.

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CORD CIRCUIT.

A skeleton cord circuit is shown in Fig. 1. The retardation coil D is employed to supply current to both plugs for speaking purposes. The circuit as shown is used for extension to extension connections. When an Exchange connection is involved the battery is substituted by a bridging coil of 200 resistance. The speaking current is then supplied over the exchange line from the main exchange operator's cord circuit.

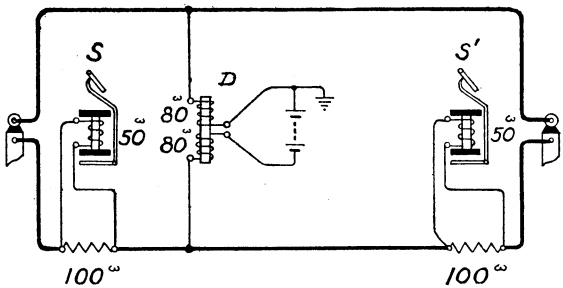


Fig. 1.

Diagram N.941 in the Loose Leaf series shows the full theoretical cord circuit. The requirements catered for are :—

(a) Feeding speaking current for extension to extension connections.

(b) Disconnecting cord circuit battery when exchange connection is involved.

(c) Clearing signals for supervision.

(d) Restoring the line calling signal on operator answering call.

(e) Provision of engaged test on lines connected.

(f) Ringing for both plugs and operator "listening in."

The action of the circuit is as follows :—

(a) It will be seen from diagram N.941 that when the sleeve relay is not actuated, battery is connected to the cord circuit *viâ* windings of the retardation coil and tongues and outers of the sleeve relay. This is the extension to extension condition. The energising of the sleeve relay depends upon the circuit obtaining *viâ* the line jack bush. On an extension line the jack bush is not connected to earth in any way (*see* Loose Leaf Diagram N.943).

(b) Referring to Loose Leaf Diagram N.942 it will be seen that when a plug is inserted, the exchange line jack bush is connected to earth *viâ* the restoring coil of the exchange line indicator. In this case the cord circuit sleeve relay is energised,

viz., negative, *winding of relay*, plug sleeve, jack bush, 100^{w} restoring coil of Exchange line indicator, to earth. The relay contacts close thereby connecting its tongues to the 200^{w} bridging coil. The tongues of the relay are connected to tip and rings of plugs *viâ* the doubly wound retardation coil. The condition will now be that, across the cord circuit is the retardation coil with the 200^{w} bridging coil in its centre as shown in Fig. 2.

(c) The supervisory signals are marked S and S1. Each is of 50^{w} resistance, bridged by a non-inductive resistance of 100^{w} for transmission purposes. For extension to extension connections the cord circuit relay, as already mentioned, is not actuated. Considering Signal S for such a connection it will

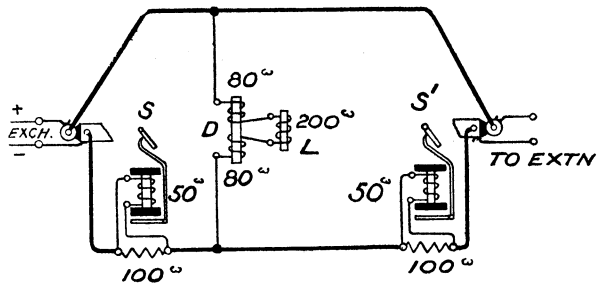


Fig. 2.

be seen that it will be actuated if a circuit is closed *viâ* the plug tip and ring. This condition would obtain during the connection (with extension receiver lifted), viz., negative, outer and tongue of sleeve relay, one winding of retardation coil, *S Signal*, key RB, plug ring, extension telephone, plug tip, key RB, second winding of retardation coil, the other tongue and outer of the sleeve relay, positive. The signal is therefore controlled by the extension telephone. Both supervisory signal actions are similar. Whereas for extension to extension working, separate supervision for each plug is given, it is quite different where an Exchange connection is involved. For this condition a clearing signal is only available for the extension connected. As already described, the cord circuit relay operates for an exchange connection. The supervisory circuit is then as Fig. 2.

The current is now obtained from the main exchange, and S1 (Fig. 2) will be controlled by the extension, but S will be actuated until the plug is withdrawn. This is due to the fact that current is always on the exchange lines, *i.e.*, either from the main exchange cord circuit or from the main exchange line calling equipment.

These supervisory signals are in effect negative signals. When actuated, the armature raises a red disc, which thereby becomes visible to the operator. When an extension "hangs up," the disc falls back. This effect is the reverse of that given by, say, a No. 1 exchange with lamp supervision, where the lamp dims during connection and glows on subscriber replacing receiver.

(d) The insertion of an answering plug into an exchange line jack will restore the shutter or flap of the calling indicator. The restoring of the exchange line calling indicator is effected by the negative on the plug sleeve, obtaining a circuit to earth *viâ* the restoring winding of the indicator. The precise action is given under the description of the exchange line circuit. In the case of an extension or private line the insertion of an answering plug will disconnect the eyeball circuit by the breaking of the contacts between the jack springs and their inners (*see* Loose Leaf Diagrams N.942 and N.943).

(e) Line jacks are "engaged" by connection of negative to the jack bushes. This is effected on a plug being inserted, as described later under "Extension line circuit."

For the circuit when the operator taps or tests a multiple jack, see description of operator's telephone circuit.

(f) It will be seen from the diagram that the actuation of the ringing key or the ringback key will connect generator to the calling or answering plug respectively. The actuating of the speaking key will "bridge in" the operator's telephone.

Cord Circuit Wiring Diagram (Loose Leaf Diagram N.941) shows the wiring for the circuit. Night extension keys are shown at the bottom of the diagram. When the switchboard is left without operators at night, etc., it is usually arranged that some or all of the exchange lines are connected to certain extensions for night working. Certain cord circuits are selected for this purpose. The straps are cut away from the tags shown (adjacent to the night extension keys) and the tags are wired to night extension keys in the manner illustrated in the diagram. The night extension keys are usually fitted on the Cable Turning section. The key springs in the diagram are in the night extension position. It will be seen that the sleeve relay circuit is broken. The circuit from the two windings of the coil retardation is also broken at the key. The cord circuit is therefore a simple loop with the two supervisory signals in series, and an extension connected through to the exchange is, for all practical purposes, a direct exchange line. In the "thrown" position of the night extension keys (all contacts made) the cord circuit becomes normal.

EXTENSION LINE CIRCUIT.

Loose Leaf Diagram N.943 shows the circuit connections of an Extension Line Circuit. The calling signal is of the eyeball type. On the extension receiver being lifted, the calling

signal is actuated *viâ* negative of battery, eyeball winding, B line *viâ* jacks, extension telephone, A line, jack springs, earth. On the operator answering, the eyeball circuit is broken by the answering plug breaking the contacts between the jack springs and their inners. The engagement of the line multiple is effected on the insertion of a plug into a jack. The jacks are of the 7-point type with an auxiliary spring and contact, the latter being common to a strip of jacks. All auxiliary springs for one extension are in parallel and normally rest on, and are in contact with, their jack bushes. Negative is connected to the contact. With a plug in a jack the auxiliary spring of that jack is pressed against the contact, thereby connecting negative to the rest of the springs of the extension multiple, and thence to the jack bushes. A 200^{w} resistance spool (one per group of lines) is shown in the circuit of the engaged test battery. This resistance prevents excessive current passing, and reduces the voltage sufficiently to provide a reasonable "click" in the receiver when the operator is tapping a line.

EXCHANGE LINE CIRCUIT.

Loose Leaf Diagram N.942 shows the circuit connections. The calling signal is of the drop indicator type, responsive to generator ringing current. In addition to its 1,000^{w} coil it possesses a restoring coil of 100^{w}, the function of which is automatically to restore the indicator flap on a plug being inserted in the jack. The extra contacts on the jack are used for this purpose. To call the Private Branch Exchange the main exchange operator applies "generator" current to the line. The calling indicator is actuated, viz., *A* line, jack springs, 1,000^{w} *winding of indicator*, condenser, thence *viâ* the jack to *B* line. The indicator flap, being released, falls forward and presses the light outer shutter upward, exposing the line number on the flap.

The insertion of a plug into a jack closes the restoring contacts, thereby energising the calling indicator restoring coil, thus restoring the indicator flap and shutter. The restoring circuit is as follows. Negative (from plug sleeve, Diagram N.941), jack bush, contact, 100^{w} *winding of indicator*, earth. The 1,000^{w} coil of the indicator is disconnected on the breaking of the inner spring contacts of the jack. The main exchange is called by the insertion of a plug into a jack. Being a C.B. main exchange its line calling signal is actuated by a loop. The loop is given from the Private Branch Exchange cord circuit (*see* Fig. 2).

The engaged test circuit is similar to that of an extension line and is described under that heading. The 2 m.f. condenser is necessary, as without it the exchange line circuit would be completed through the 1,000^{w} indicator. Its function is similar to that of the condensers fitted in direct exchange line telephone bell sets.

PRIVATE LINE (*Exchange connection prohibited*).

Loose Leaf Diagram N.944 shows the circuit. The calling signal and engaged circuits are similar to those of the extension lines. The circuit is further arranged, however, to render effective connection to the exchange lines impossible whilst allowing connections between private lines and extensions. For this, the 30ω relay and the extra jack contacts are necessary. Should the operator connect a private line to an exchange line, the 30ω relay is energised, viz., negative *relay winding*, extra contacts to jack bush (contacts make with plug in jack), thence *viâ* plug sleeves (*see* Loose Leaf Diagram N. 941) to exchange line jack bush, exchange line indicator, restoring coil, to earth.

Fig. 3 illustrates this condition.

Relay P. energised disconnects the private line entirely, thus making effective through connection impossible.

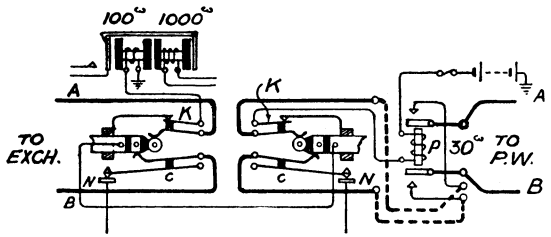


Fig. 3.

The connection of a private line to an extension is permitted by this circuit. Relay P will only actuate if a circuit to E is obtained *viâ* the plug sleeves, and it will be seen from Loose Leaf Diagram N. 946 that no path to E exists on an extension jack bush.

Wiring.—The P relays are fitted on a relay rack in a convenient position. The relays are wired to tags on the main frame or adjacent thereto, and are jumpered as required, so as to interpose the relay contacts between the line and the multiple. The relay windings are cabled to tags in the end sections for convenience in jumpering to the jacks.

TIE LINES.

Tie Lines are lines between two Private Branch Exchanges. Loose Leaf Diagram N. 945 shows the arrangement of a tie line equipment. Provision is made in this case for calling by generator and prohibition against an exchange connection. The circuit action is as follows : —

On the distant operator "ringing," generator current is received which actuates the calling indicator. The circuit is, line to repeating coil winding, inducing current in the second repeating coil winding (the condenser short circuits the 60^{w} relay for alternating currents), thence *viâ* 30^{w} relay contacts to jacks and indicator. On the operator plugging in, the 60^{w} relay is energised from the cord circuit battery (Fig. 1) *viâ* outers and tongues of 30^{w} relay, winding of repeating coil, and 60^{w} *relay*. The contacts of the latter close, completing a circuit for the restoring winding of the calling indicator, viz., negative 150^{w} resistance, contacts of 60^{w} relay, *restoring winding* of indicator. The cord circuit is now through to the tie line with the repeating coil interposed, the 30^{w} relay not being actuated. The condenser shunts out the 60^{w} relay winding for speech currents. The 30^{w} relay will actuate and disconnect the tie line if a connection is made to an exchange line. This action has already been described under the heading of "private line." The 150^{w} resistance coil limits the current in the restoring circuit, thereby ensuring the action of the 30^{w} relay. The engagement of the line is similar to that of an exchange line. The additional equipment is usually fitted on a separate relay rack and jumpered in the manner shown.

OPERATOR'S TELEPHONE CIRCUIT.

Loose Leaf Diagram K. 1,202 shows the details of this circuit, *with the exception that the lines are wired to the position switching key* in place of order wire keys, as shown. Connection to the battery bus bars is made for the transmitter circuit through a retardation coil of 165^{w} with a condenser connected as shown. The retardation coil reduces the current suitably for the transmitter. The impedance of the retardation coil will prevent high frequency current variations from traversing its winding, incidentally thus preventing overhearing from other circuits *viâ* the battery bus bars. The condenser completes a local circuit, *i.e.*, transmitter, primary windings, condenser, for the high frequency currents due to speech. The combination of the condenser and retardation coil, therefore, is to give, in some measure, the effect of a separate battery for each operator's transmitter. The two primary windings of the induction coil, each of 18^{w}, are joined up in parallel; the induction coil has also two secondary windings, each of 130^{w}. A non-inductive coil of 360^{w} is also in the circuit, the receiver being connected as shown in the diagram. The object of the 360^{w} coil arranged in the circuit in this manner is to eliminate, or at least to minimise, "side tone". "Side tone" is the reproduction of the operator's own voice in the receiver, which would occur were the receiver merely in parallel with a secondary winding. The receiver, arranged as in the diagram, becomes equivalent in the circuit to a galvanometer in a Wheatstone

bridge, the exchange or extension line and telephone resistance (averaged at 360ω) forming one arm. (Fig. 4 shows the effect, which is similar to a balanced Wheatstone bridge, the receiver being approximately balanced against currents in the secondary windings). The condenser B in the secondary circuit prevents current passing from the cord circuit and incidentally actuating the supervisory signals. The switching key is used to allow an operator to take adjoining positions during slack periods. The actuation of the key throws the position speaking key leads to the operator's set on the previous position.

Engaged test.—Fig. 5 shows the circuit when the operator is tapping a jack for the engaged condition. The condenser has a potential difference between its two coatings equal to the voltage of the battery. The plug tip is connected to the positive side of the battery. When the tip of the plug is tapped against the bush of the jack (which is negative if line engaged), the condenser potential difference is reduced. The ensuing partial dis-

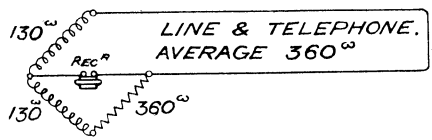


Fig. 4.

charge causes a click in the receiver, thus indicating to the operator that the line is engaged. No sound is heard in the receiver when a *disengaged* jack is tapped.

RINGING DISTRIBUTION.

Power ringing from the main exchange is generally available for a P.B.X. large enough to warrant a switchboard of this type. Hand generators, one per position, are fitted. Loose Leaf Diagram N.946 shows the arrangement. The generator switching key is fitted (one per position) to bring the hand generator into use should the ringing fail. The power ringing is wired direct from the main frame protective apparatus to the lamp (300ω resistance) and terminal on the first position, thence to succeeding positions. A resistance lamp is fitted for each position. The lamp is in the " live " side of the ringing leads. The object of the lamps is to prevent one position ringing out to a low resistance or a fault, thereby reducing the power available for other positions. Also, the lamps in conjunction with the resistance lamp in circuit at the main exchange reduce the ringing voltage to a safe value.

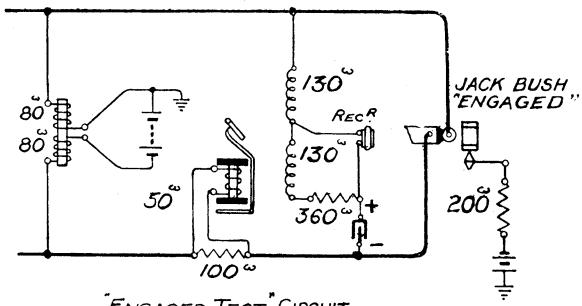
Night Alarm.—The night alarm circuit is shown in Loose Leaf Diagram N.946. The power tags referred to in the diagram are on the various sections. They are wired to the local con-

tacts of the extension and private wire eyeballs and exchange line indicators. The 200ω bridging coil reduces the voltage for the trembling bell. A condenser 2 m.f. is in parallel with the bell to eliminate speaking trouble.

POWER DISTRIBUTION.

Power is usually obtained from the main exchange accumulators *viâ* a power lead. Special instructions are issued in connection with the grouping and arrangements of power leads. A voltage of not less than 12 volts is necessary at the Private Branch Exchange during the period of busiest traffic.

The power leads are wired from the protectors to the bus bars of a fuse mounting fitted on the cable turning section at



"ENGAGED TEST" CIRCUIT

Fig. 5.

the commencement of the switchboard. Additional fuse mountings are fitted on each section, and the positive and negative bus bars of each of these are cabled to the bus bars of the fuse mounting on the cable turning section. These cables are "looped in" to the fuse mountings to prevent interruption to the remainder should one be disturbed for any reason. On the sections, the fuses are generally as follows :—

1 fuse per cord circuit.
1 per section for extension equipment.
1 per section for private wire.
1 per group of exchange lines.
1 per operator's telephone.

A 10 m.f. condenser is fitted across the bus bars on the first fuse mounting. The reason for this, in addition to maintaining the potential difference at the bus bars, is to prevent over-hearing due to the power lead resistance being common to the cord circuits. As the condenser is an effective path for high frequency speech currents, it is traversed by them and the tendency for leakage from one cord circuit to another is minimised.

Further, the circuit is closed at the bus bars by the condenser for these speech currents, thus giving greater efficiency than if the power leads were alone in circuit.

LONG EXTENSION EQUIPMENT.

Special provision is sometimes necessary to deal with extensions or private lines having a conductor resistance above a certain value. Generally, the partial failure of calling and supervisory signals would occur in these cases. In addition, owing to the type of cord circuit, too great a difference in the resistance of any two circuits connected would result in the one of least resistance taking more than its share of the current from the cord circuit battery. This would rob the higher resistance circuit of current, resulting in poor speaking efficiency. Various methods are available to suit individual cases. Factors such as line resistance and power lead voltage render investigation necessary for each case. In the example taken, viz., Loose Leaf diagram N.938, a local battery instrument is used at the extension with a condenser in its bell circuit. The unit shown is fitted on the special apparatus rack and is cabled or jumpered to the M.F. so as to interpose the apparatus in the line circuit. On the Private Branch Exchange side the ordinary extension equipment is used. Calling by the extension is as follows. The 1,000^{w} + 1,000^{w} relay is energised on receiver being lifted, *viz.*, negative 1,000^{w} *winding of relay L,* winding 7—8 of repeating coil, *B* line, telephone, *A* line, winding 2—4 of repeating coil, thence *viâ* second winding of the 1,000^{w} + 1,000^{w} relay to earth. The relay contacts close, thereby " shunting " the 2 m.f. condenser by means of the 40^{w} spool. The eyeball circuit of the private branch exchange is now completed *viâ* the repeater coil winding 1—2, 40^{w} spool, and repeater coil winding 5—6. On the extension " hanging up " a disconnection is given to the cord circuit by the relay armature falling back. The high resistance relay L will actuate through any reasonable line resistance, and so far as the private branch exchange is concerned, the effect of a low resistance line is given.

The alternating generator current employed in calling the extension, rings through the repeating coil, with no effect on the 1,000^{w} + 1,000^{w} relay owing to the presence of the 4 m.f. condenser.

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