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**POST OFFICE
ENGINEERING DEPARTMENT**

**TECHNICAL PAMPHLETS
FOR
WORKMEN**

Subject:

**Private Branch Exchanges,
Magneto.**

ENGINEER-IN-CHIEF'S OFFICE

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PRIVATE BRANCH EXCHANGES, MAGNETO.

(F. 6.)

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- D. 1. Elementary Principles of Telephony.
- D. 2. Telephone Transmission. "Loading." Telephone Repeater and Thermionic Valves.
- D. 3. Principles of Telephone Exchange Signalling.
- D. 4. Magneto Exchanges—Non-Multiple Type.
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- D.17. Internal Cabling and Wiring.
- D.19. Cord Repairs.
- F. 3. Subscribers' Apparatus, Magneto.
- F. 8. Wiring of Subscribers' Premises.

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PRIVATE BRANCH EXCHANGES.

MAGNETO.

GENERAL PRINCIPLES.

Single Exchange Station.—A subscriber's direct exchange line involving the use of a single instrument terminates at the subscriber's end upon a wall or table pattern telephone and all calls originated or received by the subscriber pass through the Public Exchange. This simple arrangement is suitable for the requirements of a subscriber who occupies only one room in a building or a small shop in which the occupier is the only person requiring the use of the telephone.

Extension Station.—If the subscriber rents a second room, or opens a branch place of business, an "extension" to the additional premises from the main telephone may be required. If provided, this second circuit would be known as an *Internal* or *External* extension (according to its position relative to the main telephone and to the nature of the route followed by the wires connecting the first and second telephones together) and the installation would then comprise two exchange stations.

Intercommunication.—In magneto systems, when intercommunication is desired in the case of an installation consisting of only two stations, it is usual to fit a switch which enables the subscriber to connect the main telephone set either to the public exchange or to the extension station and also to connect the extension to the public exchange. When the last named connection has been made, the "ring off" from the extension station actuates a bell at the switch, thus giving an audible intimation at the main telephone that the conversation is finished. The switch should then be restored to the normal position, *i.e.*, to the position in which the exchange line is connected to the main instrument and the extension to the bell at the switch.

Conditions necessary for a P.B.X.—By the use of the switch referred to in the previous paragraph the conditions necessary for working between two stations and a public exchange are met, but clearly no additional stations could be similarly provided for except by an increase in the number of springs and contacts on the switch, thus unduly complicating the system. Therefore, if more than one extension station with

intercommunication facilities is required by a subscriber, the conditions necessitate the provision of a Private Branch Exchange and the single switch must be replaced by a switchboard of suitable capacity.

From this point onwards, a greater call will be made upon the main station attendant's time and as an installation increases in size, it may become necessary for the subscriber to provide an operator whose time will be wholly occupied in attending to the calls received at the P.B.X. because, to a great extent, the quality of the service supplied depends on the efficiency with which the switchboard is operated.

Training Operators.—Telephone operators for the larger Private Branch Exchanges are usually trained for their work by the Traffic Branch of the Post Office, but in the smaller Private Branch Exchanges this facility is not always made use of by the subscribers and it is upon an engineering officer that the responsibility devolves of giving the necessary instructions for operating the P.B.X.

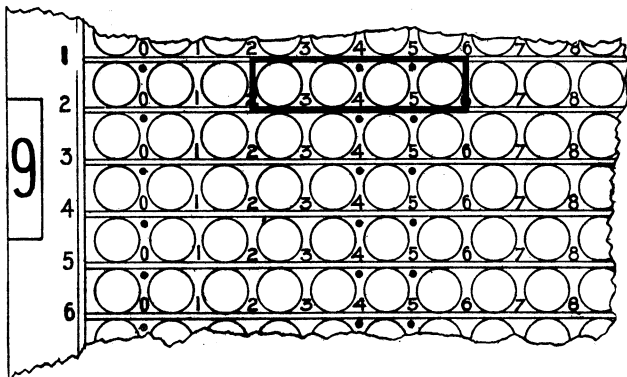
A responsible member of the subscriber's staff should always be approached before the service is opened, and the operation of the switchboard clearly explained. The fact that the efficient working of the system depends upon the employment of a reliable and quick operator should be emphasised as the advantages that should accrue from P.B.X. working are often lost by indifferent operating.

Facilities afforded.—Private Branch Exchanges are provided to enable speedy and efficient intercommunication between the various Departments of large business establishments independently of the public exchange and to afford to those Departments a quick and reliable service over the whole public telephone system. In the case of small P.B.X. installations, very little intercommunication between extension stations takes place as a rule, but as the installation increases in size, this facility becomes one of the most valuable offered to P.B.X. subscribers and renders the provision of a private telephone system quite unnecessary.

Revenue from P.B.X. Calls.—Telephone calls *via* the public exchange are paid for in accordance with the number of calls originated. Revenue is, therefore, earned whenever an extension station is connected to the public exchange for the completion of a call originated at the P.B.X.

Public Exchange Arrangements.—When a P.B.X. is served by more than one exchange line it is the practice at the public exchange to connect the exchange lines to consecutive jacks in the multiple panels and the group of jacks is enclosed by

white painted lines as shown in Fig. 1. This clearly indicates



MULTIPLE MARKINGS.

Fig. 1.

to the public exchange operator the number of exchange lines associated with the P.B.X.; hence, if one line be engaged, any of the remainder can be chosen. The figure shows four exchange lines leading to a P.B.X., the first number, *i.e.*, 923, being the number that appears in the telephone directory. Sufficient exchange lines are usually provided to carry the maximum telephone traffic at the busiest hour of the day and given efficient P.B.X. supervision, there should be little delay due to the lines becoming blocked or to "number engaged" being given to calling subscribers. This would not be so if the exchange lines, instead of being concentrated as indicated, were allotted various non-consecutive numbers and distributed over the public exchange multiple. It would not be practicable in such circumstances to introduce any method of labelling which would indicate with sufficient clearness the numbers that serve the same subscriber, and consequently a subscriber would not derive full benefit from the lines for which rental is paid.

MAGNETO SWITCHBOARDS AND AUXILIARY APPARATUS.

Magneto Signalling.—In Magneto private branch exchanges all signalling (with certain reservations which will be dealt with later) is performed by means of magneto generators; therefore the operation of the calling and ring off indicators is dependent upon the generator signal being given by the extension stations whether for the purpose of originating a call or for notifying the termination of one. The mere action of lifting or replacing the receiver is insufficient; it must be followed by the generator

signal. All subscribers' telephones used in connection with Magneto private branch exchanges are provided with magneto generators which, when actuated, generate an alternating current of low frequency at a voltage of about 65 volts, capable of operating the calling and clearing indicators fitted on magneto switchboards.

Indicators.—In the switchboards to be described, the indicators are of the "drop" pattern which require to be restored by hand.

The same indicators serve in some cases for both calling and clearing purposes and as they, therefore, remain in bridge during conversation, it is necessary in order to minimise their shunting effect on the speech currents that indicators used in this way shall have a high impedance value. To achieve this result, the indicator coils are wound to 1,000 ohms. resistance and enclosed in individual iron sheaths. The presence of this sheath increases the inductance of the winding and in consequence causes the indicators to offer high impedance to the varying speech currents which pass over the wires during conversation.

A common type of iron sheath indicator is shown in Fig. 2. When current from a generator passes through the indicator

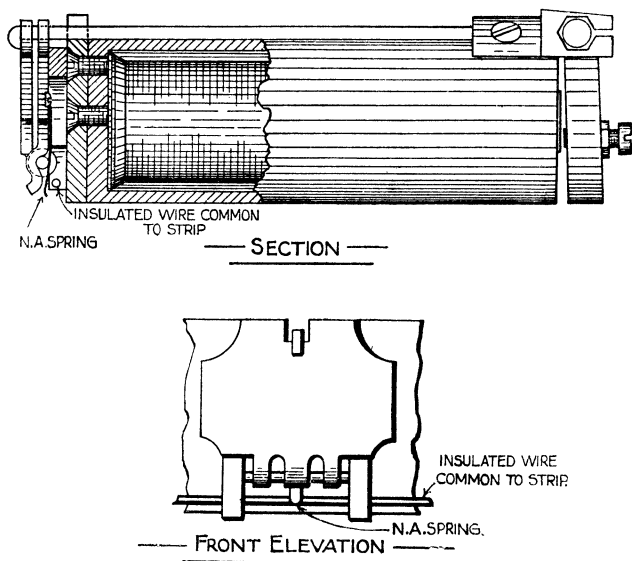


Fig. 2.

coil magnetisation of the electro-magnet core results, the soft iron armature is attracted and the "drop" falls from its normal (vertical) position to one more or less at right angles to the face of the switchboard. If the generator ringing is prolonged, the indicator armature vibrates with an audible rattle. In falling, the indicator "drop" completes a local alarm bell circuit *via* the common insulated wire and N.A. spring shown in the figure.

Condensers are not a fundamental requirement on a Magneto system but facilities for fitting them, if necessary, are usually included in the design of Magneto apparatus.

Spring Jacks.—Switching on Wall Pattern Magneto Switchboards is effected by means of Switch Springs (now known as Switchboard Jacks) and plugs and cords, or, as in the case of Cordless Boards, by Switchboard Jacks and Plugs only. Switchboard Jacks consist of two or more springs suitably mounted and insulated from each other by thin strips of ebonite. These springs are so shaped and arranged that upon inserting a switchboard plug effective contact is made between the separate conductors of the plug and the corresponding spring of the jack as shown in Fig. 3.

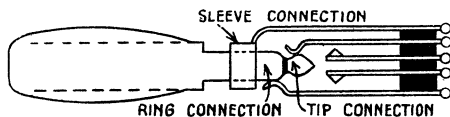


Fig. 3.

Switchboard Plugs.—These may be of the two- or three-way pattern. In the former case the plug consists of two parts insulated from each other, and known as the *tip* and the *sleeve* respectively. A three-way plug consists of *tip*, *ring*, and *sleeve* portions, all insulated from one another. The two types of plug are illustrated in Fig. 4, *A* representing the two-way and *B* the three-way pattern.

When the three-way plug is inserted into a jack the *tip* makes contact with the short outer spring, the *ring* with the long outer spring and the *sleeve* with the bush of the jack. If

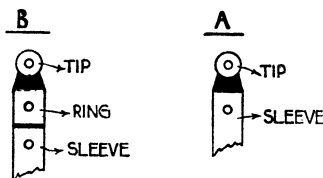


Fig. 4.

two-way plugs are used *the sleeve is in contact with both the long outer spring and the bush of the jack.*

Speaking Sets for Operators.—With the smaller pattern switchboards the operating or service instrument provided is a wall pattern telephone fitted with a hand micro-telephone and a generator. On the larger wall pattern switchboards and the floor pattern switchboards the operator's telephone is either a hand-micro-telephone or a head-gear receiver and breast-plate transmitter according to the type of switchboard and local conditions.

Supervision.—For small Private Branch Exchanges, say up to 30 lines, the switchboards required are very simple, both in construction and operation, but when this number of lines is exceeded, improved switching requirements, to expedite the answering of calls and the connection of the various lines, become necessary in order to provide the P.B.X. operator with a more efficient method of control and supervision over the various calls. In this case the conditions approximate to those met with in public exchanges.

Classification of Switchboards.—Small magneto switchboards suitable for branch exchanges requiring not more than 30 lines can be divided into three classes, *viz.* :

Cordless Switchboards.

Single Cord Switchboards.

Double Cord Switchboards.

These are of the wall pattern and means by which the operator can enter the circuit and supervise the progress of any call are provided on all these switchboards except the obsolescent types of the last class known as Switchboards W.P., D.C., N.T. 1-12 and Switchboards Magneto C.B.S. $\frac{n + n}{N}$ and described on pages 11-14 of this pamphlet. (1/27)

CORDLESS SWITCHBOARDS.

Cordless Switchboards, which are now obsolescent, were equipped with a capacity up to 5 lines only. Their use was, therefore, somewhat restricted. The general appearance and circuit wiring of a board having capacity for 3 lines, *i.e.*, one exchange line and two extensions, is illustrated in Fig. 5. The jacks in the bottom row are the *Line Jacks*, the jacks in the row above are the *Service Jacks*, and the jacks above, arranged in pyramid formation, enable any two lines connected with a switchboard to be joined through to one another.

Operation.—As the name implies, no cords are necessary in the operation of these switchboards, all connections being made by means of two-way metal switchboard plugs. The

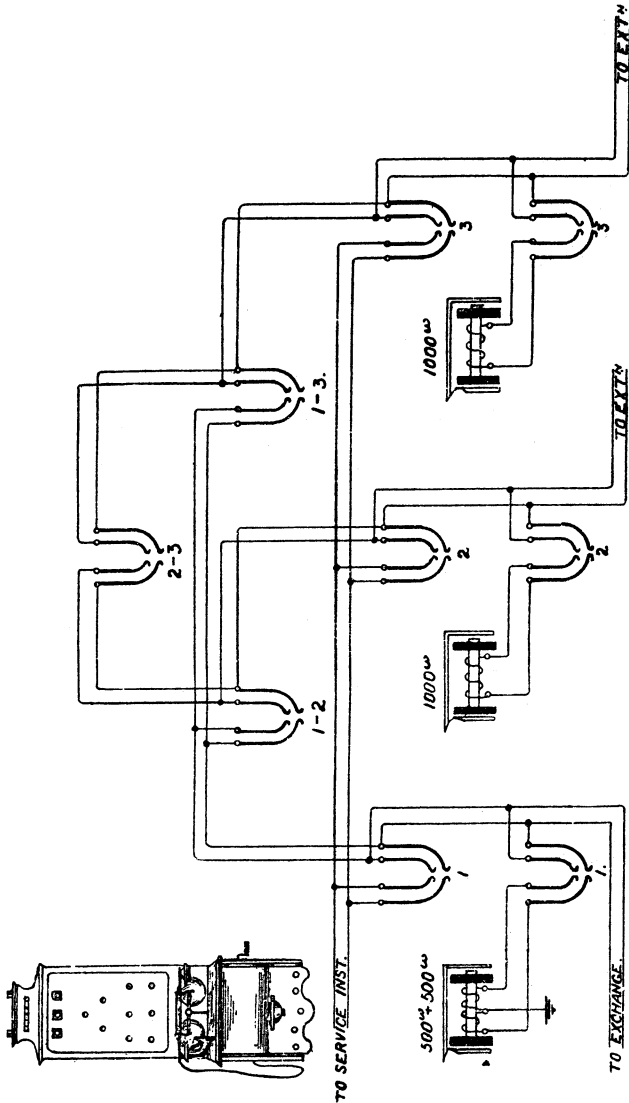


Fig. 5.—SWITCHBOARD, WALL PATTERN, CORELESS N.T.
Normally all plugs are kept in the bottom row of jacks.

normal position of these plugs is in the bottom row of jacks and care must be taken by the operator to replace them in this position immediately after each call is completed.

To make or answer a call, the plug proper to the line concerned is extracted from the bottom jack and placed in the jack immediately above. The *Service Instrument* is thus connected to the line and a call can be made or answered as required. If on answering a call, it is found that connection to another line is desired, the procedure is as follows:—

To connect the public exchange to an extension station, insert the plug of the exchange line in the service jack of the extension line required and ring. When an answer is received say "Through to....." and move the plug from the service jack to the jack within the pyramid, showing the necessary combination 1—2, 1—3, etc., as the case may be.

To connect one extension to another, insert the plug of the calling line in the service jack of the line required and ring. When an answer is received, say "Through to....." and move the plug from the service jack to the jack within the pyramid bearing the required combination of extension numbers.

To connect an Extension Line to the Public Exchange.—Having answered the extension line call, return the plug of the calling line to its normal position, then move the exchange line plug to the exchange line service jack and ring. When the desired connection is obtained, move the plug from the exchange line service jack to the service jack of the calling extension line, ring (if necessary) and say "Through to.....," then move the plug from the service jack to the jack within the pyramid showing the combination 1—2, 1—3, etc., according to the extension line number.

To clear.—When the "drop" of the indicator on one of the connected lines falls, denoting that the conversation is finished, move the connecting plug to its normal position in the bottom row of jacks.

Provision is not made on this type of board for the operator to listen in.

Auto Clearing.—The earth connection shown on the exchange line indicator is required to provide an automatic signal at those public exchanges where automatic clearing or control ringing is in use; otherwise it may be dispensed with.

SINGLE CORD SWITCHBOARDS.

Single cord boards with an equipped capacity ranging from 3 to 30 lines are issued as standard items for use in Magneto exchange areas. A general view of this type of switchboard

is shown by Fig. 6 and the connections under various conditions are shown by Loose Leaf Diagrams N. 912 to N. 919.

Each exchange line and extension has associated with it an indicator (on which both calling and clearing signals are received), a plug, and a jack.

The operating instrument is connected to a plug marked "Instrument" and to a jack also marked "Instrument." The latter, however, is not used in non-condensered exchange areas and is plugged up.

A jack marked "Hold" is provided to enable the operator, by inserting the exchange line plug in it, to hold an exchange connection, if the exchange line terminates in a condensered magneto exchange, whilst making an independent enquiry on another line. The connections of the "Hold" jack are shown in Loose Leaf Diagram N. 961.

Five terminals are fitted on each line. Two of these are the usual line terminals and the three extra terminals provide a ready means of inserting batteries or condensers in the cord and indicator circuits when required. When these items are not provided, the extra terminals are bridged by short pieces of insulated wire.

Ringing is effected by the hand generator included in the operator's instrument, with the receiver off the rest.

Operating.—On reference to the simple circuit shown on Loose Leaf Diagram N. 912, it will be observed that as each cord circuit is merely an extension of the corresponding line, any through connection can be set up by the use of a single cord.

The calling on any line is effected by inserting the instrument plug in the jack of the line concerned and ringing.

When answering a call, the instrument plug is inserted in the jack of the calling line.

Connection between one line and another is established, by first transferring the instrument plug from the calling line to the jack of the wanted line, ringing, and then, on receipt of a reply, inserting the plug of the wanted line in the jack of the calling line, after which the instrument plug is withdrawn.

The operating procedure described above is that followed in non-condensered exchange areas. In condensered exchange areas, however, a slight modification has to be made in consequence of the necessity of holding exchange connections. In these circumstances, the instrument plug is used for calling purposes only, and the plug of the calling line is inserted in the instrument jack when calls are answered.

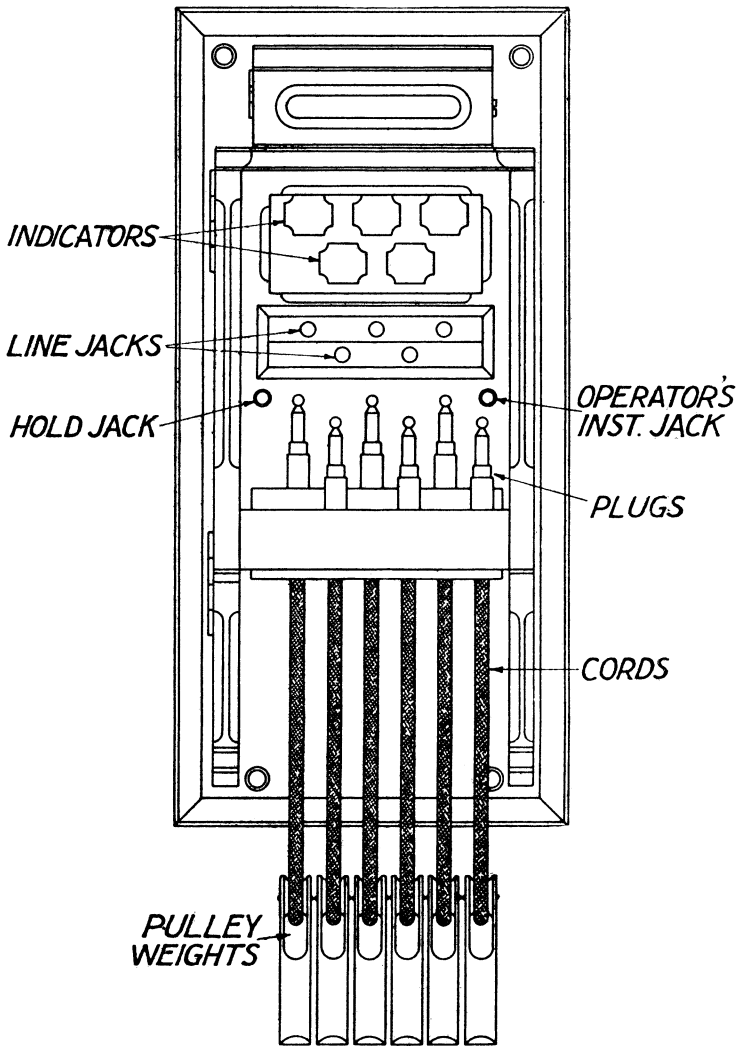


Fig. 6.—SINGLE CORD SWITCHBOARD.

Connections are cleared by withdrawing the corresponding plug and restoring the indicator.

Mixed Service Working.—In these cases in which it is desired to terminate private wires or tie lines on a P.B.X. single cord switchboard, the arrangements shown in Loose Leaf Diagrams N. 914, N. 915, N. 918 or N. 919 are used. The circuits are designed to prevent intercommunication between the private wires or tie lines and the public exchange lines. The alterations which are often referred to as “mixed circuiting” are as follows:—

Replace two-way plugs and cords by three-way on all extensions and connect the sleeve of each plug to the bush of the corresponding jack.

Replace two-way plugs and cords by three-way on all exchange lines and connect the tip and sleeve together, also join the bush and the short line spring of each exchange line jack.

Connect together the bush and long line spring of each private wire or tie line jack.

Replace two-way plug by three-way plug in operator's telephone circuit and connect the sleeve, if necessary, as shown in the appropriate diagram.

This arrangement, whilst allowing intercommunication between the extensions and the private wire or tie line, effectively prevents communication between the public exchange and the private wire or tie line. It will be seen on reference to the diagrams that if an attempt is made to connect a private wire or tie line to the public exchange, it will result in the lines becoming short-circuited.

DOUBLE CORD SWITCHBOARDS—WALL PATTERN.

Switchboards, Wall Pattern, Double Cord, N.T., No. 1-12.

—On these double cord boards which are now obsolescent, the lines are jack ended and all connections are set up by the use of two two-way switchboard plugs connected together by a flexible cord. These cords are entirely separate from the lines and hang loosely from the base of the switchboard when out of use. A general view of this type of switchboard, together with the circuit wiring, is shown by Fig. 7.

Operation.—Ringing is effected by means of a generator in the service instrument.

The extension line indicators are permanently connected across the line springs of the extension jacks and serve both for calling and clearing signals.

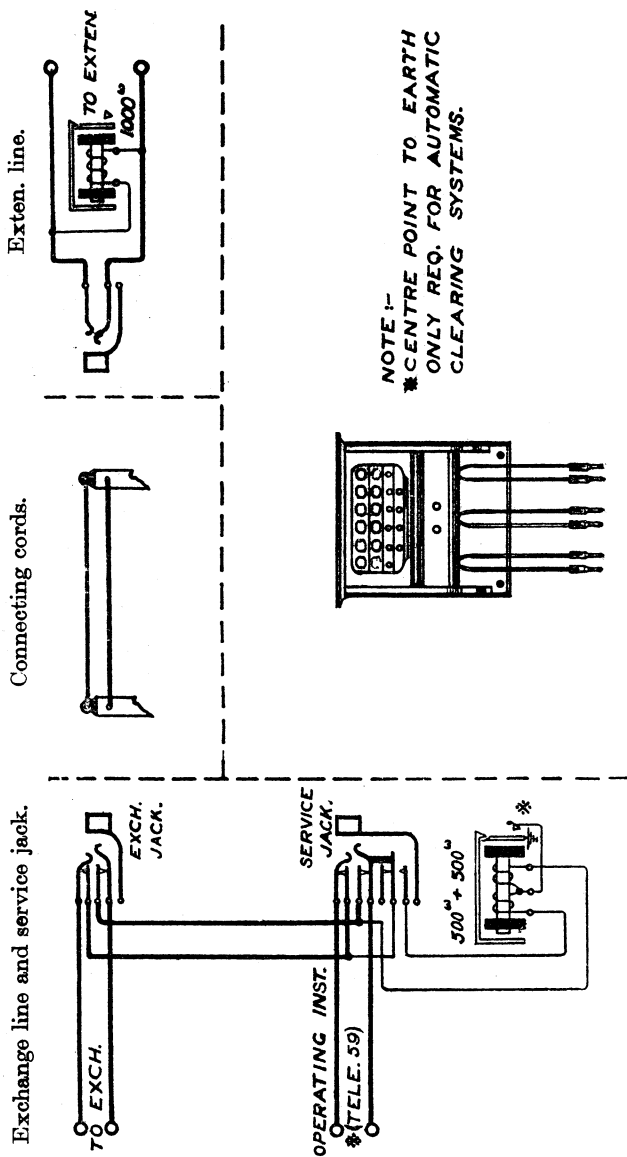


Fig. 7.—SWITCHBOARDS, W.P. DOUBLE CORD N.T. Nos. 1-12.

On reference to Fig. 7, it will be seen that in addition to the line jack, a service jack is fitted and joined in series with the exchange line and the operating instrument. It will, therefore, be clear that the public exchange can be rung or answered without the use of the cords. Incoming rings from the exchange are received normally on the operating instrument.

When it is desired to ring or answer a call on an extension, the operating instrument must be connected to the extension by means of one of the double ended cords, one plug being inserted in the service jack and the other in the extension jack.

Connection between any two lines is set up as previously indicated, by using one of the double ended cords, one plug of a pair being inserted in each line jack.

Connections are cleared by withdrawing both plugs of the connecting cord associated with the line on which a clearing signal is received, and restoring the indicator.

Listening in at the switchboard is not provided for and, therefore, the operator is entirely dependent for supervision upon the actuation of the extension line indicators at the close of a conversation.

Auto Clearing.—Fig. 7 shows that a connection to the centre point of the exchange line indicator coil is provided. This is joined to an insulated wire beneath the indicator (*see* Fig. 2) and the “drop” is earthed. This earth connection is required when clearing from the P.B.X. to the public exchange is automatic or when control ringing from the public exchange is in force, but otherwise is not used. The earth connection is required only on the exchange line indicator and the alarm bell circuit is confined to extension line indicators, an audible alarm signal being provided for on the exchange line by means of the magneto bell on the service instrument which, as previously indicated, is directly connected to the exchange line until a plug is inserted in the service jack.

Switchboards, Magneto C.B.S. $\frac{n + n}{N}$. A type of Double Cord Wall Pattern Switchboard known as Switchboard, Magneto C.B.S., primarily intended for use on C.B.S. systems, as indicated in Loose Leaf Diagram N. 910, has sometimes been used for Magneto branch exchanges. The indicators on these boards are operated by a magneto generator in a similar way to the indicators on boards previously described.

The smallest switchboard of this type issued is known as a Switchboard, Magneto C.B.S. $\frac{1 + 4}{5}$. The first and second

figures of the numerator refer to exchange line and extension line equipment respectively, and the denominator denotes the total capacity, including exchange lines and extensions.

A *Ringing Key* is associated with each line and to adapt the board for magneto use slight alterations are made to the wiring of the keys and exchange line jacks.

Operation.—The P.B.X. operator calls either the public exchange or an extension station by depressing the appropriate ringing key and turning the generator handle simultaneously. Communication is then established by inserting one plug of a double ended cord into the operator's jack and the other plug into the exchange or extension line jack as the case may be. All connections between the exchange lines and extensions are completed by means of the double cord, the extension indicator remaining in bridge. Listening in by the operator is not provided for, consequently the restoration of the circuits to their normal condition depends upon the magneto ring off signal being given at the close of a conversation.

SWITCHBOARDS WITH SUPERVISORY FACILITIES.

When the traffic at a P.B.X. increases beyond the point at which it can be satisfactorily handled on one of the switchboards previously described, it is necessary to instal a switchboard which affords the operator supervisory facilities. The requirements in these circumstances are met by the use of **Wall and Floor Pattern Double Cord Switchboards** on which the cord circuits are equipped with keys and ring-off indicators.

The **Wall Pattern Switchboards** are divided into two classes, one of which comprises **Switchboards, Wall Pattern, N.T., No. 19, 20 and 21** and the other **Switchboards, Wall Pattern, N.T., No. 22 and 23**; but there is only one class of **Floor Pattern switchboard** which comprises **Switchboards, Floor Pattern, N.T., No. 3 and 7**. These classes of switchboard will now be referred to in detail.

Switchboards, W.P., N.T., No. 19, 20 and 21.—These switchboards are designed for use on exchange lines terminating in Magneto exchanges having generator call and auto clear equipment, but, as the number of public exchanges employing this system is small, the use of this class of P.B.X. switchboard is very limited. Each of these switchboards has a capacity for 15 lines, but is equipped, when issued, for 5, 10 and 15 lines respectively.

A typical switchboard is illustrated by Fig. 8 and the circuit arrangements provided under various conditions are shown by **Loose Leaf Diagrams N. 904, N. 928 and N. 929**.

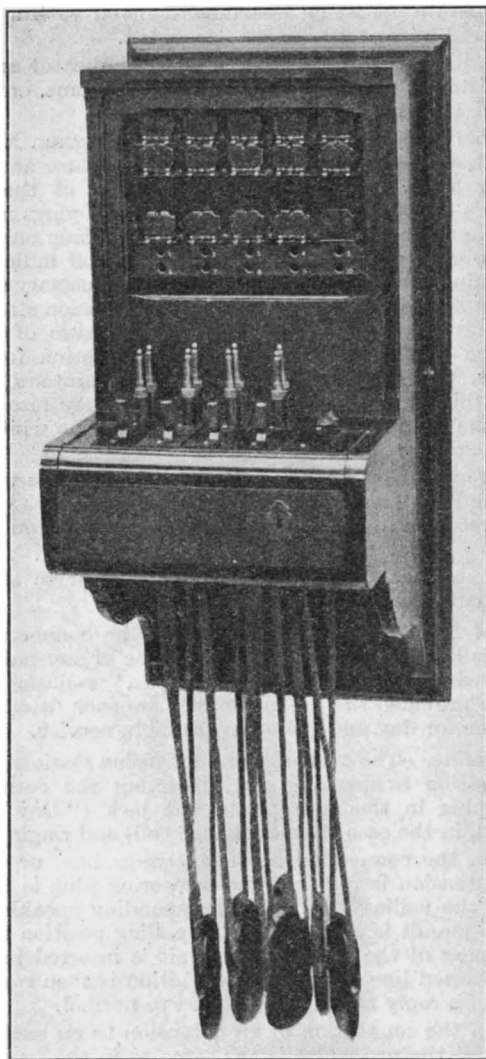


Fig. 8.—SWITCHBOARD, W.P., N.T., No. 20.

A separate operating instrument, fitted with a generator and a hand micro telephone, is provided.

Each line is equipped with a calling indicator and a jack. The resistance of the indicators is 1,000 ohms. on exchange lines and 100 ohms. on extensions.

Double cord circuits (*see* Loose Leaf Diagram N. 904) are provided, each equipped with a ring-off indicator and a double speaking key. In the answering position of the key the operator's telephone is associated with both plugs in parallel, but in the calling position with the calling plug only, leaving the answering plug connected to the ring-off indicator. On an incoming call the latter arrangement is necessary to prevent a premature clear being given from an extension station when the call is extended to the extension because of the earth connected to the bell at the extension station for clearing purposes. As the generator is in the operator's telephone circuit, this arrangement of the speaking key also serves to isolate the ringing circuit from the calling line whilst ringing is in progress on the required line.

A clear is given to the public exchange on the withdrawal of a plug from the exchange line jack or by the replacement of the receiver of any telephone connected to an exchange line.

An extension "rings off" to give a clear to the P.B.X. switchboard.

Night Service.—Any extension may be connected to any exchange line for night service by means of any pair of cords on the switchboard. If the "Calling In" facilities described later are provided the exchange lines are each fitted with two jacks, one for day and the other for night service.

Operating.—The exchange and extension stations are called by operating a speaking key, inserting the corresponding calling plug in the appropriate line jack ("Day" jack, if provided, in the case of an exchange call) and ringing.

When the connection of an exchange line, or extension, to an extension is required the answering plug is left in the jack of the calling line, the corresponding speaking key of the cord circuit is operated to the calling position before the calling plug of the same cord circuit is inserted in the jack of the wanted line, the extension station is then rung and on receipt of a reply the key is restored to normal.

When the connection of an extension to an exchange line is required the procedure is the same as in the previous case except that on receiving a reply it is necessary to ask the exchange for the required number and wait for the establishment of the call before the key is restored to normal.

If "Calling In" facilities are provided a "Calling In" signal is answered by operating the appropriate speaking key and ascertaining the requirements. Should the transfer of an exchange connection to another extension be required the plug is withdrawn from the extension already connected and the corresponding speaking key is restored. The extension station to which a transfer is to be made is then called on another cord circuit in the usual way and on the receipt of a reply the exchange connection is completed on the original pair of cords.

Switchboards, W.P., N.T. No. 22 and 23, and F.P., N.T., No. 3 and 7.—These switchboards are normally used on exchange lines terminated in public Magneto exchanges on generator call and clear equipment but have been retained in use in some cases, with slight modification, when conversion of the public Magneto exchange to C.B. working has taken place. The circuit arrangements on the two classes of switchboards are the same under both the foregoing conditions of use.

These switchboards can also be adapted for use in connection with public Magneto exchanges having generator call and auto-clear equipments, in which case they become identical in respect of the circuit arrangements with Switchboards, W.P., N.T., No. 19, 20 and 21 previously described.

Each of the Wall pattern switchboards has a capacity for 40 lines, but is equipped initially for 40 and 20 lines respectively. The Floor pattern switchboards N.T. 3 have capacity for 10 exchange lines and 50 extensions, but are equipped initially for 5 exchange lines and 50 extensions. The capacity and initial equipment respectively of the Switchboards, F.P., N.T. 7 are double that of the Switchboards, F.P., N.T. 3.

The switchboards shown by Figs. 9 and 10 are typical of the two kinds of switchboard and the circuit arrangements provided under various conditions are shown by Loose Leaf Diagrams N. 920 to N. 929.

On the Wall pattern boards each line circuit is normally equipped with one jack and a 100 ohm. indicator, but when used at a P.B.X. 10 of the indicators are replaced by ten 1,000 ohm. indicators to which the exchange lines are connected.

On the Floor pattern boards each line circuit is normally connected with one jack and an indicator. The resistance of the indicator is 1,000 ohms. in the case of the exchange lines and 100 ohms. in that of the extension.

Operating Instruments.—On the Wall pattern boards the operator's telephone is usually of the hand-micro pattern, but a headgear set is supplied if the traffic justifies it, and a

generator is fitted on the side of the switchboard. On the Floor pattern boards the operator's instrument is normally a headgear set, but this may be changed for a hand-micro telephone if the traffic is small or the local conditions render the change desirable. A generator is provided as part of the switchboard equipment.

From this point onwards the descriptive matter applies to both types of switchboard.

If the public exchange is a condensed Magneto or C.B. exchange each exchange line is connected to a second jack, and has, therefore, two jacks permanently associated with it, as shown by Loose Leaf Diagram N. 921. One of these jacks is used for day and the other for night service connections. An exchange connection is held as long as a plug remains in the "Day" jack because of the bridging coil associated with that jack (*see* Loose Leaf Diagram N. 921).

Double cord circuits, as shown by Loose Leaf Diagram N. 920 and Fig. 11, are provided, each having associated with it a ring-off indicator and a combined speaking and ringing key. In the speaking position of the key the operator's telephone circuit is connected directly across the cord circuit, hence the operator can speak to a subscriber when using either answering or calling plug or can "listen in" on completed connections without interrupting the conversation. In the ringing position the generator is connected to the calling plug and the answering plug is left connected to the ring-off indicator. When the key is in the normal position both the generator and the operator's telephone are disconnected from the cord circuit but the calling and answering plugs remain connected together with the ring-off indicator in bridge. A ring-back key, which is common to all the cord circuits, is also provided to enable the operator to ring on the answering side of the cord circuits. In some of the older boards various types of plunger keys are still in use, some being combined listening and ringing and others merely listening keys, in which latter case two separate ringing keys, one for the answering and one for the calling cords, are fitted. Although the types of key may vary in construction, the principle of their action is much the same in all cases.

Ringing Leads.—A hand generator is usually provided to furnish ringing current but as the traffic on P.B.X. switchboards increases, it becomes desirable to relieve the operator of the work of turning the generator handle. In these cases ringing current is obtained from the public exchange by means of ringing leads and ringing is therefore effected **automatically** as a normal condition when a ringing key is operated but the hand generator is retained in reserve for use in cases of failure

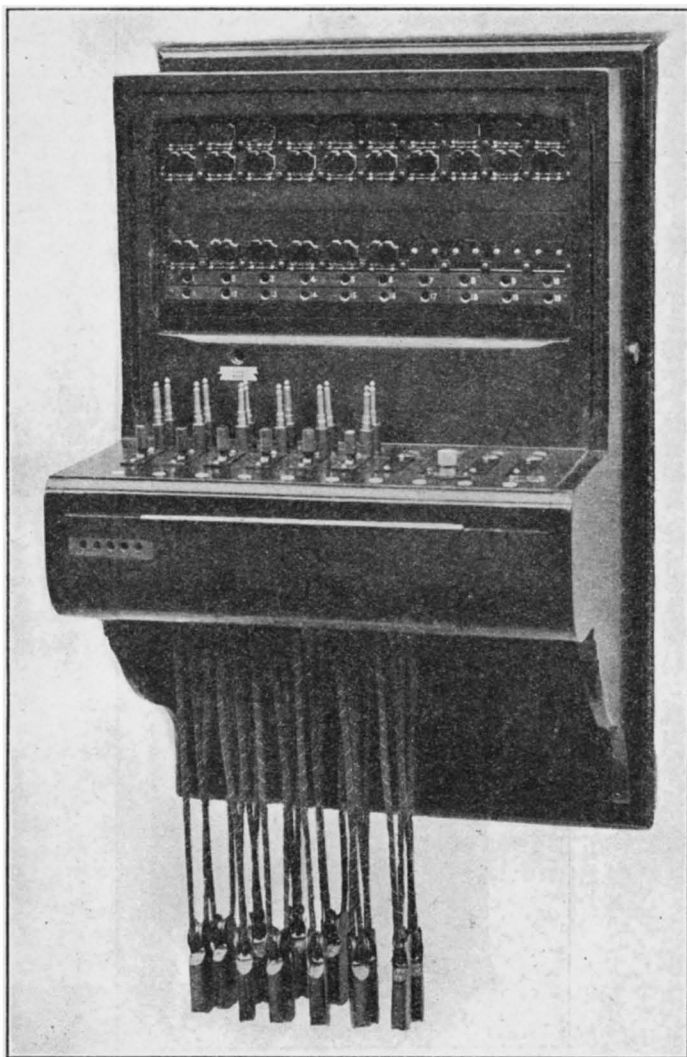


Fig. 9.—SWITCHBOARD, W.P., N.T., No. 23

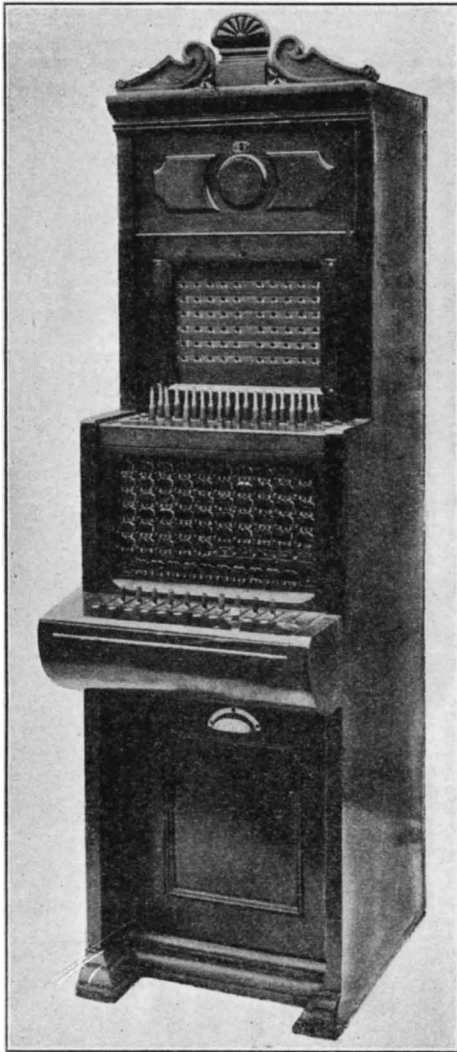


Fig. 10.—SWITCHBOARD, W.P., N.T., No. 3.

of the exchange ringing current. For the ringing leads a metallic return circuit between the public exchange and the P.B.X. is provided and a 6-point, 2-position switch or other equivalent means of changing over the ordinary generator is fitted at the P.B.X. Ringing facilities are connected to the switchboard at the P.B.X. *via* the change-over switch and at the public exchange to the ringing machines through a resistance lamp, the only earth connection on the leads being at the public exchange.

Night Service.—When working to a public **non-condensered** Magneto exchange any extension may be connected to any exchange line for night service by means of any pair of cords on the switchboards.

When the public exchange is a **condensered** Magneto or C.B. exchange the two jacks per line previously referred to are provided on all exchange lines and condensers are connected in series with all the ring-off indicators as shown by Loose Leaf Diagram N. 924. Condensers are also fitted in the bell circuits at extension stations, when night service is required. These modifications permit of any “night service” extension being connected to the public exchange by means of any pairs of cords for the P.B.X. switchboard.

Operating.—The operating procedure is identical with that which obtains on the Switchboards, W.P., N.T., No. 19, 20 and 21 except that it is not essential, as in the case of the switchboards referred to, to operate the speaking key before the insertion of a calling plug.

FACILITIES FOR “CALLING IN” P.B.X. OPERATORS.

In Magneto systems with supervisory signals actuated by generator current the supervisory signals at the public exchange and at the branch exchange are both operated if an extension station gives a generator ring in the course of an exchange call, and the operator at the public exchange at once severs the connection. Subscribers, however, sometimes desire that an extension station shall be able to obtain the attention of the P.B.X. operator, whilst an exchange call is in progress. In this case what are known as “**calling in**” facilities have to be provided by means of apparatus not ordinarily fitted on the switchboard.

The additional equipment required at the branch exchange to provide for “calling in” facilities consists of Repeating Coils, “Doll’s Eye” Indicators, a 7-Cell Battery, and Press Buttons. The repeating coil, which is included in the exchange line equipment on the P.B.X., allows generator rings to pass to line but prevents the battery current used in connection

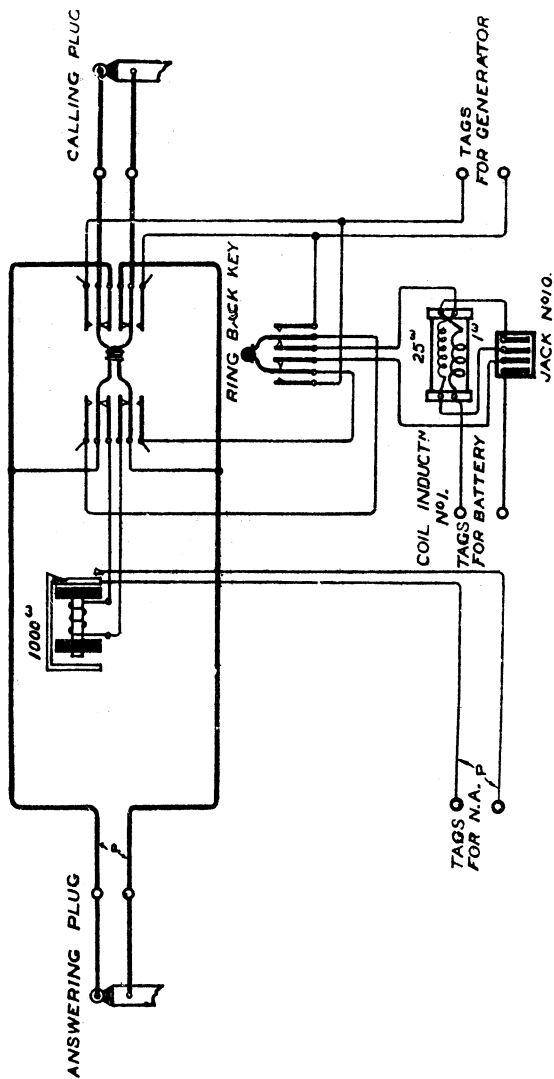


Fig. 11.—SWITCHBOARDS, W.P. D.C. N.T. No. 22 AND 23. CORD CIRCUIT.
 SWITCHBOARDS, F.P., D.C. N.T. No. 3 AND 7. CORD CIRCUIT.

with the "calling in" facility from doing so. The "Doll's Eye" indicator and the battery in series are connected to the centre point of the repeating coil windings on the branch exchange side and, therefore, to the springs of the exchange line jack. At each extension station a press button is fitted having one spring connected to earth and the other to the centre of the bell coils of the extension instrument. The depression of a press button at an extension station which is connected over an exchange line to the public exchange, therefore, completes the battery circuit through the "Doll's Eye" indicator. The indicator is thus actuated, indicating to the P.B.X. operator that attention is required on the corresponding circuit. The operator then enters the circuit and ascertains the reason for the signal and can, if required, connect the exchange line to another extension without affecting the supervisory signal at the exchange, thus preserving the continuity of the call. The "Doll's Eye" indicators are fitted in a special case mounted on the top of the P.B.X. switchboard framework and the remainder of the special apparatus is accommodated in any available convenient position. This "calling in" device is applicable to both Wall and Floor pattern switchboards, and the typical arrangement is indicated in Loose Leaf Diagram N. 925.

MIXED SERVICE WORKING ON DOUBLE CORD SWITCHBOARDS.

Mixed service working is provided for on Wall and Floor pattern double cord switchboards by:—

- (1) connecting together the tip and sleeve of each exchange line jack;
- (2) connecting together the ring and sleeve of each private wire or tie line jack;
- (3) replacing two-way plugs and cords by three-way plugs and cords.

Loose Leaf Diagrams N. 922 and N. 928 show a typical arrangement.

GENERAL PRINCIPLES FOLLOWED IN INSTALLATION.

Position for the Exchange Switchboard.—It is often difficult when arranging for the installation of a branch exchange to obtain a suitable position for the switchboard. If only a few lines are concerned, the traffic is usually too light to require the services of a full time operator, and the switchboard has often, of necessity, to be placed in a room occupied by several persons who have other definite duties to perform. In such

circumstances, the operating of the branch exchange is generally delegated to a junior member of the staff, and the subscriber's service suffers in consequence. If such conditions exist, the switchboard should be placed within easy reach of the person deputed to attend to it, due regard being paid to accessibility for maintenance purposes and lighting.

Telephone cabinets should not, for obvious reasons, be used for housing switchboards and care must be taken to avoid damp walls or walls subject to excessive vibration.

A talk with the subscriber, or a responsible member of his staff is usually well worth while. It enables the position of all apparatus and cables to be mutually agreed upon, and the opportunity can be taken to ascertain, if possible, the position occupied by gas or water pipes in walls.

The best conditions are secured when a subscriber is willing to set aside a small room for the exchange. If possible this should not be one used as a thoroughfare to other rooms. Well conducted and efficient branch exchanges exist in most towns and reference to them will often influence subscribers to adopt recommendations which will give the best results.

Cabling and Wiring.—Technical Pamphlet F. 8 should be referred to for information regarding the cabling and wiring of subscribers' premises and the provision of earth connections and power wires.

In wiring branch exchanges, however, the necessity of maintaining (a) a high insulation on all circuits; and (b) safeguarding the wires against malicious or accidental injury should be carefully studied.

A high and constant insulation resistance can be maintained only by providing suitably insulated wire in the first instance and for this reason a careful examination of the cable runs it is proposed to adopt is necessary before deciding whether lead covered or enamelled and F.P. cable should be used.

When wires or cables used in internal runs are liable to malicious or accidental injury, use should be made of wood casing or steel conduit. This, however, is required in exceptional cases only. It is often found advantageous where floors are boarded to run lead covered cables beneath the floors where they are safe from injury and need no further protection. Gas and water pipes must be avoided and if possible, a three foot clearance should be maintained.

Protection and distribution.—The principles to be followed and details of the apparatus to be used will be found in Technical Pamphlets A.5, D.18 and F.8.

Batteries.—In fitting batteries, the following points should be borne in mind :—

The position chosen must be easily accessible for maintenance purposes but should be such that there is no risk of the batteries being disturbed by the subscriber's employees during cleaning or dusting operations or by the movement of furniture.

When batteries are not placed in the telephone room, the most suitable place consistent with economical wiring must be chosen. If batteries have of necessity to stand upon damp stone floors, use should be made of "Feet, Battery (earthenware)" which will lift the batteries above the floor and allow of the circulation of air beneath them.

Testing out.—Upon completion of the installation a comprehensive test of all circuits should be made before the installation is handed over to the subscriber.

Prior to effecting any ringing or speaking tests, all batteries including those at the extension stations must be tested by means of Detector No. 2 and Coil, Testing No. 1 the use of which is explained in Loose Leaf Diagram T.102. Alarm bell circuits should be tested and any necessary adjustments made. Switchboard cords and pulley weights should be tried to see that they work freely and are not in any way fouled. All switchboard cords should be tested and the plugs examined to see that they enter the jacks in a satisfactory manner. The hand generator (or power ringing) should also be tested, making sure that the cut-out works properly. All labelling must be verified and completed.

A test must be made from each extension instrument to the branch and public exchanges and the ring-off indicators should be tested. These tests should be made in conjunction with the Test Clerk and finally the completion of the work reported to him.

It is not usually necessary to call in and employ the Test Clerk for the purpose of localising faults in Magneto Branch Exchanges. If the fitter studies the simple diagrams involved the cause of faults on the internal work should be clear. The "trial and error" method of localising faults should be avoided. An endeavour should be made to ascertain definitely the nature of any fault which occurs and the circuit it affects. Steps should then be taken to localise the trouble by carefully testing the apparatus and wiring concerned by means of a battery and a Detector No. 2. All completed work should be immediately reported, as revenue commences from the date the circuits are brought into use.

Cards of Instruction.—Instruction Cards for the various switchboards are stocked and should be supplied in every case.

MAINTENANCE.

In the maintenance of branch exchanges, cleanliness of the apparatus and the regular operation and testing of the switches and other devices provided for securing continuity of service are of primary importance and it is usual to depute to the subscriber simple duties of a non-technical character which not only tend to prevent faults arising, but help to maintain the apparatus in a clean and tidy condition.

Maintenance work allotted to subscriber.—This consists of:—

(1) Testing cords where cord test facilities are provided.

(2) Keeping the outside woodwork of the switchboard free from dust.

(3) Wiping out transmitter mouthpieces at intervals.

(4) Proving alarm bell circuit, reserve operating set and reserve batteries (if any) daily.

(5) In large works, where night watchmen or firemen are employed, it is usual to connect certain extension instruments to the public exchange for use after normal hours in case of fire or sudden emergency. These instruments should be tested daily before noon by the P.B.X. operator to ensure that any faults existing may be removed the same day. Much unnecessary confusion and annoyance can be obviated by the adoption of this simple precaution.

(6) Reporting promptly to the Public Exchange Supervisor all faults affecting the Department's plant.

Generally the maintenance for which the subscriber is responsible should be limited to the foregoing, and it will seldom be found after proper explanation has been given that any objection is raised by subscribers to allowing their P.B.X. operators to carry out the work.

Inspections.—Regular maintenance visits are not generally made but in the case of large installations or those of an exceptional nature, the question as to whether visits for maintenance purposes shall be made or not is determined locally. The plant is, of course, inspected as a matter of routine when a workman visits the premises for fault removal purposes.

In carrying out a maintenance inspection, every part of the apparatus which is likely to become worn or to get out of adjustment must be examined and replaced if necessary.

Apparatus must not be left in position until it deteriorates to such an extent that even a skilled mechanic cannot repair it.

The Department's system of Maintenance Exchange provides a ready means of exchanging damaged or worn out parts and there is no necessity for retaining any faulty part in use.

If the maintenance officer contracts the habit of testing and examining each part of the installation in a systematic manner, taking each part in a definite sequence, he will find that after a time the various operations become almost automatic and the risk of omitting any operation will be reduced to a minimum. The inspection should include the following :

(1) Test batteries in accordance with the instructions given in Loose Leaf Diagram T. 102.

(2) Dust the inside of switchboard including key board and base by means of instrument dusting brush and small bellows.

(3) Examine all ringing and listening keys. See that the axle pins have not become badly worn. If they have, the operation of the springs will be affected and the key should be replaced.

(4) Examine all soldering tags and screw connections.

(5) Test, repair or replace all switchboard or instrument cords which are faulty or which show signs of wear. In small P.B.X's the cords can be tested by means of a speaking test with the Test Clerk. When such tests are made care should be taken to shake the cord gently during conversation. A cord test circuit is now fitted on the larger types of P.B.X. switchboards and the test is made by inserting the plug associated with the cord to be tested in the cord test jack. A grating noise in the receiver caused by broken strands of the conductor will indicate faulty cords.

(6) Test all ring off and supervisory signals and make any necessary adjustments.

(7) Examine working and reserve operating instruments and replace any missing nuts, &c.

(8) Examine protector and distribution cases, dust out, see that labelling is intact, and that the earth connections are firm. Examine protectors, replace any damaged mica separators and verify that fuses are properly gripped by their holders.

(9) Examine hand generator, and connections of ringing leads (if provided).

Spare switchboard and instrument cords should be carried by the maintenance officer. Public Exchange switchboard cords which have been cut down in the course of maintenance

until they can no longer be used for their original purpose should be utilised for making up cords for P.B.X.'s unless they are too short or otherwise unsuitable.

Before fitting new or repaired cords, the spring terminal connection to which the tag end of the cord is connected must always be examined to ascertain that the connection is sound.

It should be fully realised by all men responsible that the efficiency of a Magneto System is dependent very largely on the economical and efficient maintenance of primary batteries and that if the Department's standard is strictly adhered to the actual faults that occur will be mostly of a simple nature and generally confined to working parts.

Damage to Apparatus.—Special care should be exercised in adjusting the springs of listening keys or switchboard jacks. If any difficulty arises in making satisfactory adjustments the faulty items should be replaced and handed over to the mechanic for attention.

Faulty keys or jacks should be extracted from their normal position for examination when faults occur. It will seldom be found that a subscriber's service need be stopped even when the replacement of a key or a jack is involved and when necessary use can be made of spares which are generally obtainable at short notice from the district mechanic.

LIST OF

Technical Pamphlets for Workmen.

(Continued.)

GROUP E.

1. Automatic Telephony. Step by Step Systems.
2. Automatic Telephony. Codex 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, &c.
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.

===== LIST OF =====

Technical Pamphlets for Workmen.

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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. Quadruplex. 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, &c.
21. Call Offices.

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