 PW—F2

Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject

Subscribers' Apparatus. C.B.S.

PART I. C.B.S. No. 1 System

ENGINEER-IN-CHIEF'S OFFICE
1919

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14. Maintenance of Manual Telephone Exchanges.
15. Telephone Testing Equipment.
16. Routine Testing for Manual Telephone Exchanges.
17. Internal Cabling and Wiring.

[*Continued on page iii of Cover.*

CORRECTION SLIP TABLE

The month and year of issue is printed at the end of each amendment in the Correction Slips, and the number of the slip in which any particular amendment is issued can, therefore, be traced from the date. In the case of short corrections made in manuscript, the date of issue of the slip should be noted against the correction.

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SUBSCRIBERS' APPARATUS.
C.B.S.
(F. 2)

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

D. 1. Elementary Principles of Telephony.

D. 3. Principles of Telephone Exchange Signalling.

D. 6. C.B.S. No. 1 Exchanges—Non-Multiple type.

D. 7. C.B.S. Exchanges—Multiple type.

D. 15. Telephone Testing Equipment.

D. 19. Cord Repairs.

D. 21. Call Offices.

F. 8. Wiring of Subscribers' Premises.

TABLE OF CONTENTS.

PART I. C.B.S. No. 1.

Part II. C.B.S. Nos. 2 and 3 (in preparation).

SUBSCRIBERS' APPARATUS, C.B.S.

PART I. C.B.S. No. 1.

(1) INTRODUCTORY REMARKS

The No. 1 Common Battery Signalling or C.B.S. No. 1 system is a **"loop call"** and **"earth clear"** system in which the signals are automatically controlled by the removal and replacement of the subscriber's receiver. Generators are provided at the subscriber's station, only when required for ringing over extension lines. The common battery located at the exchange is used for all general signalling purposes and a battery of 2 cells for speaking purposes is associated with each telephone at the subscribers' stations. It follows, therefore, that C.B.S. No. 1 standard telephones do not require to have generators associated with them as a general rule.

(2) SUBSCRIBERS' INSTALLATIONS

The C.B.S. No. 1 system provides for all the various services usually required by exchange subscribers.

Subscribers' installations may, therefore, be subdivided into the following classes :—

(*a*) Direct exchange lines with one subscribers' station.

(*b*) Direct exchange lines with one or two simple extensions, *i.e.*, extensions without facilities for intercommunication between any of the stations.

(*c*) Direct exchange lines with one or two extensions, having facilities for intercommunication between the main and extension stations, independently of the exchange connection.

(*d*) Direct exchange lines terminating on a Private Branch Exchange switchboard and extensions therefrom, with full facilities for intercommunication between all stations.

(*e*) Party lines (2 or 12 party).

(*f*) Party lines, with one or two simple extensions at individual main stations.

In classes (*a*) to (*d*), the subscriber has exclusive use of the exchange line, but in classes (*e*) and (*f*), the use of the exchange line is shared by the subscribers connected therewith.

(3) TYPES OF APPARATUS FOR DIRECT EXCHANGE LINES, PARTY LINES AND EXTENSIONS

The design of telephones used at subscribers' stations has changed from time to time, and although in the standard

Plan Number diagrams, Telephones No. 3, 4 and 11 only are shown, it is necessary, for stock reasons, to use some of the earlier types, *e.g.*, Telephones No. 59, 69, 88, etc., in connection with C.B.S. No. 1 installations.

As indicated above, Telephones No. 3, 4 and 11 are depicted in the standard diagrams.

The first and third are **Wall** Type telephones, and the second is a **Table** telephone.

The **Wall** telephones are self-contained units. In both types, the transmitter is mounted on the outside and the bell mechanism, induction coil, gravity switch and two-cell speaking battery are placed inside the case. The switch arm associated with the switch protrudes from a slot in the side of the case and normally forms a rest for the receiver. In addition to the items common to both types of telephone, the Telephone No. 11 is fitted with a generator inside the case and is fitted only at extension stations with intercommunication. In all other respects Telephones Nos. 3 and 11 are identical.

The **Table** telephone is of the pedestal type and includes the transmitter, receiver, gravity switch and receiver rest (switch arm) with the necessary transmitter and receiver connecting cords.

A complete Table telephone consists sometimes of 2 and sometimes of 3 units, according to the kind of installation (*see* Section (2)) with which it is associated. Its composition in various circumstances is as shown below :—

On a direct exchange line with one station.	A telephone and a bell set.
On a direct exchange line with one or two simple extensions.	A telephone and a bell set at each station.
On a direct exchange line with intercommunication extensions.	*At the main station.*—A telephone and two bell sets. *At extension station.*—A telephone, a bell set, and a generator.
On P.B.X. lines	*At extension stations.*—A telephone and a bell set, and in some circumstances a generator also.
On party lines	*At main and extension stations.*—A telephone and a bell set.

Bell Sets are cases containing items of apparatus, complementary to the ordinary telephone at subscribers' stations. There are four standard types for use in connection with C.B.S. telephones, *viz.*: Bell Set No. 5, Bell Set No. 6, Bell Set No. 7 and Bell Set No. 15.

Bell Set No. 5 contains an induction coil and magneto bell.

Bell Set No. 6 contains an induction coil, and a trembler bell is mounted on the outside of the case.

Bell Set No. 7 contains a 4-position switch operated by an external handle, an indicator, a generator, and a magneto bell.

Bell Set No. 15 contains an induction coil, a magneto bell and a condenser.

Bell Sets No. 5, 6 and 15 need not be closely associated with the telephone but may be placed on a wall or other suitable support.

Bell Sets No. 7 must be closely associated with the telephone in order that the switching and ringing apparatus may be within reach for easy manipulation.

Generators.—The generators used in Telephones No. 11 and Bell Sets No. 7, and as separate units at some extension stations, are of the 3-magnet type.

Telephones No. 3 are suitable for use :—

(*a*) On direct exchange lines with one extension.

(*b*) At main and extension stations on direct exchange lines with simple extensions.

(*c*) At the main station on direct exchange lines with intercommunication extensions.

(*d*) At the extension stations on extension lines connected with a P.B.X. switchboard, if a generator is not required.

(*e*) At main and extension stations on party lines.

Telephones No. 4 are suitable for use :—

(*a*) On direct exchange lines with one station.

(*b*) At the main and extension stations on direc exchange lines with simple extensions.

(*c*) At the main and extension stations on direct exchange lines with intercommunication extensions.

(*d*) At the extension stations on extension lines connected with a P.B.X. switchboard.

(*e*) At main and extension stations on party lines.

Telephones No. 11 are used at extension stations on direct exchange lines with intercommunication extensions.

Connections of the various telephones and bell sets are shown in the " N " series of Loose Leaf Diagrams.

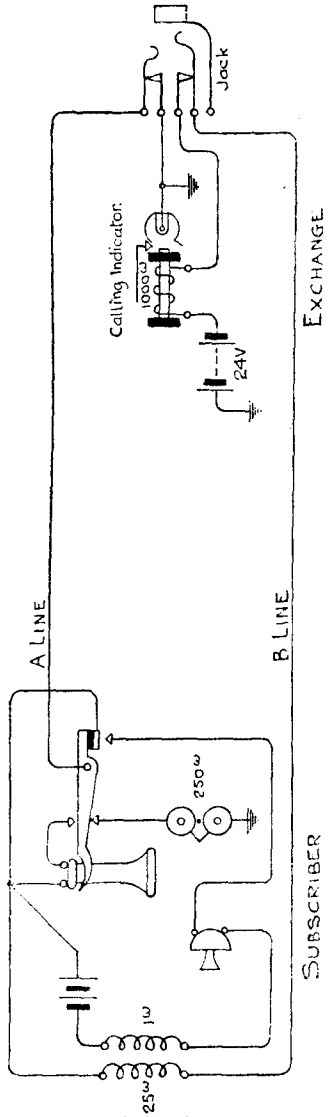

FIG. 1.—Principle of Subscribers' Circuit.

(4) C.B.S. No. 1. SUBSCRIBERS' CIRCUIT. GENERAL PRINCIPLES

Fig. 1 illustrates the principles of a subscriber's exchange line circuit. It will be observed that the connections of the apparatus at the subscriber's end are controlled by the position of the switch arm on which the receiver rests normally. When the receiver is on the rest the A-wire is to earth *viâ* the magneto bell and the B-wire, which is connected to the 25Ω winding of the induction coil and receiver, is disconnected. The local transmitter circuit is also disconnected. Under this condition, the exchange can ring the subscriber by applying a generator with earth return, to the A-wire.

When the receiver is lifted from its rest, the movement of the gravity switch disconnects the bell and loops the A- and B-wires through the 25Ω winding of the induction coil and the receiver, and, also, completes the local circuit of the transmitter. Under this condition, the circuit of the signalling battery at the exchange is completed *viâ* the calling indicator, the "B" springs of the exchange jack, the B-wire, subscribers' apparatus, A-wire and the "A" springs of the exchange jack. The indicator at the exchange is, therefore, actuated and displays a calling signal The exchange operator's attention can thus be directed to the circuit in order that a call may be made.

When a connection with another line has been established at the exchange by means of a cord circuit, the earthing of the A-wire *viâ* the bell, on the replacement of the receiver at the subscriber's station, causes a clearing signal to be received at the exchange on an indicator included in the cord circuit, as described in detail in pamphlets P.W.-D.6 and P.W.-D.7.

(5) SUBSCRIBERS' CIRCUIT ARRANGEMENTS AND DIAGRAMS

Direct exchange line with only one station and party lines.—Telephones No. 3 (Wall type) or Telephones No. 4 (Table type) with Bell Set No. 5 or 15, as already described, are standard for use on these classes of line. The connections of the wall telephone when fitted on a direct exchange line are shown by Loose Leaf Diagram N. 103, and when fitted on a party line, by Diagram C.B.S. 141. The connections of a table telephone set when fitted on a direct exchange line are shown by Loose Leaf Diagrams N. 104 (Telephone) and N. 505 (Bell Set) and, when fitted on a party line, by Diagram C.B.S. 141 (N. 1276).

Direct exchange lines with extensions.—If more than one telephone is fitted in connection with an exchange line, the first point at which a telephone is installed, *i.e.*, the point

at which an incoming ring is received normally, is referred to as the "**Main Station,**" and the other points at which the telephones are fixed are known as "**Extension Stations.**"

Installations comprising a main and one or more extension stations are divisible into the three classes indicated under (*b*), (*c*) and (*d*) in Section 2 and are repeated here for convenience.

(*b*) Direct exchange lines with one or two simple extensions, *i.e.*, extensions without facilities for intercommunication between any station.

(*c*) Direct exchange lines with one or two extensions having facilities for intercommunication between the main and extension stations, independently of the exchange connection.

(*d*) Direct exchange lines terminating on a P.B.X. switchboard and extensions therefrom, with full facilities for intercommunication between all stations.

For installations falling into classes (*b*) and (*c*), *i.e.*, for direct exchange lines with extensions on which **full** intercommunication facilities are not afforded and for P.B.X. extensions (class (*d*)), on which certain extra facilities are provided, a series of standard circuit arrangements has been designed, which is usually referred to by plan numbers.

A brief description of each of these arrangements and a reference to the numbers of the diagrams on which they are shown follows :—

Plan 1

Loose Leaf Diagram N. 1424 is a diagrammatic representation of this arrangement which is provided on *internal extensions only*. The maximum number of extensions that may be installed on the basis of this plan is three or six, according to the rate of payment for the service.

The diagrams showing the circuit connections for two extensions and the various types of telephones, etc., that may be used are given in the following table :—

Diagram No.	Main Station		Extension 1		Extension 2	
	Telephone	Bell Set	Telephone	Bell Set	Telephone	Bell Set
N. 1340	No. 4	No. 5	No. 4	No. 6	No. 4	No. 6
N. 1341	,, 4	,, 5	,, 4	,, 6	,, 3	—
N. 1342	,, 4	,, 5	,, 3	—	,, 3	—
N. 1343	,, 3	—	,, 3	—	,, 3	—
N. 1344	,, 3	—	,, 3	—	,, 4	No. 6
N. 1345	,, 3	—	,, 4	No. 6	,, 4	,, 4

If more than two extensions are provided, the apparatus installed at the extra points would be of the same type as that fitted at either extension station 1 or 2.

All the extension telephones are connected in parallel with the telephone at the main station. Conversation emanating from, or received at, any station can, therefore, be overheard at any other station, and the removal of the receiver from its rest on any of the telephones calls the exchange. Intercommunication between one extension station and another, or between an extension station and the main station, is not provided for.

All incoming calls are received at the main station, where the only magneto bell used in connection with the installation is fitted.

Local bell circuits are provided to enable the main station to gain the attention of extension stations, when required for an incoming exchange call. Each of these circuits comprises a trembler bell, which is included in the bell set, or fitted separately as the case may be, at the extension station, wired to a corresponding press button at the main station, and includes the speaking batteries at the extension and main stations. The connections are such that, when a press button is depressed, the speaking batteries at the main and called extension stations are connected in series and supply current for the operation of the bell.

Plan 1a

Loose Leaf Diagram N. 1425 is a diagrammatic representation of this arrangement, which is provided *only on internal extensions*. The number of extensions on this plan is limited to one.

The diagrams showing the circuit connections and the various types of telephones, etc., that may be used are given in the following table :—

Diagram No.	Main Station		Extension	
	Telephone	Bell Set	Telephone	Bell Set
N. 1346	No. 4	No. 5	No. 4	No. 5
N. 1347	,, 4	,, 5	,, 3	—
N. 1348	,, 3	—	,, 3	—
N. 1349	,, 3	—	,, 4	No. 5

The magneto bell at the main station is permanently in circuit but at the extension station the bell is controlled by

a tumbler switch, thus providing an arrangement whereby an incoming ring may be received when desired at the extension as well as at the main station.

As in the case of Plan 1, the extension station telephone is connected in parallel with the telephone at the main station, and the exchange may be called from both points by lifting the receiver from its rest. Neither secrecy nor intercommunication is provided for.

Plan 2

No arrangement has been standardized under this number.

Plan 3

Loose Leaf Diagram N. 1426 is a diagrammatic representation of this arrangement which is provided *only on internal extensions.* The number of extensions on this plan is limited to one.

The circuit connections and the various types of telephones, &c., that may be used are given in the following table :—

Diagram No.	Main Station		Extension	
	Telephone	Bell Set	Telephone	Bell Set
N. 1350	No. 4	No. 5	No. 4	No. 6
N. 1351	,, 4	,, 5	,, 3	—
N. 1352	,, 3	—	,, 4	—
N. 1353	,, 3	—	,, 4	No. 6

Under normal conditions the exchange line is connected *viâ* a 6-point, 2-position switch at the extension station to the telephone at the main station, and the latter station calls the former when required by means of a press button which is associated with the trembler bell included in the bell set or fitted separately as the case may be at the extension station.

The talking circuit of the telephone at the extension station is permanently connected to the exchange line and is, therefore, in parallel with the telephone at the main station when the switch is in the normal position. Under these conditions, the magneto bell at the extension station is not in circuit.

Should it be desired to obtain secrecy at the extension station on an exchange call, the main station can be cut out

by operating the switch. The operation of the switch simultaneously connects the magneto bell to the circuit in such a manner that, in the event of the non-restoration of the switch, the exchange is able to call the subscriber, although the main station is cut off. If it be desired, a switch which must be held over during conversation and which, on release will automatically restore the normal connections, can be fitted, instead of one of the usual pattern that must be deliberately restored after operation.

As in the case of Plan 1 extensions, intercommunication is not available.

Plan 4

Loose Leaf Diagram N. 1427 is a diagrammatic representation of this arrangement which provides for the *internal extension* of an exchange line to one or more points whence calls can be made or answered by means of a portable telephone.

The circuit connections are shown in Diagram N. 1354.

The exchange line is connected to a Bell Set No. 5 at the main station, and thence to jacks fitted at any point from which it is desired to talk. A Telephone No. 4 terminated on a plug, is provided and connection with the bell set is established by inserting the plug in the jack at the various points. One of the jacks is, of course, at the main station.

The bell at the main station is permanently in circuit. If this bell cannot be heard at any extension point, a magneto bell is associated with the jack at that point. The connections between the jack and the bell are such that the latter is joined in series with the bell at the main station when a plug is inserted in the jack. An incoming ring will, therefore, be received at the main station and heard at points within hearing distance, and also at any point where an additional bell is fitted outside that distance, if the telephone plug is in the jack at that point.

Plan 5 and 5a

Loose Leaf Diagram N. 1428 is a diagrammatic representation of this arrangement which is provided *only on internal extensions*. These arrangements are a combination of Plan 7 or 7A and Plan 1A with slight modifications, and they afford limited facilities for intercommunication between stations. Plan 5 is a modified combination of Plan 7 and Plan 1A. Plan 5A is a modified combination of Plan 7A and Plan 1A. The number of extensions on these Plans is limited to two.

The diagrams showing the circuit connections and the telephones, etc., that may be used are given in the following table :—

Diagram No.	Main Station		Extension 1			Extension 2		
	Telephone	Bell Set	Telephone	Bell Set	Generator	Telephone	Bell Set	Generator
N. 1355	Table Set (Tele. No. 4, with Bell Set No. 5) or Wall Set (Telephone No. 3.)	No. 7	No. 4	No. 5	No. 4	No. 4	No. 5	No. 4
N. 1356	,,	,, 7	,, 4	,, 5	,, 4	,, 11	—	—
N. 1357	,,	,, 7	,, 11	—	—	,, 11	—	—
N. 1358	,,	,, 7	,, 11	—	—	,, 4	No. 5	No. 4

A full description of the Bell Set No. 7 is given later in connection with Plans 7 and 7A.

The extension station telephones are connected in parallel and the extension stations are called from the main station by means of the generator in the Bell Set No. 7 and individual press buttons. The magneto bells at the extension stations are not connected to the line in the usual way, but to a third wire between the main and extension stations. At the main station, this wire is connected to one side of each press button, whilst on one press button the opposite side is connected to the bell set and on the other it is earthed. This arrangement enables the main station to ring either extension station at will.

A generator is included in the apparatus fitted at each extension station and the attention of the main station can be gained by a generator ring in all positions of the switch on the Bell Set No. 7.

When the switch is in the " through " position each extension station can call and clear direct to the exchange and rings from the exchange are received at both main and extension stations.

An indicator controlled by a small subsidiary switch is provided on the Bell Set No. 7, in order that a means may be available of ascertaining if the line is engaged when the switch is in the " through " position. The small switch enables the indicator to be disconnected when it is desired to

leave the exchange line " through " for extended periods either at night or at other times.

Night service can be afforded on either one of the extensions. When such service is required, a tumbler switch is fitted at the main station. During the period of night service, this switch is thrown, the main switch is left in the " through " position and the indicator switch is opened. The function of the tumbler switch, when operated, is to short-circuit the bell at the extension station at which night service is **not** available. Direct communication between the night service extension station and the exchange is thus available.

Secrecy at the main station against the extension stations is provided for but the extensions are not secret against each other. Secrecy at the extension stations against the main station depends on whether the circuit is arranged according to Plan 5 or Plan 5A, that is to say, whether Plan 7 or Plan 7A connections are adopted at the main station. When the switch is in the " through " position Plan 7A provides for secrecy at the extension stations against the main station, whereas Plan 7 does not. This difference is dealt with in detail in connection with Plans 7 and 7A.

Plan 6

No arrangement has been standardized under this number.

Plans 7 and 7a

Loose Leaf Diagram N. 1429 is a diagrammatic representation of alternative arrangements which may be provided on internal or external extensions. The number of extensions connected to the main station on this plan is limited to one.

Diagrams showing the circuit arrangements and the various types of telephones, etc., that may be used are given in the following table :—

Diagram No.	Main Station		Extension Station		
	Telephone	Bell Set	Telephone	Bell Set	Generator
N. 1359	Wall Set .. .. (Telephone No. 3) or Table Set (Telephone No. 4 with Bell Set No. 5)	No. 7	No. 4 or No. 11	No. 5	No. 4

The Bell Set No. 7 fitted at the main station comprises a main switch, a magneto bell, a subsidiary switch and indicator, and a generator. To this bell set are connected the exchange line, the extension, and the main station telephone.

Details of the connections of the latest pattern Bell Set No. 7 are given in Diagram N. 507, Sheet 4, which also includes figures showing the skeleton connections of the Bell Set in the four positions of the main switch. The four positions of the main switch are :—

No. 1—Main to Exchange, Extension on Extension bell.
No. 2—Main to Extension, Exchange held.
No. 3—Main to Extension, Exchange on Extension bell.
No. 4—Exchange to Extension.

In the Plan 7A arrangement, terminals A-A1 and B-B1 of the bell set are not strapped. Secrecy is, therefore, afforded on exchange to extension calls.

In the Plan 7 arrangement, terminals A-A1 and B-B1 are strapped together, thus placing the main station talking circuit in parallel with the extension station telephone when the switch is in the fourth or " through " position and rendering the service non-secret so far as the extension stations are concerned. The advantage of this arrangement is that the main station is able to supervise the setting-up of a connection between the extension and the public system.

There is no difference, except in the foregoing respects, in the functions and connections of the switch under the Plans 7 and 7A arrangements.

In both the Plan 7 and Plan 7A arrangements, the extension is connected to a bell when the exchange line is connected to the main station telephone and *vice versâ*.

Position 2 of the main switch " Main to Extension, Exchange held " is provided in order that a clear shall not be given to the exchange while the attention of the extension is being obtained for an incoming call.

In the fourth position of the main switch, the indicator is actuated when the line is disengaged if the subsidiary switch is closed.

The exchange rings the main station by generator and is called from the main station by lifting the telephone receiver from its rest.

If the main switch is in the " through " position, a ring from the exchange will actuate the bells at the main and extension stations simultaneously, and under this condition the extension station can call and clear direct to the exchange by lifting and replacing the receiver.

The main station gains the attention of the extension station and *vice versâ* by generator ring.

Night service is available at the extension station by leaving the main switch in position 4, but the subsidiary switch in this case should be open in order that the indicator at the main station may be left disconnected.

Plan 8

Loose Leaf Diagram N. 1430 is a diagrammatic representation of this arrangement, which is provided *only on internal extensions*. The number of extensions on this Plan is limited to one.

The diagrams showing the circuit arrangement and the telephones, etc., that may be used are given in the following table :—

Diagram No.	Main Stations, No. 1 and 2		Extension	
	Telephone	Bell Set	Telephone	Bell Set
N. 1360	No. 3 or No. 4	— No. 5	No. 4	No. 6
N. 1361	No. 3 or No. 4	— No. 5	No. 3	—

This arrangement provides for one extension common to two exchange lines.

Each exchange line is permanently connected to a separate main instrument and also by a " teed " connection to the contacts of a 3-position key switch at the extension station. The extension station telephone is wired to the moving springs of this switch and it may, therefore, be connected to either exchange line in parallel with the main telephone on the exchange line selected by the operation of the switch, or it may be left disconnected by placing the switch in the normal position.

Since the extension telephone when connected is in parallel with one or other of the main telephones, the extension station can call and clear direct to the exchange.

The circuit of the magneto bell associated with each main telephone passes through the extension station telephone and switch, a special signalling wire being provided between the extension station and each main telephone. This circuit, by

means of which clearing signals are given to the exchange, is controlled by the switch arm on each instrument, and is so arranged that it is completed in any of the three positions of the extension station switch when the receivers on each telephone are on their respective rests.

The magneto bell of the extension telephone is not used, all incoming rings being received at the main station. To enable the main station to signal the extension station when required, a press button is associated with each main telephone and connected to trembler bells of different tones at the extension station.

The arrangements under this Plan number do not provide for secrecy or intercommunication.

Plan 9

Loose Leaf Diagram N. 1432 is a diagrammatic representation of this arrangement, which is suitable for use in connection with either internal or external extensions. *The arrangement is limited to groups of two extension lines connected to a Private Branch Exchange.*

The circuit connections of the apparatus required are shown in Loose Leaf Diagram N. 1362.

This arrangement provides a means whereby a subscriber on a P.B.X. extension telephone may use the same telephone to make an independent enquiry over a second extension without releasing the first connection.

The two extensions are both connected to calling equipment on the switchboard, but at the extension station, means of receiving a call is not normally provided on the second extension. Calls may, therefore, be originated on either line, but the second line cannot be used for incoming calls. It is usual, however, to reserve the first extension for both originated and incoming traffic and the second extension for local enquiries.

Both extensions are connected to a switching key. In the normal position of this key, the telephone is connected to the first extension and the second is left disconnected.

The operation of the key transfers the telephone from the first to the second extension and joins an earthed condenser and a 250Ω bell to the A-wire of the first extension. The second extension can then be used for the purpose of making a local enquiry, whilst an incoming call is held on the first. The connection of the bell and condenser to the first extension when the switching key is operated, enables the extension station to be rung as usual on the first extension, if the key is inadvertently left in the operated position.

Plan 10

Loose Leaf Diagram N. 1433 is a diagrammatic representation of this arrangement, which is provided *only on internal extensions*. The number of extensions that may be fitted on this Plan is limited to one connected to a Private Branch Exchange.

The circuit connections of the apparatus required are shown in Loose Leaf Diagram N. 1363.

With this arrangement, the line or lines from the main exchange are connected to the P.B.X. switchboard *viâ* break jacks *at the extension station*, where the telephone is terminated on a plug.

The extension from the P.B.X. is also connected to a break jack at the extension station, the inner A-wire spring of which is wired to an earthed magneto bell.

Normally the telephone plug is kept in the extension jack, and all calls are effected over the extension in the usual way. Should the extension station desire secrecy on an exchange call, the telephone plug may be transferred to the jack of the particular exchange line on which the connection has been established. Arrangements must, of course, be made by the subscriber for the P.B.X. operator, when putting the call through, to advise the extension station, when there is not more than one exchange line, of the line on which a call has been received.

It is not intended that calls from the extension station shall be originated directly on an exchange line, as provision is not made for an indication on the P.B.X. switchboard when the extension station telephone plug is in an exchange line jack. If calls were originated in this way, any attempt on the part of the switchboard attendant to make a call on the same exchange line would be unsuccessful.

In order that an indication may be given at the P.B.X. switchboard of an incoming ring on any exchange line left plugged up at the extension station, a bell connected in series with the extension station telephone bell is fitted adjacent to the switchboard, the connections between the two bells being taken *viâ* the exchange line break jacks. The second bell is disconnected except when the telephone plug is in an exchange line jack, and is then controlled by the switch arm of the extension station telephone.

Plan 11

Loose Leaf Diagram N. 1434 is a diagrammatic representation of this arrangement, which may be characteristically described, as a *filter arrangement*. It is provided *only on internal extensions*, the number of which on this plan is limited to groups of two, one of which must be an extension on the other.

The diagrams showing the circuit arrangements and the telephones, &c., that should be used are given in the following table :—

Diagram No.	Main Station		Extension 1		Extension 2	
	Telephone	Bell Set	Telephone	Bell Set	Telephone	Bell Set
N. 1364	No. 4	No. 5	No. 4	No. 6	No. 4	No. 6
N. 1365	,, 4	,, 5	,, 4	,, 6	,, 3	—
N. 1366	,, 4	,, 5	,, 3	—	,, 3	—
N. 1367	,, 3	—	,, 3	—	,, 3	—
N. 1368	,, 3	—	,, 3	—	,, 4	No. 6
N. 1369	,, 3	—	,, 4	No. 6	,, 4	,, 6

In addition to the apparatus shown above, a press button is required at the main and first extension stations, and trembler bell is required at each of the extension stations.

With this arrangement, as in Plan 1, the extensions are connected in parallel with the main station telephone, and secrecy and intercommunication is, therefore, not available.

The magneto bell at the main station is the only bell connected to the exchange line, therefore all calls from the exchange are received at that station. A local bell circuit is provided between the main station and the first extension station by means of a press button at the former and a trembler bell on the bell set at the latter. Another local bell circuit is similarly provided between the first and second extension stations.

As previously indicated, all incoming calls are received at the main station. By means of the local bell circuits, the first extension can be called into circuit, if necessary, from the main station and, in addition, the second extension station can be signalled from the first.

Any of the stations can originate calls and clear direct to the main exchange.

Private Branch Exchange Installations.—If full intercommunication facilities are required between the stations, a switchboard which serves the purpose of a Private Branch Exchange is fitted. Switchboards of various capacities are available to meet the requirements at P.B.X.s. For new installations having not more than 12 lines, the standard switchboards are of the C.B.S. No. 1 cordless type. These switchboards supersede an earlier type of Magneto C.B.S. switchboard, which has become obsolescent. For larger

installations double-cord switchboards of the C.B. type are fitted at the P.B.X. and auxiliary apparatus is associated with the P.B.X. lines at the main (Public) exchange as a connecting link between the C.B. and C.B.S. systems.

As there is a large number of Magneto C.B.S. switchboards in use as P.B.X.s, this type of switchboard and the method of working will be briefly described before the standard switchboards are dealt with.

Switchboards, Magneto C.B.S.—The principles of the electrical circuits are shown in Figs. 2, 3 and 4 and Loose

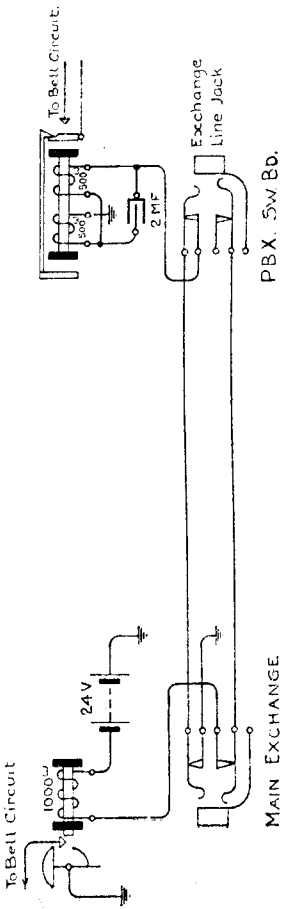

FIG. 2.—Magneto C.B.S. P.B.X. Exchange Circuit.

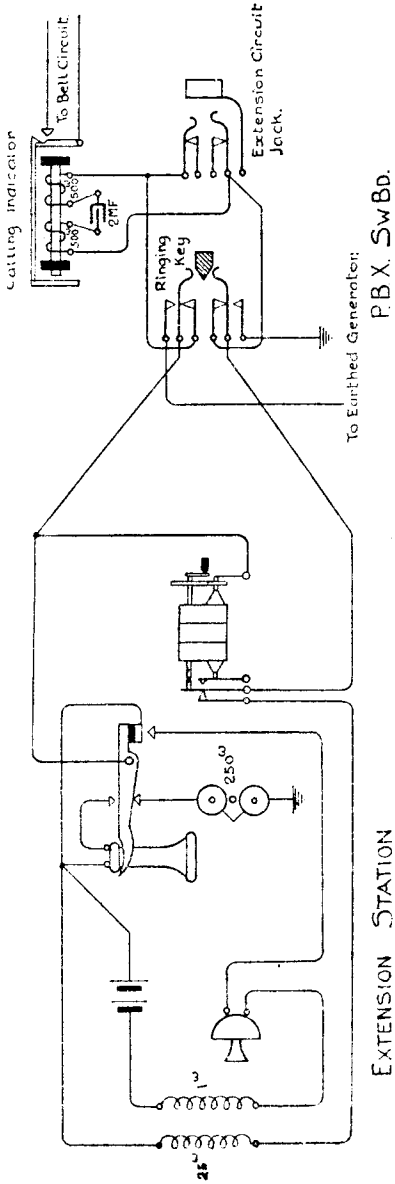

FIG. 3.—Magneto C.B.S. P.B.X. Extension Circuit.

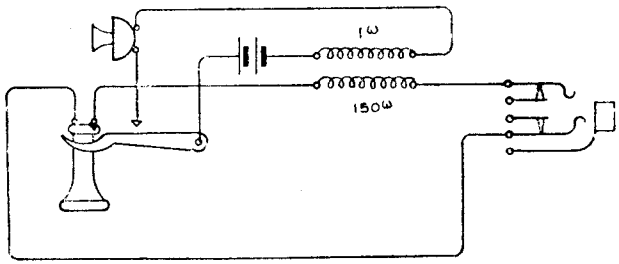

FIG. 4.—Magneto C.B.S. P.B.X. Operator's Telephone Connections.

Leaf Diagram N. 910. Pairs of plugs connected by two-conductor cords are used to connect one circuit with another.

Wall or table telephones with generator are employed at an extension station. If a table telephone is required at the extension station, Telephone No. 4, with Bell Set No. 5 and Generator No. 4 as complementary apparatus, is fitted. Diagram N. 910 indicates that if a wall-type telephone is required at extension stations a Telephone No. 59 may be used, but the standard Telephone No. 11 is equally suitable.

The P.B.X. rings an extension station by generator *viâ* the extension A-wire, bell and earth return. When connected through at the P.B.X., an extension station is able to give a clearing signal direct to the main exchange. The extension station calls and clears to the P.B.X. by a generator ring over the loop, thus dropping the indicators bridged across the circuit at the P.B.X.

The main exchange rings the P.B.X. in the standard C.B.S. way, that is, *viâ* the A-wire of the exchange circuit, the P.B.X. indicator and earth, thus dropping the shutter of the calling indicator on the exchange circuit at the P.B.X. The P.B.X. clears to the exchange on removing the plug from the exchange line jack, thereby restoring the $500\Omega + 500\Omega$ calling indicator between the A-wire and earth. This indicator is not actuated by direct current as the connections are so arranged that direct current traverses the coils in opposite directions, but it is rendered susceptible to generator rings by shunting one of the cells with a 2 μf. condenser. It is, therefore, dropped only when the main exchange rings by generator and is not affected by clearing signal currents.

Switchboards, C.B.S. No. 1 Cordless.—The principles of the electrical circuits at the P.B.X. are shown by Loose Leaf Diagram N. 908. The circuit arrangements at the main

exchange and of a P.B.X. line are shown in an explanatory form by Fig. 5 and at an extension station by Fig. 6.

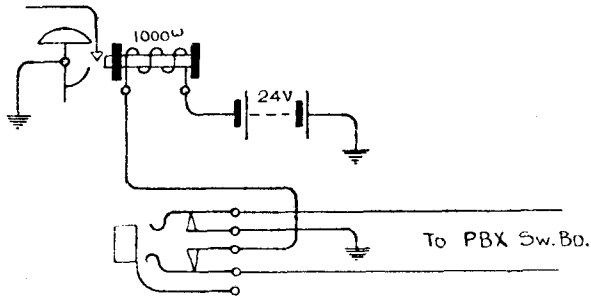

FIG. 5.—Exchange Line Connections at Main Exchange.

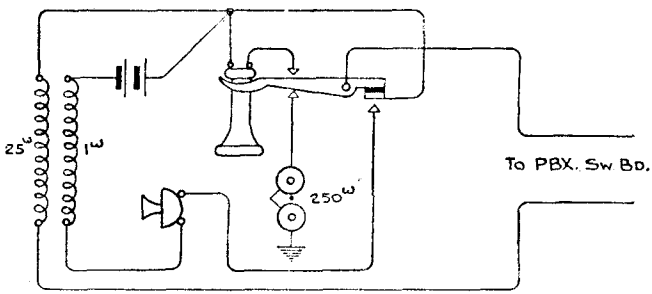

FIG. 6.—Extension Line Connections at Subscribers' Station.

Standard C.B.S. wall or table type telephones with bell sets, but without generators in both cases are required at the extension station.

It will be seen on reference to Loose Leaf Diagram N. 908 that on cordless switchboards each line is connected to an indicator and a number of keys in vertical alignment below the indicator, the operating telephone being connected to a similar set of keys in vertical alignment on the extreme right of the switchboard panel.

The extension line ringing keys are placed in the bottom horizontal row and the outer springs of these are connected by common wires to the generator. The keys in each of the other horizontal rows are wired together to form connecting circuits; by moving in the same direction any two keys in

the same horizontal row (of connecting circuits), the corresponding lines are connected together.

When a connection is established the extension line indicator is controlled by a series relay and operates as a positive supervisory signal controlling an audible alarm, which is usually a buzzer.

On an extension to extension connection, the two line indicators are in parallel and are operated when the receiver of either extension is replaced on its rest; on an extension to exchange connection the replacement of the receiver at the extension station causes the clearing signal to be given on the extension line indicator at the P.B.X. and simultaneously at the main exchange.

No special provision is made for holding an exchange line while an extension is being called to answer an exchange call, as the clearing earth at the P.B.X. is disconnected from the exchange line whenever an exchange line key is moved from the normal position. Any exchange line can, therefore, be held when necessary by throwing the corresponding exchange line key of a disengaged connecting circuit.

The main exchange rings the P.B.X. by means of an earthed generator applied across the exchange line loop, thus actuating the indicator bridged across the exchange line at the P.B.X.

The P.B.X. calls the main exchange by looping the exchange line through the operator's instrument associated with the switchboard, and the extension stations by applying an earthed generator to the A-wire of the extension, the ringing circuit in the latter case being completed *viâ* a magneto bell and earth at the extension station.

The extension stations call the P.B.X. automatically on lifting the receiver from its rest and clear also automatically when the receiver is replaced on the rest.

On this type of switchboard, a clearing signal from an extension station at the finish of an exchange call is received at the main exchange and the P.B.X. simultaneously as stated previously, but on switchboards of the C.B. double cord type, clearing signals from the extensions are received only at the P.B.X. and on exchange calls the exchange line is "cleared" when the P.B.X. operator takes down the connecting cord circuit.

C.B., P.B.X. Switchboards.—The double-cord C.B., P.B.X. switchboards, which are fitted at C.B.S. No. 1 Private Branch Exchanges if the installation exceeds a total of 12 lines, are described in pamphlets P.W.—F 4 and F 5. Whenever one of these switchboards is used at a P.B.X. connected to a C.B.S.

No. 1 main exchange, an auxiliary apparatus, Unit No. 18, is connected in each P.B.X. exchange line at the Main exchange. The connections of the unit are arranged as shown in Fig. 7 and Diag. L. 106, Fig. 1 (*a*) for lines having a resistance less than 100 ohms, but for lines of 100 ohms or over, the connections are modified in accordance with Diag. L. 106, Fig. 1 (*b*).

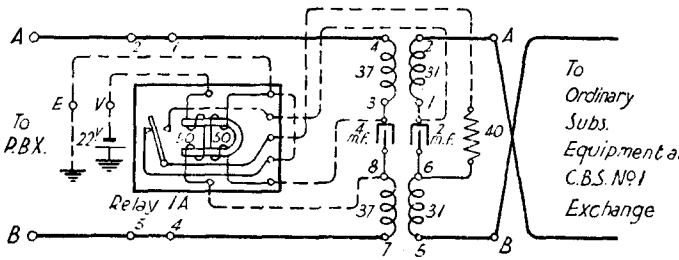

FIG. 7.—Exchange Line Auxiliary Apparatus.

The auxiliary apparatus provides for the supply over the exchange line of the current required for signalling and speaking purposes in accordance with C.B. practice and for the conversion of the C.B. loop and disconnection (calling and clearing) system of signalling, for which the P.B.X. switchboard is designed, to the C.B.S. No. 1 loop and earth (calling and clearing) system of signalling, in order that the exchange lines may be terminated at the C.B.S. exchange on standard C.B.S. subscribers' equipment, and that the use of special cord circuits may be avoided. The operation of the auxiliary apparatus will be clear if Fig. 7 is considered in conjunction with Fig. 5 (Main Exchange portion) and Loose Leaf Diagrams N. 930, Fig. 1 and N. 931.

With a P.B.X. switchboard of the C.B. type, it follows, of course, that the apparatus fitted at the extension stations must also be of the C.B. type.

Party-Line Circuits.—The circuit arrangements are shown by Diagram C.B.S. 141 (N. 1276).

Standard C.B.S. No. 1 telephone sets, wall or table type, as described in Section 3, are used on party-line circuits.

The party-line subscribers operate their instruments in precisely the same way as exclusive exchange line subscribers, calling the exchange by lifting their receivers and clearing by replacing them.

Subscribers connected to a party line are divided into two groups for exchange ringing purposes. The stations in one group are known as *X* stations and in the other group as *Y* stations. On 2-party lines there is, of course, only one *X* station and one *Y* station, but on 12-party lines the number in each group may be any number up to 6.

On a 2-party line, an *X* station telephone is joined up in the same way as that of an exclusive line subscriber—that is, with the bell connected between the A-wire and earth, but at a *Y* station, the bell is connected to the B-wire and a condenser is inserted between the bell and earth.

On 12-party lines, the bells at all the *X* stations are connected to the A-wire and those at all the *Y* stations to the B-wire. At all the *Y* stations and at all the *X* stations except the last one in the group, however, a condenser is inserted between the bell and earth at each station. At the last *X* station, which should be the station most distant electrically from the exchange, the condenser in the bell circuit is omitted in order that a clearing signal may be given to the exchange in the ordinary way at the close of a call from any of the stations.

The exchange rings 2-party line subscribers selectively, and 12-party line subscribers semi-selectively, by code rings. An *X* station is called by ringing over the A-wire of the circuit and a *Y* station by ringing over the B-wire The normal connections of the exchange ringing device are such that when a cord-circuit calling-plug is inserted in a subscriber's jack and a ringing key is depressed, bells connected to the A-wire will be actuated. *X* stations are, therefore, rung in the same way as exclusive line subscribers, but to enable stations with bells connected to the B-wire to be called, a reversal of the ringing connections is necessary. To provide for this, a ringing reversing key is fitted on each operator's position in non-multiple exchanges and in many multiple exchanges, but in modern exchanges of the latter type, this special key is dispensed with by allotting two jacks per multiple in the subscriber's multiple to each party-line circuit. On one of these jacks, the tip and ring connections are reversed. *X* stations can, therefore, be rung on one jack and *Y* stations on the other in the ordinary way.

On 2-party lines each subscriber hears only the rings intended for his own station. On 12-party lines each *X* station receives a ring for any *X* station, and similarly each *Y* station bell is rung whenever the call is for a *Y* station. Each station should, however, take notice of and reply only to its own distinctive number of rings.

For intercommunication between stations on the same party line, the exchange must be called and asked to ring the wanted station.

Bells on party lines should have the coils joined in series, thus making their resistance a maximum.

Party-Line Circuit Extensions.—Extensions from the party-line subscriber's main instrument may be provided in accordance with Loose Leaf Diagram N. 1378. The operating conditions will be the same as in the case of similar extensions in connection with an exclusive line subscriber's installation on the Plan 1 arrangement.

Miscellaneous Arrangements.—*Extension Bells.*—An extension bell is fitted as an extra requirement when calls from the exchanges are required to be heard at a point other than one where the ordinary telephone bell is fixed. As a general principle, an extension bell is joined in series with the bell on the telephone, and when required a tumbler switch is provided to enable the extension bell to be short-circuited when it is not required to ring.

If an extension bell is connected in series with the telephone bell, the coils of both should be joined up in parallel in order that the resistance of the exchange clearing indicator circuit may be kept within reasonable limits, as otherwise the efficiency of the clearing signal might be impaired.

Call Office arrangements are dealt with in the pamphlet on Call Offices (P.W.–D 21).

Coin Boxes are provided on certain circuits when required. On circuits fitted with coin boxes, the exchange is called in the ordinary way and the person making a call inserts each penny of the charge for the conversation in the slot of the coin box when requested to do so by the operator. After the insertion of a penny, it is given a rotary movement by the caller turning a handle on the coin box. The penny thus completes the circuit of a buzzer which forms a part of the coin box and the buzz is transmitted to the exchange. The operator is, therefore, able to check the number of coins put into the box. The buzzer is worked from the speaking battery of the telephone as a shunt on the transmitter, consequently the buzzer interruptions in the telephone primary circuit are reproduced in the secondary circuit through the medium of the induction coil and are heard in the operator's telephone as the buzz previously referred to. The release of the coin-box handle after the rotation of each penny restores the buzzer circuit to the normal or disengaged condition in readiness for the insertion of more pennies to the extent of the payment required.

Speaking Batteries.—Leclanché cells of the wet type are used for speaking purposes. The electrolyte in the cells is a solution of manganese chloride, which has been adopted instead of the solution of ammonium chloride (sal-ammoniac) used in the past. The use of manganese chloride renders it essential that the batteries be enclosed in an airtight container; therefore, any ventilation holes that may exist in telephones or battery boxes are effectively sealed up. If this is not done, the batteries deteriorate very rapidly.

The adoption of a solution of manganese chloride instead of one made with ammonium chloride has resulted in the elimination of faults due to the corrosion of wiring, &c., which was previously a source of much trouble.

Replenishment of the electrolyte is necessary only after very long periods of service, as evaporation is prevented or takes place very slowly owing to the absence of ventilation.

Battery boxes are now fitted with two terminals. To one of these, the wire on the negative pole of the battery (zinc element) should be directly connected and the positive pole of the battery should be connected to the other terminal by means of bare tinned copper wire of not less than No. 18 gauge. In the case of batteries fitted in Wall-type telephones, the negative pole should be connected directly to one of the instrument battery terminals and the positive pole of the battery should be joined to the other by means of bare tinned copper wire of not less than No. 18 gauge.

(6) MAINTENANCE OF SUBSCRIBERS' APPARATUS

Batteries.—Battery elements, unlike other parts of a telephone, are slowly consumed as the telephone is used and renewal is required from time to time. It is, therefore, necessary to make a careful test and thorough examination of the cells on the occasion of each visit to a subscriber's premises and to renew such elements, as may be necessary, to bring the battery to first class condition.

The wiping dry of the top of the cells and of the terminals with a cloth or rag lightly smeared with petroleum jelly after the work of recharging or refreshing has been completed will greatly assist in prolonging the life of the cells and ensuring satisfactory working.

The maintenance and testing of batteries is dealt with in detail in the pamphlet on Batteries (P.W.-A.2).

Contacts.—Apart from the speaking battery, the parts most likely to require attention are the various apparatus contacts. These are particularly the gravity switch or receiver arm contacts, and in the earlier pattern telephones, the trans-

mitter press key contacts and those of the cradle on which the receiver rests. Contacts should be carefully examined and kept clean by means of contact cleaners.

Telephones fitted in positions where they are exposed to steam, dampness and atmospheric changes are liable to suffer from faulty connections at the contacts unless these are periodically cleaned. Under the foregoing conditions, trouble is also likely to arise through low insulation if ordinary cords are fitted. Special waterproof cords are available and authority can be obtained to fit them where the circumstances can be shown to justify it.

Adjustments.—Intermittent difficulties or definite faults arise through the springs associated with the cradle on the earlier pattern table telephones and the springs associated with the gravity switch on the wall and later pattern table telephone becoming weakened in the course of time. Faults due to this cause may prevent rings being received by the subscriber or the subscriber from calling the exchange. Bad contacts due to this cause may also give rise to faint speech. Adjustment and tightening up of these springs and the cleaning of contacts from time to time is, therefore, necessary.

Indicators on P.B.X. switchboards and subscribers' bells occasionally require adjustment.

As a general rule, the apparatus parts most used are those most likely to need attention, so that such parts should be specially examined when a visit is paid to a subscriber's premises. Screwed connections should also be examined and tightened up if necessary, as vibration tends to loosen them.

(7) FAULT LOCALIZATION

The probable locality of a fault can usually be readily determined by considering the electrical circuits shown in Fig. 1 (subscriber's circuit) and the exchange cord circuit as illustrated in pamphlets P.W.-D.6 or D.7.

From these the following circuits can be traced :—

(*a*) Outward ringing circuit.
(*b*) Subscriber's calling circuit.
(*c*) Subscriber's clearing circuit.
(*d*) Subscriber's primary speaking circuit.
(*e*) Subscriber's secondary speaking circuit.

In following up a fault, **the plan should be to localize it, if possible, from its nature, to one or other of the foregoing circuits.** A fault in (*a*) would give rise to failure on the part

of the exchange to gain the subscriber's attention or to difficulty in doing so; similarly a fault in (*b*) might prevent a subscriber from gaining the attention of the exchange. One in (*c*) would affect the clearing indicator at the exchange; one in (*d*) would affect outward, and one in (*e*) incoming speech.

In regard to faults liable to arise, it will be clear **that the insulation resistance of the circuits must be kept high** or the common battery will be drained unnecessarily and run down, thus leading to failures on the part of subscribers to obtain the attention of the exchange. Also **a short-circuit of the A- and B-wires** or **an earth on the B-wire** would complete the common battery circuit and give a permanent call at the exchange. **A full earth on the A-wire** would short-circuit the outward ringing from the exchange, leaving the exchange unable to obtain the subscriber's attention and, similarly, **a partial earth on the A-wire** would weaken the ringing heard on the subscriber's bell. Neither of these earth faults on the A-wire would prevent the subscriber from calling the exchange, but they would give rise to trouble or noise during speech and possibly to a false clear on the exchange cord circuit indicator, according to their complete or partial nature.

The speaking battery circuit, *viz.*, 2 cells, gravity switch connection, or press key on microtelephone and primary of induction coil, is local to the subscriber's instrument. Any failure on the part of the subscriber to be heard by his correspondent, while he himself hears the latter well, would be attributable to a fault in a subscriber's primary speaking circuit if it be clear that the correspondent can speak to and hear the exchange clearly. This latter test proves that the correspondent's circuit is in order. A fault in a subscriber's receiving (secondary) circuit would affect incoming speech and would probably evince itself as a fault under (*a*), (*b*) or (*c*).

Cords.—The cord connection strips fitted in connection with table telephones increase the risk of faults arising through broken wire connections. Faults due to trouble of this nature may happen through accidental rough usage of the transmitter portion of table instruments. Wall telephones, being self-contained, are less exposed to such risks, and their use is recommended where possible.

The external cords connecting the different portions of the various table telephones are also liable to accidental injury at a subscriber's office. They may be crushed or pierced by some sharp object or broken at some point or other. Resulting faults may be intermittent and difficult to locate, as the handling of the instrument may temporarily restore the

circuits to their normal condition, and thus cause the fault to disappear. Cords often develop faults just at the point where they emerge from the interior of the instrument.

Faults in cords can usually be located by shaking the cord piece by piece while listening on the receiver for any abnormal noise.

The strain cord provided on cords to take the tension and thus relieve the electrical conductors from excessive strain should always be used.

Facilities for Testing.—The protectors on the main frame at the exchange afford facilities for localizing trouble on either the exchange or line side of the circuit. Similarly, at the subscriber's end the trouble can be localized to the instrument or line side, by dividing the circuit either at the protector or instrument.

Test of subscriber's instrument.—The transmitter and receiver circuits of the subscriber's instrument can be proved by disconnecting the line wires and short-circuiting the two line terminals of the instrument. On moving the gravity switch up and down or depressing and releasing the press key of the microtelephone, a good click should be heard in the receiver if the circuits are in order ; also if, when the speaking battery circuit is closed, the transmitter be blown into, a noise should be heard in the receiver. This latter test would prove that the transmitter granules were not packed, and that they responded properly to the sound waves. The motion of the gravity switch or press key, as previously indicated, makes or breaks the local speaking circuit of the instrument, giving rise to induced currents in the secondary circuit, the effect of which is heard in the receiver. The absence of a click would indicate that a fault existed, and steps should be taken to locate it to either the transmitter or receiver circuit of the instrument. The transmitter circuit obviously offers more points than the receiver circuit at which the disconnection or other fault may occur, and it should be examined first, special attention being given to the cells and other connections. The receiver cord is sometimes injured through undue tension, due to careless handling or accident, and a fault in it would have to be traced, as already indicated, and the faulty cord repaired or changed.

Coin boxes.—A bent penny inserted in a coin box will not drop freely, and may block the chute.

The buzzer is likely to fail if the speaking battery falls below the maintenance standard. The battery may be sufficiently good for speaking purposes, but not for working

the buzzer, which is in shunt across the transmitter and, therefore, depends on the 2-cell speaking battery for current. For this reason, the speaking battery on instruments fitted with coin boxes requires to be maintained at a high standard. Adjustment of the tension on the buzzer armature will sometimes effect an improvement in its action.

General.—Different types of telephone may be expected to develop their own peculiar faults, dependent on the design of the particular instrument. A careful scrutiny of an instrument will suggest where the difficulties are liable to occur. A detailed examination of instruments with a view to detecting possible weaknesses will greatly facilitate the tracing of faults. Each instrument has the electrical circuits already described, and by considering the nature of the fault and its reference to one or other of those circuits, its probable location is brought within narrow limits and its early removal facilitated.

When difficulty is experienced in treating a fault on any apparatus, the circuit connections should be proved from point to point, by means of a receiver or detector and a battery.

PART II

Subscribers' Apparatus, C.B.S. Nos. 2 and 3 is in course of preparation.

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(Continued.)

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20. Superposed Circuits. Transformers. Bridging Coils and Retardation Coils.
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3. Subscribers' Apparatus Magneto.
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