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# Post Office Engineering Department

## TECHNICAL PAMPHLETS FOR WORKMEN

*Subject :*

### SUBSCRIBERS' APPARATUS Common Battery System

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## **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

## Common Battery System

(F1)

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

- D. 1. Elementary Principles of Telephony
- D. 2. Telephone Transmission. "Loading." Telephone Repeaters and Thermionic Valves.
- D. 3. Principles of Telephone Exchange Signalling.
- D. 8. C.B. Exchanges—No. 9 Type.
- D. 9. C.B. Exchanges—No. 10 Type.
- D.10. C.B. Exchanges—No. 12 Type.
- D.11. C.B. Exchanges—22 Volts.
- D.12. C.B. Exchanges—40 Volts.
- D.19. Cord Repairs.
- D.21. Call Offices.
- F. 1. Subscribers' Apparatus C.B.
- F. 4. Private Branch Exchange—C.B.
- F. 5. Private Branch Exchange—C.B. Multiple No. 9.
- F. 8. Wiring of Subscribers' Premises.

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# SUBSCRIBERS' APPARATUS COMMON BATTERY SYSTEM

## DESCRIPTION OF APPARATUS

The purpose of every telephone is to transform the physical vibrations of the air into electrical and magnetic waves and *vice versa*. The methods by which this is achieved are described and illustrated in the pamphlet entitled "Elementary Principles of Telephony" (P.W.—D.1), to which reference should be made. The principal pieces of apparatus which make up a Subscriber's Apparatus set will, therefore, only be briefly described in this pamphlet.

**The Receiver.**—The receiver consists of a horse-shoe shaped permanent magnet upon the ends of which are mounted small soft iron pole pieces. Upon these pole pieces are wound small bobbins containing the magnetizing coils, the current round which, varying in intensity and direction, serves to vary the strength of the poles. The use of the pole pieces is necessary, as otherwise the small current flowing in the coils would be unable to vary the much more powerful magnetizing force of the permanent magnets.

The magnetic circuit of such a receiver is (a) the horse-shoe magnet, (b) the soft iron pole pieces, (c) the diaphragm. The horse-shoe magnet creates the permanent magnetic field. The soft iron pole pieces are directly affected by variation in the strength of the line current. Such variations produce changes in the magnetic field, which act on the diaphragm, causing it to vibrate.

**The Transmitter.**—The transmitter is a piece of apparatus designed to vary the resistance of a circuit and, therefore, the current flowing. The working of a transmitter depends upon the fact that a variation in the pressure between two surfaces completing an electrical circuit will also vary the resistance of the circuit, and therefore, the strength of any current flowing across the surfaces.

The C.B. Transmitter depends for its operation upon a small cell of brass which contains granular carbon. The back of this cell is solid. The front of the cell consists of a small carbon disc fastened to a delicate diaphragm of mica which, in turn, is screwed to the main stout diaphragm of hard copper or brass. This type of transmitter is fairly free from faults. Trouble may be experienced from packing, which occurs when the granules become packed into a solid mass and thus prevent the variation in resistance which is essential for the proper working of any transmitter.

Before full use could be made of the transmitter it was necessary to find some means of excluding it from the line circuit, and to meet this need the induction coil was designed.

**The Induction Coil.**—If the resistance of a transmitter is very small in comparison with the total resistance of the circuit, it is obvious that a change in current will also be small and, therefore, little effect will be produced on the distant receiver, *e.g.*, if the resistance of a transmitter varies 1 ohm during speech and the total resistance of the circuit is 200 ohms, then the variation is  $1/200$  or 0.5 per cent., which would be very small. Such a circuit would not be commercially satisfactory, and in order to overcome this drawback Edison designed a modification which is now made use of in all local battery instruments. He divided the circuit into two parts (*see* Fig. 1) making the transmitter and battery quite in-

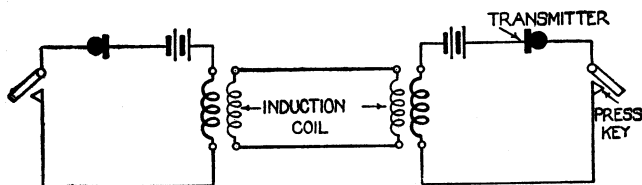


Fig. 1.

dependent of the line by means of an induction coil consisting of two coils of wire wound on a soft iron core. In modern practice, the first or primary coil, which forms part of the local circuit, is wound to a resistance of 1 ohm, whilst the secondary coil, which is in the external line circuit, has a resistance of 25 ohms. By these means it is possible to vary the current and pressure relations of the two coils nearly in proportion to the ratio of the number of turns in the primary to the number of turns in the secondary. By increasing the pressure the high resistance of the line is overcome.

The use of the induction coil in C.B. working will be considered later.

**The Magneto Bell.**—If a current passes through a coil wound upon a bar of soft iron, it will magnetize that iron, and the polarity of the ends will depend upon the direction in which the current is flowing.

The two coils of a magneto bell are wound on soft iron pole pieces which are secured to a soft iron base. In the centre of this base is secured a permanent magnet, which produces a polarity at the pole piece ends of the same nature as that of the permanent magnet attached to the base.

The armature of the magneto bell is placed in this magnetic field so that the armature is in a state of magnetic equilibrium. The flow of an alternating current through the bell coils (which are joined up so that the current flows in opposite directions) polarizes the cores in opposite directions. The equilibrium of the armature is thus upset, and each end is alternately attracted and repelled. If there were no controlling magnet the pole pieces would each exert the same pull on the armature ends, and no movement would follow.

**The Trembler Bell.**—Another type of bell much used in telephone extension work is the electric trembling bell. In this type of bell a battery is used as power, and on completion of the circuit, by means of a push, current is passed through the bell coils in series with a contact on the armature which is controlled by a spring. The attraction of the armature towards the bell coils breaks the electric circuit, and the armature falls back to be once more attracted by the closing of the circuit. A hammer attached to the armature is used to strike the bell gong.

**The Condenser.**—Every insulated conductor is capable of receiving a certain charge when subjected to an E.M.F., and the amount of this charge will be determined by its capacity. The electro-static capacity of a conductor is measured by the quantity of electricity that must be imparted to it in order to raise its potential from zero to unity.

A condenser may be defined as a device for storing an electrical charge. In telephone work, the condenser consists of two plates of tin-foil separated by a dielectric of paper. The plates of tin-foil may take the form of thin coatings of metallic paint, painted on the paper dielectric.

The uses to which a condenser is put in subscribers' apparatus work may be classified under three headings. (1) As a convenient means for preventing the passage of continuous current while permitting the passage of speech or ringing currents. (2) To improve the transmission by increasing the range of current changes in the speaking circuit. (3) To absorb fluctuations in power leads which would otherwise cause a noise in the speaking circuit.

**The Magneto Generator.**—The magneto generator is a machine designed to send out an alternating current in order to ring a polarized bell or drop an indicator at a distant station. The armature is of a shuttle-wound type revolving between the poles of a group of permanent magnets. The space between the pole pieces of the magnets is a powerful magnetic field due to the lines of force passing from one pole to the other, and the armature coil revolving in this field cuts the lines of force and generates current.



The direction in which the lines of force pass through the coil is reversed with each half revolution, and therefore a complete revolution gives rise to two currents in opposite directions. A typical generator consists of three permanent horse-shoe magnets *PM* (Fig. 2) fitted with pole pieces *PP*, a coil of insulated wire *C* wound on an iron core

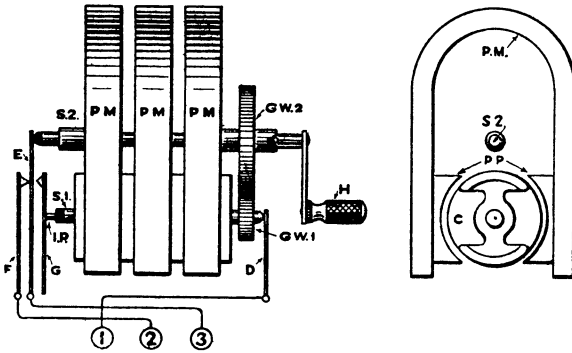


Fig. 2.

through which is fitted a shaft *S.1* carrying a small gear wheel *GW.1*. A second shaft *S.2* carrying a large gear wheel *GW.2* and a handle *H* are also provided. One end of the coil is terminated on an insulated pin *IP*, fixed in one end of the shaft and permanently in contact with spring *G*. The other end of the coil is connected to the shaft itself with which spring *D* is permanently in contact.

To the generator is fitted an automatic cut-out. When at rest, the pressure of the insulated end of shaft *S.2* against spring *E* keeps it in contact with spring *F* and out of contact with spring *G*.

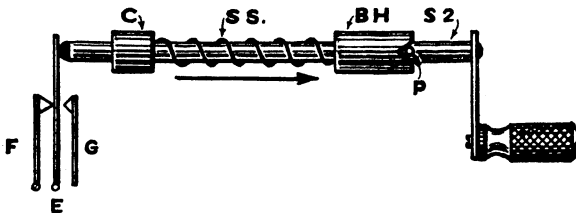


Fig. 3.

When the handle of the generator is turned, the shaft *S.2* on which the handle is fixed (*see* Fig. 3) is moved in the direction of the arrow by the pin *P* riding up the V-shaped groove in the bush *BH* against the pressure of the spring *S S* on the collar *C*. The spring *E* follows the shaft *S.2*, thus breaking contact with *F* and making contact with *G*.

In C.B. extension working, the line over which it is desired to ring is connected to terminals 1 and 3 (Fig. 2) and the local bell or telephone, which is to be cut out during the ringing period, is connected to terminals 1 and 2 (Fig. 2).

### FUNDAMENTAL CIRCUITS

In an ordinary subscriber's instrument there are four distinct circuits which may be called :—

(1) The in-signalling circuit that enables the subscriber to be called.

(2) The out-signalling circuit by which the subscriber calls the Exchange.

(3) The speaking circuit.

(4) The listening circuit.

(1) **The in-signalling circuit** consists of the bell and condenser. It will be seen from Fig. 4 that the gravity switch

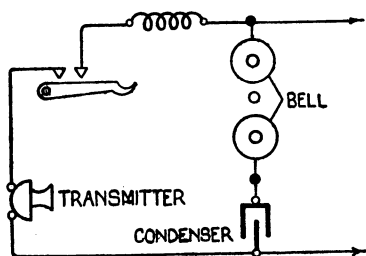


Fig. 4.

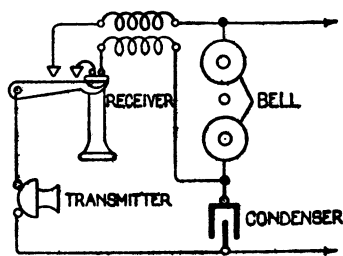


Fig. 5.

not in the bell circuit, as must be the case in magneto instruments, where a shunt to the generator current would cause trouble in ringing.

(2) and (3) **The out-signalling circuit**, in the case of a C.B. instrument, is the same as the **speaking circuit**, and consists of the primary of the induction coil, the gravity switch, and the transmitter. This circuit forms a loop across the line when the gravity switch is raised, and completes a relay circuit at the Exchange in order to give a calling signal.

(4) **The listening circuit** is a local one, and includes the receiver, condenser, transmitter, gravity switch and induction coil secondary. The speech waves are received in the primary coil, and reproduced in the secondary circuit.

The complete circuit is shown in Fig. 5.

An extension bell is frequently fitted. If this is done, it is inserted in series with the instrument bell, thus increasing the resistance of the bell circuit. In C.B. working, extension bells must not be joined in parallel with the main bell, as this would make the Exchange ringing circuit unreliable.

The C.B. instrument is made up in two forms suitable for the desk or wall. From a maintenance point of view the wall telephone is less liable to faults than is the pedestal instrument, largely on account of its freedom from the breakages due to the overturning of the table instrument.

## EXTENSION CIRCUITS

When more than one telephone is required in connexion with an exchange line, the first telephone, *i.e.*, that at which an incoming ring is normally received, is referred to as the main station. The second and subsequent telephones are known as extensions.

When full intercommunication between one extension and another is required, a switchboard is fitted at the main station and the installation becomes a Private Branch Exchange. To meet the requirements in those cases where full intercommunication is not required between one extension and another or where only one extension is required, a series of arrangements has been designed which is usually referred to by plan numbers.

The following is a brief description of each of the arrangements and a reference to the diagrams concerned.

### *Plan 1.*

Loose Leaf Diagram N.1424 gives a diagrammatic representation of this arrangement which is provided on internal extensions only. The circuit connexions with various types of telephone are shown in the following diagrams :—

Diagram No.	Main Station.	Extension 1.	Extension 2.
N.1300	Telephone No. 2	Telephone No. 2	Telephone No. 2
N.1301	„ 2	„ 2	„ 1
N.1302	„ 2	„ 1	„ 1
N.1303	„ 1	„ 1	„ 1
N.1304	„ 1	„ 1	„ 2
N.1305	„ 1	„ 2	„ 2

All the extensions are connected in parallel with the main station, a common induction coil being used when table telephones are provided. Any conversation can, therefore, be overheard on any telephone, and the removal of the receiver from any telephone calls the exchange. Inter-communication between one extension and another or between an extension and the main station is not available.

Magneto bells are not connected at the extensions, but to enable the main station to signal an extension when required on an incoming call trembler bells are provided at extension points with corresponding press buttons at the main station.

#### *Plan 1A.*

Loose Leaf Diagram N.1425 gives a diagrammatic representation of this arrangement which is provided on internal extensions only. The circuit connexions with various types of telephone are shown in the following diagrams :—

Diagram No.	Main Station.	Extension Station.
N.1306	Telephone No. 2	Telephone No. 2
N.1307	„ 2	„ 1
N.1308	„ 1	„ 1
N.1309	„ 1	„ 2

A magneto bell is fitted at each station and that at the main station is permanently in circuit. At each extension the bell is controlled by a switch, thus providing arrangements whereby an incoming ring may be received when desired on any extension as well as at the main station.

As in Plan 1, all the extension telephones are connected in parallel with the main station, a common induction coil being used when table telephones are provided. Each extension calls the exchange direct by removing the receiver and neither secrecy nor intercommunication is available.

*Plan 2.*

No arrangement has been standardized with this number.

*Plan 3.*

Loose Leaf Diagram N.1426 gives a diagrammatic representation of this arrangement, which is provided on internal extensions only. The circuit connexions with various types of telephone are shown in the following diagrams :—

Diagram No.	Main Station.	Extension.
N.1310	Telephone No. 2	Telephone No. 2
N.1311	„ 2	„ 1
N.1312	„ 1	„ 1
N.1313	„ 1	„ 2

In the normal condition, the exchange line is connected *via* a switch at the extension to the main station. The main station calls the extension when required by means of a press button and trembler bell.

At the extension station, the talking circuit is connected permanently to the exchange and with the switch in the normal position is in parallel with the main telephone. The magneto bell at this point is normally out of circuit.

Should the extension desire to cut out the main station and thus obtain secrecy on an exchange call, this can be done by the operation of a 6-point, 2-position switch.

This switch also completes the circuit of the magneto bell at the extension ; thus should the switch be left in the operated position, any incoming ring would be received at the extension instead of at the main.

As in Plan 1, intercommunication is not available.

#### *Plan 4.*

Loose Leaf Diagram N.1427 gives a diagrammatic representation of this arrangement which is provided on internal extensions only. The circuit connexions are shown in N.1314. The exchange line is connected to a Bell Set, No. 1, at the main station. A Telephone, No. 2, is terminated on a plug ; connexion between the telephone and the bell set is established by means of jacks fitted in any required positions.

The bell at the main station is permanently in circuit ; and, if this bell or any other bell which is permanently in circuit cannot be heard at the point where an extension jack is fitted, an additional magneto bell is fitted at that point and so arranged that the insertion of the plug into the jack connects the bell there in series with the bell at the main station ; thus an incoming ring can be heard at any point where the telephone plug is inserted in the jack, and at the main station in any case.

#### *Plans 5 and 5A.*

A diagrammatic representation of this arrangement is shown in Loose Leaf Diagram N.1428, and the circuit connexions in the following diagrams.

Diagram No.	Main Station.	Extension 1.	Extension 2.
	Telephone No.	Telephone No.	Telephone No.
N.1315	1 or 2	2	2
N.1316	„	2	1
N.1317	„	1	1

These arrangements are a combination of Plan 7 or 7A and Plan 1A with slight modification and are provided on internal extensions only.

The extensions are called from the main station by the generator in the Bell Set, No. 4. The bells of the extensions are not connected across the line, but to a third wire which is run from each extension to the main station where it is connected to a press button. By this arrangement the main station can ring either extension when required.

When the switch at the main station is in the through position, the extensions call the exchange direct by removing the receiver. In any other position of the switch, the extensions call the main by generator.

As stated, the bells at the extensions are not normally connected across the line, but should direct service at night to the main exchange be required at any one of the extensions, a switch is fitted there to bring the bell into circuit when required.

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 connexions 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 connexion with Plans 7 and 7A.

#### *Plan 6.*

No arrangement has been standardized with this number.

#### *Plans 7 and 7A.*

A diagrammatic representation of this arrangement is shown in Loose Leaf Diagram N.1429 and the connexions in N.1318.

At the main station a combined switch, bell and indicator known as a "Bell Set, No. 4," is fitted and to this are connected the exchange line, the extension and the main station telephone. Details of the connexion to the Bell Set are given in Loose Leaf Diagram N.504, sheet 1. Figures showing the skeleton connexions of the switch in various positions are given in sheet 2 of the same diagram.

In the Plan 7A arrangement, terminals A-A1 and B-B1 are not strapped. The three talking positions of the switch are :—

- No. 1 Main to Exchange,
- No. 2 Main to Extension,
- No. 4 Exchange to Extension,

and in none of these positions can conversations be overheard on the remaining circuit. The Plan 7A arrangement, therefore, gives full intercommunication and secrecy.

In the Plan 7 arrangement, terminals A-A1 and B-B1 are strapped together. The three talking positions of the switch remain as in Plan 7A, but in the exchange to extension position the main instrument is in parallel and the arrangement is therefore non-secret on such conversations. The advantage of this arrangement is that the main station is able to supervise the setting up of a connexion between the extension and the public system.

In both the Plan 7 and Plan 7A arrangements, the extension is connected to a bell when the exchange is connected to the main telephone, or the exchange is connected to the bell when the extension is connected to the main telephone. The third position of the switch "Main to Extension—Exchange held" is provided in order that the clear should not be given to the exchange whilst the attention of the extension is being obtained on an incoming call. In the 4th, *i.e.*, the "Exchange to Extension" position of switch, a signal is provided which is operated when the extension is talking on an exchange connexion. This avoids the necessity for the main station disturbing the circuit when it is desired to ascertain whether the line is free or otherwise.

Both Plan 7 and Plan 7A arrangements are suitable for use on either internal or external extensions.

#### *Plan 8.*

A diagrammatic representation of this arrangement is shown in Loose Leaf Diagram N.1430 and the circuit connexions in N.1320.

This arrangement provides for one common extension on two exchange lines. Each exchange line is permanently connected to a separate main instrument and from each line a tee is made to the contacts of a 6-point, 2-position switch. The extension telephone is wired to the moving springs of this switch and is connected to one exchange line or the other in depending upon the position of the switch.

The magneto bell of the extension telephone is not connected, all incoming rings being received at the main station. To enable the main station to signal the extension when



required, press buttons are provided at the main telephones and connected to trembler bells of different tones at the extension.

The arrangement does not provide secrecy nor inter-communication and is fitted on internal extensions only.

#### *Plan 8A.*

A diagrammatic representation of this arrangement is shown in Loose Leaf Diagram N.1431 and the circuit connexions in N.1321. This arrangement provides for a common extension on two exchange lines with secrecy on exchange conversations and without intercommunication. It is fitted on internal extensions only.

Each exchange line is connected to a separate main telephone *via* a switch and signal at the extension point. The switches in the two lines are combined in the form of a three-position key which is mounted in a case with the signals. This combination is known as a "Switch, N.T., 20."

The movement of the key in either direction disconnects one of the exchange lines from its main station and connects it to the extension telephone. The signal is provided in series with each line at the extension station to avoid interruption by the operation of the key when the line is engaged.

The bell of the extension telephone is in circuit with the receiver on the rest and if the key is left in the operated position any incoming ring is received at the extension station. In the normal condition, all incoming rings are received at the main stations, and to enable the extension to be signalled when required press buttons are provided at the main stations and connected to trembler bells of distinctive tones at the extension point.

#### *Plan 9.*

A diagrammatic representation of this arrangement is shown in Loose Leaf Diagram N.1432 and the circuit connexions in N. 1322.

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

Two extension lines to the P.B.X. are provided, and both are connected to calling equipments on the switchboard but no bell is provided on the second line at the extension station. Calls may thus be originated over either line, but incoming calls cannot be effected over the second.

A key is provided in the base of the telephone and in the normal position of this key the telephone is connected to the first line, whilst the second is left disconnected. The first line is normally used for both incoming and originated calls.

The operation of the key transfers the extension telephone to the second line and connects a low resistance bell directly across the first line. The second line can then be used for the purpose of making enquiries whilst an incoming call is held on the first. The use of a bell as a holding device enables the extension to be rung if the key is accidentally left in the operated position.

#### *Plan 10.*

A diagrammatic representation of this arrangement is shown in Loose Leaf Diagram N.1433 and the circuit connexions in N.1325.

In this arrangement, the line or lines from the main exchange to the P.B.X. are connected *via* break jacks at the extension point where the telephone is terminated on a plug. The extension line from the P.B.X. is also connected to a jack, the inner springs of which are wired to a bell and condenser.

In the normal condition, the telephone plug is kept in the extension jack and all calls are effected *via* the extension line in the usual way. Should the extension station desire to obtain secrecy on an exchange call the telephone plug can be transferred to the jack of the particular exchange line on which the connexion has been established.

It is not intended that calls should be originated directly on the exchange line, as no intimation is given at the P.B.X. when a plug is in an exchange line jack at the extension, and any attempt on the part of the switchboard attendant to make a call on the same exchange line would be unsuccessful.

In order, however, that an indication may be given at the P.B.X. of an incoming ring on any exchange line left plugged up at the extension point, a second bell is connected in series with the telephone bell of the extension and fitted adjacent to the P.B.X. switchboard. This bell is short-circuited when the telephone plug is in the extension jack.

The arrangement is fitted on internal extensions only.

#### *Plan 11.*

A diagrammatic representation of this arrangement which is fitted on internal extensions only, is shown in Loose Leaf Diagram N.1434 and the circuit connexions with various types of telephone in the following table.

Diagram No.	Main Station.	Extension 1.	Extension 2.
N.1324	Telephone No. 2	Telephone No. 2	Telephone No. 2
N.1325	„ 2	„ 2	„ 1
N.1326	„ 2	„ 1	„ 1
N.1327	„ 1	„ 1	„ 1
N.1328	„ 1	„ 1	„ 2
N.1329	„ 1	„ 2	„ 2

In this arrangement, as in Plan 1, the extensions are provided in parallel with the main telephone. Neither secrecy nor intercommunication are, therefore, provided.

The magneto bell at the main station only is connected and all incoming rings are, therefore, received at that station.

A local bell circuit is provided from a push at the main station to a bell at the first extension, and a second local bell circuit is similarly provided from the first to the second extension.

All incoming calls are thus dealt with primarily at the main station, then, if necessary, the first extension can be called into circuit, and finally the second extension, if required, can be signalled from the first.

Any station can originate calls direct to the main exchange.

#### COIN-COLLECTING BOXES.

**Coin-Collecting Boxes** are provided in connexion with Public Call Offices wherever possible, and consist of:—

- (1) A means of collecting the proper fee with
- (2) A means for intimating to the operator that the money has been inserted in the box.

Essentials for a satisfactory mechanism are:—

- (1) That it shall not place extra work on the operator, and will indicate by means of a buzz the insertion of each penny individually.
- (2) That it shall be fool-proof.
- (3) That it shall be reasonably thief-proof.
- (4) That it shall not be operated by a coin or coins less in value than those appropriate for the required fee, in the case of coin boxes of the prepayment type.

Figs. 6 and 7 show diagrammatically the arrangement in the post-payment coin-box, and also, the position of the penny in the front and side elevation. The buzzer circuit is completed through two contacts, "H" and "K" (Fig. 7) in series.

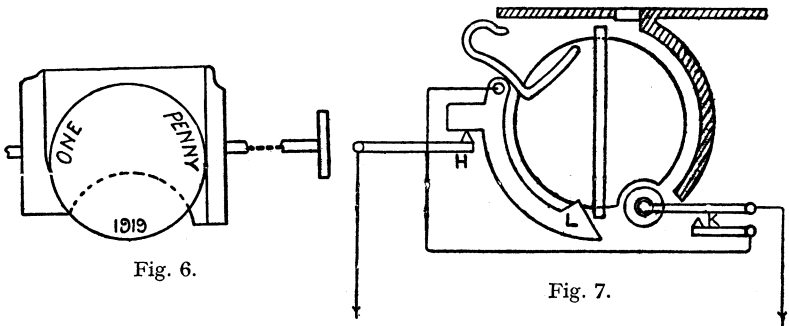


Fig. 6.

Fig. 7.

Fig. 6 shows the front elevation of the coin-carrier with the penny in position. The width is just sufficient to hold a penny, but allows a smaller coin to pass through. The lower portion of the sides of the carrier is cut away as indicated by the dotted line in Fig. 6. This enables the lower portion of the penny to engage with lever "L" (Fig. 7).

On turning the disc on the right-hand side of the box, the penny forces out the lever "L" and breaks contact at "H." At the same instant, the small wheel rising in the recess is also forced outwards, "making" the buzzer circuit at "K."

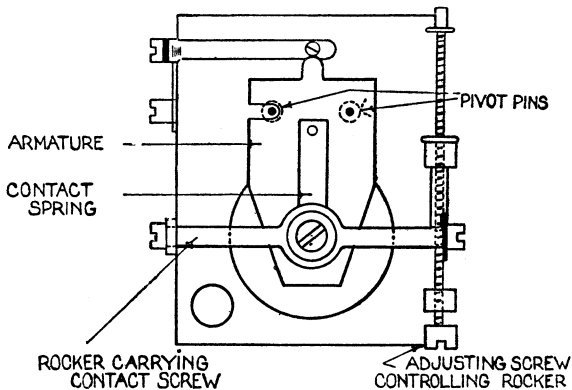


Fig. 8.

The purpose of placing the two contacts in series is to ensure that the buzz is not given before the penny is in such a position that the buzzer cannot be operated twice with the same coin.

Figs. 8 and 9 give the types of buzzer in general use. They are delicate pieces of apparatus and of very small proportions.

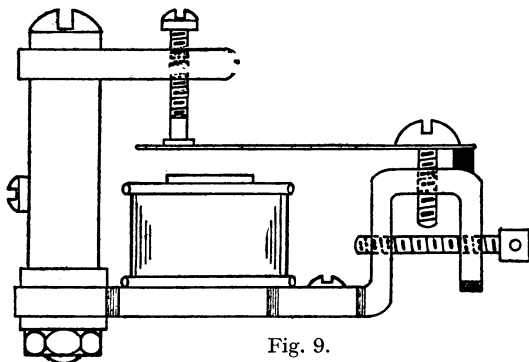


Fig. 9.

and require careful handling to ensure their successful operation. The necessary power is obtained in C.B. areas by current direct from the B-wire of the Exchange line.

### MAINTENANCE OF SUBSCRIBERS' APPARATUS

After the Test Clerk has located a fault to be outside the Exchange building, it is assumed to be on the subscriber's installation unless, by the nature of the fault, it is obviously on the line. The instrument lineman is thereupon sent round to the subscriber's premises, and it is his first duty, if the fault is in the nature of an earth, short-circuit, or disconnexion, to determine whether it is inside or outside the subscriber's office. This entails a visit to the junction point between the outside and the inside line, which may be a distribution case, an instrument protector, or a terminating block. In no case should the external lead be soldered directly to the internal wiring. Localization of the fault is then carried out by means of a detector, or by a joint test with the Test Clerk. If the fault proves to be on the line, the matter is explained to the subscriber, and the instrument is examined to verify that everything is in order. The line fault is thereupon taken in hand.

If, however, the fault proves to be towards the instrument, the cause of the fault must be sought. In a C.B. instrument, the most frequent electrical faults are due to the inter-

mittent disconnexions in the flexible cords, though sometimes high resistance faults occur due to loose connexions on the bell set or defective contacts at the gravity switch springs.

Another source of trouble is bad transmission due to high resistance in the primary circuit which causes noisiness. This may be due to excessive current which produces minute sparks between the carbon granules. Care should be taken, however, to verify that the cause of noisiness is actually due to the transmitter itself, and is not the result of a high resistance fault on the line or some other part of the primary circuit. If the fault is located to the transmitter, this should be changed, as adjustments cannot be satisfactorily carried out by the lineman. Another cause of trouble, when the "self-connecting" type of induction coil is used, is due to the shrinkage of the woodwork of the induction coil, which results in a poor contact on the four plates on which the four ends of the coils terminate. If the subscriber complains that he is unable to hear clearly, the fault will probably be due to a badly adjusted diaphragm on the receiver. In the old type of receiver the adjustment could be readily ascertained by an experienced lineman by the sound of the diaphragm when it was tapped. In the Siemens' receiver now issued, this is not practicable, as the diaphragm is dead on the magnets until the receiver cap is screwed up, when the pressure on the outside edge raises the diaphragm from the magnets.

A ready means of testing the distance of the diaphragm from the magnets is to rest the diaphragm on the edge of the receiver case so that its edge touches the magnets. The cant of the diaphragm should be very small.

Another frequent cause of ringing trouble is the adjustment of the magneto bell. This adjustment is normally made by revolving the bell-gongs which are mounted eccentrically. Under normal circumstances, it should not be necessary to adjust a bell by any movement of the armature, which has been so adjusted that each end of the armature will touch its corresponding coil core. The cause of an unsatisfactory ring is sometimes due to contact between the primary and secondary of the induction coil, in which case the bell coils are shunted. This should always be looked for when difficulty is experienced in adjusting the bell by the recognized methods.

An intermittent disconnexion in the receiver cord is generally easily found by the ordinary test of shaking the cord while listening; but another means of testing for intermittency is to request the testing operator to connect the busy-back to the line.

A further source of trouble is a disconnexion on the protective apparatus. All external lines that are partly made

up of overhead wire are provided with an Instrument Protector at the point where the external lead enters the building. This protector usually consists of a porcelain base with cover and fitted with carbon arrestors as a protection against lightning. If the overhead circuit is endangered by neighbouring power circuits this protector is also fitted with heat coils and fuses. (These protectors are fully described in P.W.—A.5.)

In extension working, trouble is frequently experienced on long extensions due to the current received over the exchange line being insufficient to ring the trembler bell. This can be overcome by earthing the distant bell, and so cutting out the resistance of the return lead. Small points of this nature can only be appreciated by experience, and linemen are advised to take every opportunity of learning from their more experienced colleagues or their Inspector.

In the maintenance of Call Offices, the chief trouble is caused by the blocking of the money chute; but, in the case of the older type of coin box, the chief electrical trouble is due to the fine adjustment necessary for the efficient working of the buzzer. Under no circumstances should the shunt be removed; it is provided to prevent an excessive noise in the operator's receiver. In certain cases it may be necessary to earth the buzzer and so to cut out the resistance of the return circuit, but permission to do this should be obtained from the Inspector.

A few general hints are given which should be borne in mind at all times.

Except on rare occasions, do not remedy a fault temporarily, as the probability is that the fault will repeat before the matter has been put right permanently.

If there are cells, these should be examined to see that the electrolyte has not evaporated, and that the zinc is clean.

The cells should be tested in accordance with the Standard Battery Testing Instructions.

Make a general survey of the office wiring, and report the matter if it is a case where any wires require renewing. See that the switchboard markings are complete and in a legible condition, the Private lines being clearly marked on the Indicators.

Always examine the receiver diaphragm, and, if buckled, replace it. See that there are no filings on the polepieces.

Leave everything tidy upon completion of the work.

In conclusion, it should be borne in mind (1) that the reputation of the Department largely depends on the conduct of the local staffs, and (2) that courtesy is only second in importance to technical ability.

# LIST OF Technical Pamphlets for Workmen

(Continued.)

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## **GROUP D.**—*continued.*

18. Distribution Cases, M.D.F. and I.D.F.
19. Cord Repairs.
20. Superposed Circuits. Transformers. Bridging Coils and Retardation Coils.
21. Call Offices.

## **GROUP E.**

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

## **GROUP F.**

1. Subscribers' Apparatus. Common Battery System.
2. Subscribers' Apparatus, C.B.S. Part I—C.B.S. No. 1 System.
3. Subscribers' Apparatus. Magneto.
4. Private Branch Exchanges—Common Battery System.
5. Private Branch Exchange—C.B. Multiple No. 9.
6. Private Branch Exchanges—Magneto.
7. House Telephone Systems.
8. Wiring of Subscribers' Premises.

## **GROUP G.**

1. Maintenance of Secondary Cells.
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—Conduits.
5. Underground Construction, Part II—Cables.
6. Underground Maintenance.
7. Cable Balancing.
8. Power Circuit Guarding.
9. Electrolytic Action on Cable Sheaths, etc.
10. Constants of Conductors used for Telegraph and Telephone Purposes.

## **GROUP I.**

1. Submarine Cables.

## **GROUP K.**

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