MAGNETO TELEPHONES

1. INTRODUCTION ........................................... 1
2. BASIC SPEAKING CIRCUIT ................................. 3
3. BASIC SIGNALLING CIRCUIT .............................. 5
4. BASIC MAGNETO TELEPHONE ............................ 6
5. ANTI-SIDETONE INDUCTION COIL ...................... 8
6. 300 SERIES TELEPHONES ............................... 12
7. 400 SERIES TELEPHONES ............................... 14
8. TEST QUESTIONS ........................................ 16

1. INTRODUCTION.

1.1 How to study telephone circuits. A telephone circuit consists of -

(i) a speaking circuit containing a transmitter and receiver, 
   by which you speak to and hear the person at the distant 
   telephone, and

(ii) a signalling circuit by which you are called to the 
   telephone and also obtain access to other telephones via 
   the exchange.

Some circuits look complicated because they perform a number of functions, but the 
circuit operation is simplified when these functions are studied separately. When 
studying telephone circuits, therefore, it is convenient to separate the speaking 
and signalling circuits. In the speaking circuit, the transmitting and receiving 
conditions may be considered separately. In the signalling circuit, the incoming 
and outgoing signalling conditions may also be considered separately.

1.2 Although to Technicians, the circuit and its performance are important in the opera-
tion of a telephone and must be thoroughly understood, the form of the instrument 
is important to the subscriber. Two forms have been designed for general require-
ments - table telephones and wall telephones.

Although many modern telephones use the one type of case for magneto, C.B. manual 
and automatic table telephones, and another type of case for the magneto, C.B. 
manual and automatic wall telephones, the circuit and the operation of the corre-
spending table and wall models are similar.
1.3 Many different types of magneto telephones (sometimes called local battery telephones) have been used and some early types are shown on page 2. The types commonly used at present are in the 300 and 400 series, and these are available in table and wall models.

1.4 Magneto telephones are identified by the code letters -

(i) MT for a Magneto Table Telephone,
(ii) MW for a Magneto Wall Telephone.

1.5 This paper describes the principle of operation of the early magneto telephones and also the modern handset magneto telephones which use the anti-side-tone induction coil.

2. BASIC SPEAKING CIRCUIT.

2.1 Simple one-way circuit. Fig. 1 shows a simple magneto telephone speaking circuit. The transmitter and battery are connected to the primary winding of the induction coil; the secondary connects to the line and distant receiver.

![FIG. 1. MATCHED ONE-WAY SPEAKING CIRCUIT.](image)

The functions of the induction coil in a magneto telephone are -

(i) To enable the transmitter to operate in a low resistance circuit. This reduces the battery voltage and, therefore, the number of cells required to supply the minimum D.C. (about 50 mA) for satisfactory transmitter operation. If the transmitter were connected directly to line, the resistance of the circuit would be very high (particularly on long lines) and too many cells would be required. In practice, the resistance of the primary winding is 1 ohm; the battery voltage is usually 3 volts, provided by two No. 6 dry cells in series.

(ii) To prevent D.C. flowing through the receiver coils. The D.C. would tend either to oppose and weaken the permanent magnet in the receiver or to saturate the magnetic circuit, depending on the direction of current. In either case, the efficiency of the receiver would be reduced.

(iii) To match approximately the transmitter impedance (about 60 ohms) to that of the line and distant receiver (about 600 ohms) for better transmitting efficiency.

2.2 The Induction Coil No. 12 (I.C.12) is a typical open magnetic circuit transformer used in early magneto telephones. It consists of two insulated windings -

(i) A 1 ohm winding of 430 turns.
(ii) A 25 ohm winding of 1,350 turns.

This gives a transmitting primary to secondary turns ratio of about 1 : 3.

The core comprises a bundle of soft iron wires insulated from each other to reduce eddy current losses. Due to the open core, all the flux produced by the primary current does not cut or link the secondary winding. The efficiency of the induction coil is about 80%.

The open core, however, prevents saturation of the magnetic circuit due to the transmitter current in the 1 ohm winding. If magnetic saturation were to occur, variations in magnetising force (caused by the varying D.C. in the primary circuit) would not cause similar variations in the flux density. The alternating voltage induced across the secondary would not then follow the primary current variations, the induction coil would be very inefficient, and distortion would occur.
2.3 Two-way circuits. Telephone circuits must be two-way. This may be achieved by the circuit shown in Fig. 2. This is called a "four-wire circuit" because four wires or two pairs are used, one pair for each direction of transmission.

![Two-Way Speaking Circuit](image)

**TWO-WAY SPEAKING CIRCUIT.**  
**FIG. 2.**

Four-wire circuits are costly as regards provision of lines, and a compromise is made between economy and efficiency by connecting the receivers in the secondary circuit to produce a two-wire circuit (Fig. 3).

![Basic Magneto Speaking Circuit](image)

**BASIC MAGNETO SPEAKING CIRCUIT.**  
**FIG. 3.**

2.4 The circuit operation of Fig. 3 for either direction of transmission is as follows:

D.C. from the battery flows through the 1 ohm winding and the transmitter. When a person speaks into the transmitter, the transmitter resistance and, therefore, the D.C. in the primary circuit follows the frequency and amplitude variations of the sound waves.

The A.C. component of speech induced in the 25 ohm winding flows in a series circuit consisting of the local receiver, line conductors, and the receiver and 25 ohm winding at the distant telephone.

Speech signals are heard, therefore, in both the local receiver and the distant receiver.
3. BASIC SIGNALLING CIRCUIT.

3.1 In the magneto telephone signalling circuit -

(i) the magneto bell provides an audible signal when the exchange rings the subscriber, and

(ii) the hand generator provides a calling signal to the exchange, when the subscriber wants to make a call, and a clearing signal when the subscriber has finished a conversation. The differentiation between the calling and clearing signals is provided by suitable connection of the apparatus at the exchange.

3.2 Two types of signalling circuit are used in magneto telephones (Fig. 4).

![Diagram of signalling circuits](image)

(a) Short-circuit type.  
(b) Open-circuit type.

**MAGNETO SIGNALLING CIRCUITS.**

**FIG. 4.**

Fig. 4a shows the arrangement in early type magneto telephones using the Generator No. 1. In the normal position, incoming A.C. ringing current energises the bell via the generator frame, shaft and contact assembly which short circuits the generator armature. When the generator handle is turned, the spring-set operates to short circuit the bell and the short-circuit is removed from the armature. The generator voltage is applied to line via the short-circuit on the bell.

Fig. 4b shows the arrangement in later type telephones. In the normal position, the bell is connected to the line and the generator armature is disconnected. When the handle is turned, the change-over spring operates to open the bell circuit and apply the generator voltage to line.

3.3 Reasons for Generator Spring-set. The hand generator "switching" or "cut-out" springs have two functions -

(i) When the telephone is not in use, they switch the generator armature out of circuit and connect the bell across the line. Thus, the impedance of the generator does not reduce the ringing current through the bell.

(ii) When the generator handle is turned, they switch the bell out of circuit and connect the armature across the line. Thus, the impedance of the bell does not reduce the ringing current sent to the exchange. This also prevents the local bell from ringing on outgoing calls and possibly annoying the calling subscriber.
4. **BASIC MAGNETO TELEPHONE.**

4.1 For economy, the speaking and signalling circuits are combined so that their separate currents are transmitted to the exchange and distant telephone over the same pair of wires.

Fig. 5a shows the basic circuit used in the type 135 MW telephone (Fig. 5b) which is typical of the early type magneto telephones. The dry cells for the transmitter operation are mounted inside the telephone.

![Schematic Circuit](image)

(a) Schematic Circuit.

![Telephone 135 MW](image)

(b) Telephone 135 MW.

**FIG. 5.**
In Fig. 5a, the signalling circuit is connected permanently across the line but the speaking circuit is switched out of circuit by placing the receiver on the switch hook when the telephone is not in use or during signalling.

The switch hook operates a spring-set (the switch hook contacts) which performs two functions:

(i) Opens the transmitter circuit to prevent unnecessary current drain from the battery when the telephone is not in use.

(ii) Opens the receiver circuit to remove the shunt on the bell or generator during signalling.

The common electrical connection between the primary and secondary of the speaking circuit simplifies the wiring as it enables three switch hook contacts to be used instead of four.

4.2 Speaking circuit. During a conversation, the receiver is off the hook and the switch hook contacts close to complete the circuit for the transmitter and connect the receiver circuit to the line.

The bell is connected across the speaking circuit. Because of the high impedance of the bell (about 18,500 ohms at 1,000 c/s), it has no noticeable effect on the speaking circuit during either transmitting or receiving.

The speaking circuit operation is similar to that described for Fig. 3 (see paragraph 2.4) in which the primary and secondary circuits are separate.

4.3 Signalling circuit. To receive an incoming ring from the exchange, the switch hook contacts must be open to disconnect the low impedance of the receiver and 25 ohm induction coil winding from across the bell. Similarly, when signalling the exchange, the switch hook contacts must be open to disconnect the low impedance of the receiver and 25 ohm induction coil winding from across the generator armature.

The signalling circuit operation is similar to that described for Fig. 4a (see paragraph 3.2).

4.4 Testing. The basic magneto telephone circuit may be tested before installation by the following simple tests:

Generator Test.

(i) Turn the generator handle - it should turn freely.

(ii) Place a short-circuit on the line terminals - the generator handle should be hard to turn.

Bell Test. Open the generator cut-out make spring and with a short circuit on the line terminals, turn the generator - the bell should ring.

Speaking Test. Place a short circuit on the line terminals, lift receiver to your ear and blow or speak into the transmitter - sound should be heard in the receiver. If this test fails, the next test will prove the receiver circuit.

Receiver Test. Remove the short circuit from the line terminals, lift the receiver to your ear and turn the generator handle. Generator output should be heard in the receiver.
5. ANTI-SIDETONE INDUCTION COIL.

5.1 When sounds picked up by a telephone transmitter are reproduced by the local receiver, the effect is called sidetone. In the speaking circuit used in early magneto telephones, all the transmitted speech passes through and is heard as sidetone in the local receiver.

Excessive sidetone has two disadvantages —

(i) When a speaker hears his own voice too loudly in the local receiver, he tends to lower his voice. This decreases the amplitude of the sound in both the local receiver and the distant receiver, and is equivalent to reducing the transmitting efficiency.

(ii) Loud room or background noises tend to "mask" the received speech, making it difficult to hear and understand the person at the distant telephone. This is equivalent to reducing the receiving efficiency.

The elimination or reduction of sidetone is, therefore, equivalent to raising the transmitting and receiving efficiencies. In practice, it is not desirable to eliminate sidetone completely but merely to reduce it, because many people gauge the efficiency of a telephone by the presence of sidetone.

The early transmitters and receivers were relatively inefficient and did not produce excessive sidetone. However, improvements in transmitters and receivers caused a corresponding increase in sidetone, and anti-sidetone circuits were developed to reduce this effect. All modern telephones use an anti-sidetone induction coil, abbreviated to A.S.T.I.C.

5.2 The principle of operation of the magneto telephone A.S.T.I.C. circuit is explained from Figs. 6 and 7, which show the conditions at a particular instant. For the other half cycle of speech, the conditions reverse.

The A.S.T.I.C. circuit is similar to the basic speaking circuit with the addition of an extra winding on the induction coil and a balance network.

For simplicity of explanation, it is assumed that —

(i) the CB and BD windings connected in series, have equal turns and resistance, and

(ii) the impedance (Z1) of the line and distant telephone equals the impedance (Z2) of the balance network fitted in the telephone (600 ohms).

Transmitting (Fig. 6a). When a person speaks into the transmitter, the A.C. component of speech induced in the CD winding flows through the balance network (Z2) and over the line and distant telephone (Z1).

The turns ratio of the induction coil windings helps to match the transmitter to the load which consists of Z1 and Z2 in series.


FIG. 6.
Sidetone Suppression. Fig. 6b is an equivalent simplified "bridge" circuit of Fig. 6a. The alternating voltage induced across the CD winding when the transmitter is operated by sound waves, exists also across the load.

As point B is the mid-point of the CD winding and point A is the mid-point of the load impedance, points A and B, at all times, have the same potential. As the receiver is connected between these points, no sidetone is heard.

Receiving (Fig. 7). Alternating speech currents from line flow through the receiver and CB winding.

![Diagram](image)

**FIG. 7. OPERATION OF A.S.T.I.C. (RECEIVING).**

Although it would appear that a large portion of the speech current flows through the balance network, this is not so. The alternating magnetic flux produced by the CB winding sets up an e.m.f. of mutual induction across the BD winding, the polarity of which tends to oppose any current through the network.

Under certain conditions (for example, when the receiver impedance equals the impedance offered by the CB winding, the CB and BD windings have equal turns and the induction coil is 100% efficient), the voltage across the CB winding and, therefore, the e.m.f. induced in the BD winding equals the p.d. across the receiver. Fig. 7 shows the polarities at a particular instant for an applied e.m.f. of 1 volt.

The balance network is then connected to points A and D which, at all times, have the same potential. Thus, no incoming speech currents flow through the network and all pass through the receiver.

Compared with the basic speaking circuit, therefore, this basic anti-sidetone circuit eliminates sidetone when transmitting but does not reduce the receiving efficiency.

It is interesting to note that when the circuit to the balance network is open, the transmitting and receiving efficiencies are not appreciably altered but there is no reduction in sidetone.

5.3 In modern magneto telephones, the A.S.T.I.C. is designed for satisfactory transmitting and receiving efficiencies and sidetone suppression.

In practice, the optimum ratio of turns of the three windings and the impedance provided by each, differ for each function; for example, if the A.S.T.I.C. is designed for maximum transmitting efficiency, it may not necessarily give satisfactory receiving efficiency or sidetone suppression. Also, the line impedances to which the telephone may be connected vary considerably depending on the primary constants, lengths and types of lines; also both the line and receiver impedances vary over the V.F. range.

In the practical design of A.S.T.I.C's, therefore, it is necessary to adopt a compromise which gives satisfactory performance for each condition of operation. As a result, a number of different A.S.T.I.C's have been used, each development giving some degree of improved performance compared with the earlier types, but they are all basically similar in operation to the arrangement described in paragraph 5.2.

A typical coil is the A.S.T.I.C. No. 21A used in 300 series telephones.
5.4 The A.S.T.I.C. No. 21A (Fig. 8) has four windings:

(i) A 1 ohm "transmitter" winding of 400 turns.
(ii) A 17 ohm "line" winding of 1,000 turns.
(iii) A 33 ohm "balance" winding of 1,500 turns.
(iv) A 900 ohm non-inductive resistance.

The core comprises a bundle of soft iron wires insulated from each other to reduce eddy current losses.

The open core prevents saturation of the magnetic circuit due to the transmitter current in the 1 ohm winding.

One important difference is that the A.S.T.I.C. No. 21A has more turns on the "balance" than on the "line" winding. The reason for this is as follows:

Due to the open magnetic circuit, all the flux produced by the 17 ohm "line" winding by incoming speech currents does not cut all the turns of the 33 ohm "balance" winding. Thus, for equal turns, the e.m.f. induced in the 33 ohm winding would be less than the P.D. across the receiver. The balance network would not be connected to points of equal potential and it would shunt some incoming speech current from the receiver thus lowering the receiving efficiency. The increase of turns raises the induced e.m.f. in the 33 ohm winding to equal, approximately, the P.D. across the receiver.
The increased turns would unbalance the circuit and produce excessive sidetone when transmitting, and to compensate for this, the impedance of the balance network is similarly increased, compared with the impedance of the line and distant telephone.

To keep sidetone to a minimum over the V.F. range, the impedance of the balance network must vary with frequency in the same manner as the impedance of the line and distant telephone. In an attempt to simulate the variation in line impedance, which decreases as the frequency rises, a capacitor is connected in the balance network.

The balance network consists of the 900 ohm N.I.R. in series with an 0.4 μF capacitor.

In practice, this anti-sidetone circuit does not entirely eliminate sidetone because it is impossible to maintain a perfect impedance balance between the balance network and the different types of telephone lines used, over the V.F. range. However, compared with the earlier circuits, it greatly reduces the sidetone, without any noticeable effect on the efficiency of the speaking circuit.

5.6 To produce a practical telephone circuit (Fig. 10), a magneto bell, hand generator and cradle switch contacts are added to the anti-sidetone speaking circuit.

The signalling circuit operation is similar to that described for Fig. 4b (see paragraph 3.2).

5.7 The 1.7 μF capacitor in series with the bell allows the ringing current to pass through and operate the bell, but ensures that a D.C. circuit is not provided when the telephone is not in use. Under certain conditions (for example, a call from a subscriber connected to an automatic exchange to a subscriber connected to a magneto exchange within the same unit fee area), this D.C. circuit is used to provide for the metering of the call against the calling subscriber (automatic) when the called subscriber (magneto) removes the handset from the cradle switch to answer the call.
6. 300 SERIES TELEPHONES.

6.1 Some of the telephones in this series are -

(i) The types 334 MT and 338 MT, developed in England.
(ii) The types 300 MT and 300 MW, developed by the Australian Post Office.

The general appearance of the table telephones is similar, and the main difference is in the construction and layout of the component parts. For example, the type 334 telephone uses a type C hand generator mounted on the chassis, but the type 300 telephones use the A.P.O. generator mounted on the case. (Fig. 11.)

The schematic circuit and the operation of the table and wall telephones are similar.

6.2 Both table and wall instruments are made up of two units -

(i) A moulded case containing a 1,000 ohm bell, A.S.T.I.C. No. 21A, 1.7 µF and 0.4 µF capacitors (in the one metal can), cradle switch contacts and hand generator.

(ii) A handset No. 164 or No. 184 containing the transmitter No. 13, and either a type 1L or 2P receiver. A cord 3306 connects the handset to the case.

In the table models, the exchange line and the connections to the dry cell battery (mounted in a battery box) terminate on a terminal block No. 20/4 which is connected to the case by a cord 3406. In the wall telephone, the exchange line and the local battery connect directly to terminals inside the case.

(a) Magneto Table Telephone.  (b) Magneto Wall Telephone.

(c) Internal View of 334 MT.  (d) Internal View of 300 MT.

FIG. 11. TYPICAL 300 SERIES HANDSET TELEPHONES.
6.3 Fig. 12 shows typical schematic circuits for the types 334 and 300 telephones. These circuits are similar in operation to the anti-sidetone magneto telephone circuit developed in Section 5.

(a) 334 MT Telephone.

(b) 200 MT and 300 MW Telephones.
7. 400 SERIES TELEPHONES.

7.1 The 400 series telephone will in future, be the standard telephone used by the Australian Post Office. This telephone uses a rocking armature receiver which is superior, both in volume efficiency and frequency response, to receivers previously used. It also uses a more efficient A.S.T.I.C., designed to raise the transmitting efficiency of the circuit at the expense of some of the increased receiving efficiency.

Because of the increased transmitting and receiving efficiencies, these telephones will give a better performance with existing lines than the equivalent 300 series telephones. Alternatively, for similar performance, they can be used on longer lines or smaller gauge wires.

7.2 A typical telephone in this series is the 400 MT (Fig. 13), which is made up of two units:

(i) A moulded case containing a 1,000 ohm bell, A.S.T.I.C., 1.7 μF and 0.3 μF capacitors (in the one metal can), cradle switch contacts and hand generator.

(ii) A handset No. 400 containing the transmitter No. 13 and rocking armature receiver.

The exchange line and the connections to the dry cell battery (mounted in a battery box) terminate on a terminal block No. 204 which is connected to the case by a cord 4406; and a cord 3306A connects the handset to the case.
7.3 The A.S.T.I.C. has five windings (Fig. 14) -

(i) A 1 ohm "transmitter" winding of 250 turns.
(ii) A 15 ohm "line" winding of 800 turns.
(iii) A 10.5 ohm "balance" winding of 463 turns.
(iv) A 530 ohm non-inductive resistance.
(v) A 115 ohm non-inductive resistance.

![Fig. 14. A.S.T.I.C. USED IN 400 SERIES MAGNETO TELEPHONES.](image)

The silicon iron core is built up in two sections, each L-shaped and laminated to reduce eddy current loss. A spacer provides a small gap in the magnetic circuit to avoid saturation by the transmitter current. The higher permeability of the core material and lower reluctance of the almost closed magnetic circuit enables the use of fewer turns on each winding than are required when the magnetic circuit includes a large air path, as in the A.S.T.I.C. No. 21A. Thus, the higher overall efficiency of the A.S.T.I.C. is the result of reduced magnetic and copper losses.

7.4 The speaking circuit operation is similar to that described in paragraph 5.2 and can be developed from Fig. 15 which shows the basic connections to the A.S.T.I.C.

Owing to the improved efficiency of the speaking circuit compared with the 300 series telephones, the balance network (comprising the 530 ohm and 115 ohm N.I.R.'s, wound on the A.S.T.I.C., and the 0.3 μF capacitor) is designed to balance more accurately the line impedance variation to ensure satisfactory sidetone suppression over the V.F. range.

7.5 To produce a practical telephone circuit, a magneto bell, hand generator and cradle switch contacts are added to the anti-sidetone speaking circuit as in Fig. 16. The signalling circuit operation is similar to that described for Fig. 4b (see paragraph 3.2).

![Fig. 15. ANTI-SIDETONE SPEAKING CIRCUIT.](image)

![Fig. 16. SIMPLIFIED CIRCUIT OF 400 SERIES MAGNETO TELEPHONES.](image)
2. MAGNETO SWITCHBOARDS.

2.1 In manual telephone systems -

The calling subscriber (or calling party) is the person originating a call.

The called subscriber (or called party) is the person for whom a call is intended.

Switchboards are provided at the exchange to interconnect the lines.

The telephonists (or operators) make the switchboard connections between the lines.

The operator's position (or simply position) is the part of a switchboard normally controlled by one telephonist.

2.2 Facilities. Magneto switchboards provide facilities for the telephonist -

(i) to receive a visual signal from a calling subscriber,
(ii) to answer the calling subscriber,
(iii) to signal the called subscriber,
(iv) to connect the two subscribers' lines,
(v) to supervise (monitor) the through connection,
(vi) to receive a visual clearing signal at the end of the call,
(vii) to receive an audible alarm signal, sometimes called a night alarm (N.A.), if required, in conjunction with (i) and (vi) above, and
(viii) on some boards, to record the calls made by the calling subscribers for charging purposes.

These switchboards are also used as private manual branch exchanges (P.M.B.Xs.) in subscribers' premises; but all new P.M.B.Xs. in magneto areas are the C.B. type.
3. CORD SWITCHING.

3.1 Cord type magneto switchboards are designed for either wall or floor mounting. They consist of—

(i) A line circuit for each subscriber, comprising
- a line jack on which the subscriber's line terminates, and
- a line indicator for signalling purposes.

(ii) A number of cord circuits, each consisting of—
- two plugs and cords, one used for answering an incoming call and one for calling (ringing) the required subscriber,
- a clearing indicator for supervisory purposes, and
- a three-position lever key for connecting the telephonist's speaking and ringing circuits.

3.2 Basic Magneto Switchboard. Fig. 2 shows the basic principle of connecting two magneto telephones by a cord circuit. The subscribers' lines connect via the exchange M.D.P. to the tip and ring springs of the line jacks. The line indicators connect to the inner springs.

Each cord circuit, however, must have speaking and ringing facilities, and a lever key, sometimes called and R and L key (for ring and listen), is connected as shown in the simplified schematic circuit of Fig. 3.

A telephonist's (or operator's) anti-sidetone circuit similar to the 300 type magneto telephore circuit can be connected to any cord circuit to enable the telephonist to speak to the caller and ascertain the required number, or to supervise (monitor) the progress of the call once it is set up.

Ringing current can be connected to any cord circuit to signal the called subscriber. This is obtained from a hand generator at small exchanges and at larger exchanges from a machine-driven generator or a mains operated static device called a sub-cycle ringer, both of which supply all the switchboards at an exchange. Hand generators are individual to each board and are usually provided as an alternative should the power ring supply fail.
3.3 Circuit operation (refer Fig. 3).

Incoming signalling. The A.C. ring from a calling subscriber's hand generator operates the line indicator via the inner springs of the line jack. The shutter drops to give the telephone operator visual notice of the subscriber's number. The indicator contacts complete the night alarm bell or buzzer circuit, if the N.A. switch is closed.

To answer the call, the telephone operator inserts the answering plug of any pair of cords in the calling subscriber's line jack. This disconnects the line indicator, the shutter of which is restored by hand. The telephone operator's circuit is connected to the calling subscriber's line by operating the lever key associated with the cord circuit to the "speak" (locking) position.

To ring the called subscriber, the telephone operator inserts the calling plug of the same cord circuit in the called subscriber's line jack, operates the lever key to the "ring" (non-locking) position, and turns the hand generator if power ringing is not provided. The ring is not heard by the calling subscriber, since this line is disconnected at the inner springs of the key in the ringing position.

To connect the lines, the telephone operator restores the lever key to the normal (centre) position.

To monitor the call, the telephone operator operates the lever key to the "speak" position. This connects the telephone operator's circuit across tip and ring of the cord circuit, but does not interrupt the through connection.

When the subscribers "ring off" at the end of the call, the clearing indicator operates to give a visual signal and also an audible alarm, if the N.A. switch is closed. The clearing indicator is connected across the speaking circuit, but has no appreciable shunting effect on the conversation as it offers a very high impedance to A.C. at speech frequencies.

The telephone operator records the call against the calling subscriber on a tally card, and takes both plugs from the line jacks, restoring the circuits to normal.
4. WALL SWITCHBOARDS (CORD TYPE).

4.1 Cord type switchboards for wall mounting (Fig. 4) are wired for a maximum capacity of 30 subscribers' lines, 10 outgoing junction or trunk lines, and 10 cord circuits.

The switchboards, however, may be installed partially equipped for either 10 or 20 subscribers' lines.

4.2 The face layout (Fig. 4a) covers -
- four rows each of ten indicators, three for line and one for clearing indicators,
- a row of ten lever keys (3-position) for speaking and ringing,
- four rows each of ten line jacks, one row of which is for outgoing junction or trunk lines,
- a special jack for testing cord circuits, and
- a night alarm switch.

The cord shelf carries two rows of ten switching plugs and cords (two-conductor). The rear cords (nearest the face of the switchboard) are for answering and the front cords (nearest the telephonist) for calling. Each cord is fitted with a weighted pulley which hangs below the switchboard.

A telephonist's handset is provided on the left hand side of the switchboard, and a hand generator (not shown in Fig. 4a) on the right hand side.

4.3 The circuit operation (Fig. 4b) is similar to that described in Section 3. The transmitter circuit is closed by a pair of auxiliary springs when any lever key is operated to the "speak" position.

4.4 The Cord Test Jack enables testing of the switching cords for faulty connections and the operation of the clearing indicators. When any plug is inserted, the clearing indicator should operate, proving continuity of the cord conductors. With the speaking key operated, hold the plug and shake the cord. Fractured cord conductors are indicated by noise in the receiver.

4.5 Junction and trunk lines. This type of switchboard is often installed at small country centres which are connected by junction and trunk lines to other exchanges.

Calls originated by local subscribers may be switched -
- to another subscriber in the same exchange area,
- to another exchange within the unit fee area over a junction line, or
- to a distant exchange beyond the unit fee area over a trunk line.

Also incoming calls over these junction and trunk lines may be switched to local subscribers.

Incoming or both-way junction and trunk lines are terminated on subscribers' line circuits, with consequent reduction of subscriber capacity. Both-way lines are used for both incoming and outgoing calls.

For incoming signals on trunk lines, particularly when the switchboard is not constantly attended, the line indicator is generally replaced by a magneto bell which is connected permanently across the line.

Terminations are often arranged so that a trunk line may be "sectionised" to permit simultaneous calls over two different sections. This requires three jacks, one for termination of each direction, and one for listening across the line (see paragraph 7.4).
(a) Face Layout.

(b) Schematic Circuit.

MAGNETO WALL SWITCHBOARD (CORD TYPE).

FIG. 4.
5. FLOOR SWITCHBOARDS (CORD TYPE).

5.1 Cord type switchboards for floor mounting (Fig. 5) have a maximum capacity of either 100 or 200 subscribers lines. 100 line switchboards can be installed equipped for 30, 50, 80 or 100 lines, and 200 line switchboards for 100, 140, or 200 lines. The number of cord circuits varies from 10 to 17, depending on the number of lines connected. In magneto exchanges with more than 200 subscribers, a number of these switchboards may be placed side by side.

5.2 The general principles and circuit operation are similar to the wall pattern cord type switchboard, and the following additional facilities are provided.

The Generator Switching Key is a two-position locking lever key which connects either the hand generator or power ringing current to the cord circuit.

The Ringing Vibrator, in series with the ringing supply, gives the telephonist a visual indication that ringing current is going to line. On some boards, an A.C. relay is used, contacts of which complete the circuit to a "Ring Pilot" lamp.

The Ring-back and Coupling lever key is a three-position key. The telephonist's circuit is connected via this key, in its normal position, to the "speak" keys.

The Ring-back (non-locking) position is used in association with the "speak" key of any cord circuit, so that the telephonist can ring and recall any calling subscriber via the answering plug. In the wall pattern board, it is necessary to interchange the plugs. The clearing indicator is connected to the inner springs of the "speak" key, which open to prevent the operation of the indicator when ringing back.

The Coupling (locking) position is used when more than one board is installed, so that a telephonist can attend to more than one position. When operated, the key connects the telephonist's circuit to the "speak" keys on the other coupled positions. This enables all cords on coupled positions to be used with the transmitter and receiver plugged into any one position.

5.3 Trunk and junction lines terminate on jacks below the subscribers' line jacks. The trunk line indicators are mounted immediately below the subscribers' line indicators.

5.4 A and B Positions. In some large exchanges, the trunk and junction lines terminate on trunk or "B" positions separate from the subscribers' lines which terminate on local or "A" positions. To give full interconnecting facilities, either transfer or multiple working is used, or some combination, such as -

(i) A subscriber's multiple on the "B" positions only, and transfer working between "A" positions.

(ii) Transfer working between all positions, plus a full or partial trunk multiple between the "B" positions and alternate "A" positions.

These and other similar expedients have been added to magneto centres as the size of the exchange and the volume of traffic have increased. They facilitate the handling of traffic but are not ideal.

Magneto multiple exchanges having meters, electrically self-restoring indicators or lamp signalling for both calling and supervisory purposes, and full I.D.F. facilities have been installed, but very few are still in service.

The principles of transfer and multiple working, lamp signalling, metering and the I.D.F., which are used also in C.B. manual exchanges, are described in the paper "C.B. Exchange Principles".
(a) Face layout (100 line switchboard).

(b) Schematic Circuit.

MAGNETO FLOOR SWITCHBOARD (CORD TYPE).

FIG. 5.
6. PYRAMID SWITCHBOARDS.

6.1 These cordless switchboards (Fig. 6a) are used at small exchanges, usually of non-official status, and may be either table or wall mounted. To connect any two lines (subscribers or trunk), the telephonist inserts a plug which has the tip and ring connected together in a jack appropriate to the required connection.

The plugs normally remain in the bottom row of jacks, termed the indicator jacks. Answering and calling on any line is done from the line jacks immediately above the indicator jacks. The remaining jacks are arranged in the form of a pyramid, one for each possible cross-connection, such as 1-2, 1-3, 1-4, 2-3, 2-4, 3-4. A jack must be provided for each possible connection and, thus, the scheme is not practicable for more than 10 lines.

A telephone handset and a switch-hook are provided for the telephonist. The switch-hook also controls the battery supply to the handset transmitter. A hand generator is fitted for signalling. The drop indicators mounted at the top of the switchboard, are ironclad and are used for both calling and clearing signals. A night alarm bell with switch is commoned to all indicator contacts.

This board is cheap to manufacture and simple to operate. Also, due to the absence of switching cords, it has low fault liability, which is important as the boards are usually installed in remote country areas where delays may occur in attending to switchboard faults.

6.2 Sizes of Boards.

- 4-line switchboard; equipped with 14 jacks, 4 plugs and 4 drop indicators.
- 6-line switchboard; equipped with 27 jacks, 6 plugs and 6 drop indicators.
- 10-line switchboard; equipped with 65 jacks, 10 plugs and 10 drop indicators.

6.3 Circuit operation (refer Fig. 6b).

An incoming ring from a calling subscriber, say, line 1, operates the associated indicator via A side of line, auxiliary springs of indicator jack, drop indicator, tip and ring springs of indicator jack (through the connection between tip and ring of the plug), to B side of line.

To answer the call, the telephonist removes the plug from indicator jack 1, places it in line jack 1, and removes the handset from the switch-hook. This disconnects the drop indicator, the shutter of which is restored manually, and connects the telephonist’s circuit to line 1.

To ring the called subscriber, say, line 2, the telephonist restores plug No. 1 to indicator jack 1, and transfers plug No. 2 from its indicator jack to line jack 2. This connects the telephonist's circuit to line 2. The telephonist then replaces the handset on the switch-hook and turns the generator handle.

To connect the lines, the telephonist inserts plug No. 2 into jack 1-2. This connects the A sides of the lines via the auxiliary springs on jack 1-2, and the B sides via the connection between tip and ring of the plug. The telephonist’s circuit is then disconnected and indicator No. 1 is bridged across the connection for supervisory purposes.

To monitor the call, the telephonist's circuit is bridged across the connection by insertion of a plug into line jack 1 or 2.

When the subscriber's "ring off" at the end of a call, indicator No. 1 operates to give a clearing signal.

The telephonist records the call against the calling subscriber, and restores the switchboard to normal by transferring the plug from jack 1-2 to indicator jack 2.
(a) 10 Line Switchboard.

(b) Schematic Circuit.

FIG. 6. MAGNETO CORDLESS SWITCHBOARD (PYRAMID TYPE).
MAGNETO SWITCHING PRINCIPLES.

7. JUNCTION, TRUNK AND PARTY LINES.

7.1 Junction and trunk lines are used to connect magneto switchboards to nearby magneto, C.B., and automatic exchanges (see paragraph 4.5).

At the smaller exchanges, these lines terminate on jacks in the same jack field as the subscribers' line jacks; but at larger centres, separate trunk switchboards are generally used.

Between very small exchanges, a line may be both-way; but between larger exchanges it is usual to divide the lines into incoming and outgoing groups.

7.2 Signalling. High impedance 2000 ohm line indicators or 2000 ohm magneto bells are used to receive an incoming call. These have more turns than the lower impedance 1000 ohm types, to increase the sensitivity to ringing currents on long lines. They also reduce the shunting effect on the signalling and speech currents, when several are connected in parallel.

Bells are satisfactory for no more than about three or four lines at a particular exchange, the bell on each line being given a different tone for identification.

A dial is fitted on a magneto switchboard which has junction or trunk lines to an automatic exchange.

7.3 Omnibus working (Fig. 7). In smaller exchanges, many magneto trunk lines are omnibus lines (the same trunk connects to several exchanges). A 2000 ohm magneto bell is connected across the line at each exchange. Bells are preferred to indicators as each exchange is called by a different combination of long and short rings (code ringing).

7.4 Divided working is used on some trunk lines so that a call on one section of the line does not busy the entire line. Fig. 8 shows the arrangement at an intermediate exchange. Note that both sections of the line can be used at the same time to set up calls. When either section is in use, the other section is disconnected at the inner springs of the jack and terminated on a high impedance indicator or bell. The listening jack enables the telephone to monitor whether the trunk line is being used for a call over the entire line, before plugging into jack A or B to ring either terminal.
7.5 **Party Lines.** In a party line service (Fig. 9), two or more subscribers (parties) are connected in parallel across the same line to the exchange.

![Diagram of Party Line Service]

**FIG. 9. MAGNETO PARTY LINE SERVICE.**

A party line saves line plant, and is used to provide a service (usually in country areas where long distances are involved) for subscribers who are reasonably close to one another and in the same general direction from the exchange. The number of magneto party line telephones is generally limited to six, although more may be permitted in special cases. The same exchange number is used with a separate distinguishing letter for each party. The telephonist signals each party by using an individual code. Also, the parties can signal each other by code ringing.

The main disadvantages are:

(i) No secrecy between the parties, either on incoming or outgoing calls.

(ii) No discrimination at the exchange between calls for other parties and exchange calls, as the line indicator operates in either case.

Various selective ringing arrangements using special generators and bells, have been devised to overcome the latter disadvantage but they are not used to any great extent.

7.6 **P.P.E. Lines.** In certain cases a subscriber is permitted to build a portion of a telephone line. This is called a P.P.E. (part privately erected) line. In magneto areas, the privately erected portion of the line is either single-wire (earth return) or two-wire (metallic). The single-wire line connects to the two-wire Departmentally erected line via a pole mounted transformer (Fig. 10).

![Diagram of P.P.E. Line]

**FIG. 10. EARTH RETURN P.P.E. LINE.**

A party line service may be used in conjunction with P.P.E. lines.